DOE/AL/62350-149
REV. 0

BASELINE RISK ASSESSMENT OF GROUND WATER CONTAMINATION AT THE URANIUM MILL TAILINGS SITE NEAR CANONSBURG, PENNSYLVANIA

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September 1994

Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico

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CITIZENS' SUMMARY

This baseline risk assessment evaluates potential impacts to public health and the environment resulting from ground water contamination from past activities at the former uranium processing site in Canonsburg, Pennsylvania. The U.S. Department of Energy Uranium Mill Tailings Remedial Action (UMTRA) Project has placed contaminated materials from this site in an on-site disposal cell. Currently, the UMTRA Project is evaluating ground water contamination. This risk assessment is the first document specific to this site for the UMTRA Ground Water Project.

Currently, no domestic or drinking water wells tap into contaminated ground water of the two distinct ground water units: the unconsolidated materials and the bedrock. Because there is no access, no current health or environmental risks are associated with the direct use of the contaminated ground water. However, humans and ecological organisms could be exposed to contaminated ground water if a domestic well were to be installed in the unconsolidated materials in that part of the site being considered for public use (Area C). Potential exposure to contaminants in bedrock ground water was not evaluated because only one isolated area of contamination is in the bedrock and it does not appear to have migrated downgradient. This small area of contamination is located on the site where ground water use is permanently restricted.

In addition, humans, domestic animals, and wildlife could be exposed through surface expressions of ground water in Chartiers Creek.

This risk assessment follows the approach outlined by the U.S. Environmental Protection Agency. The first step is evaluating ground water data collected from monitor wells at the site. For the Canonsburg site, this evaluation showed the contaminants in ground water exceeding background in the unconsolidated materials in Area C are ammonia, boron, calcium, manganese, molybdenum, potassium, strontium, and uranium. Based on potential toxicity, the human health risk assessment evaluated a subset of these contaminants (manganese, molybdenum, uranium, and some products of radioactive decay of uranium).

The next step in the risk assessment is estimating how much of these contaminants people would be exposed to if a drinking water well were installed in the contaminated ground water or if there were exposure to contaminants in Chartiers Creek. Exposure to ground water could occur through ingestion of drinking water or garden vegetables irrigated with ground water or absorption of contaminants through the skin. Potential exposure to contaminants in Chartiers Creek includes ingestion of surface water, sediment, or fish or absorption of contaminants through the skin.

The estimated amounts of contaminant intakes are then compared with both toxic and safe or normal dietary intake levels of these contaminants. Based on this analysis, no adverse health effects are expected for children who swim or wade in Chartiers Creek. In addition, no adverse health effects are expected from ingesting fish from Chartiers Creek. However, adverse health effects are likely if ground water in the unconsolidated materials is used for drinking. The most significant health hazard in the ground water at the Canonsburg site is manganese. The amount of manganese potentially ingested from a well in the unconsolidated materials is expected to affect the nervous system and may result in symptoms of intoxication, such as muscle rigidity, tremors, and mental disturbances.

Concentrations of uranium and uranium decay products at the site may slightly increase the risk of cancer. The average additional cancer risk from ingesting contaminated ground water for a lifetime is 1 in 100,000.

This risk assessment also evaluates potential effects on ecological organisms. Based on available data, no threat exists to plants whose roots contact the most contaminated ground water in the unconsolidated unit. However, ground water would not be suitable for continuous long-term irrigation of plants due to manganese levels.

The assessment of aquatic health in Chartiers Creek is inconclusive due to limited surface water and sediment sampling data and the absence of sediment quality guidelines or water quality criteria for all the contaminants of concern. However, water quality criteria were not exceeded for those contaminants for which they were available.

The mill tailings disposal cell at the Canonsburg site is being monitored. The Canonsburg site will be further evaluated under the UMTRA Ground Water Project. Based on the results of this new information and this risk assessment, an approach will be developed to address ground water contamination. The overall ground water decision-making framework will be presented in a programmatic environmental impact statement and other ground water documents. These will include public involvement. In the interim, mechanisms for the control of access to contaminated ground water in Area C are being considered.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
ac	acre
ACL	alternate concentration limit
AEC	Atomic Energy Commission
BCF	bioconcentration factor
cm^2/s	square centimeters per second
DOE	U.S. Department of Energy
°C	degrees Celsius
°F	degrees Fahrenheit
EPA	U.S. Environmental Protection Agency
ft	foot
ha	hectare
HEAST	Health Effects Assessment Summary Tables
IRIS	Integrated Risk Information System
kg	kilogram
km	kilometer
L/kg	liters per kilogram
L/cm^2	liters per square centimeter
µg/kg	micrograms per kilogram
m	meter
MCL	maximum concentration limit
mg/L	milligrams per liter
mg/kg-day	milligrams per kilogram per day
mi	mile
MSL	mean sea level
NCP	National Contingency Plan
NRC	Nuclear Regulatory Commission
pCi/L	picocuries per liter
PEIS	Programmatic Environmental Impact Statement
Rfd	reference dose
TAC	technical assistance contractor
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Control Act

1.0 INTRODUCTION

The purpose of this baseline risk assessment is to determine whether ground water contamination at the Canonsburg, Pennsylvania, uranium processing site can adversely affect public health or the environment. The Canonsburg site is one of 24 abandoned uranium processing sites undergoing remediation in accordance with the requirements of the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) of 1978 (42 USC §7901 *et seq.*) under the oversight of the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project.

Under the UMTRA Surface Project, the DOE has stabilized contaminated materials in a disposal cell that minimizes radon and other radiation emissions and further contamination of ground water. Remedial action at the Canonsburg site was completed in 1986 with stabilization of tailings, contaminated materials, and soils in a disposal cell at the former uranium processing site.

Under the UMTRA Ground Water Project, ground water contamination at the site will be evaluated to determine whether any remedial action is necessary and to implement such action. The 1988 amendments to the UMTRCA authorized the DOE to perform ground water restoration.

The *Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (DOE, 1994) (PEIS) describes the evaluation strategy and remediation methodology for contaminated ground water at the UMTRA project sites. This baseline risk assessment is one of the site-specific documents prepared to evaluate potential health and environmental risks and provide information to help determine the remedial action, if any, required. Following the PEIS, this risk assessment, a site observational work plan, and a site-specific environmental assessment will be prepared to evaluate and select a ground water compliance strategy for the Canonsburg site.

This risk assessment is a baseline assessment in the sense that it describes preremediation ground water conditions at the site, with ground water contamination only partially characterized. Nonetheless, this document evaluates the potential for imminent public health or environmental risks that may need attention before the site is fully characterized.

The evaluation is based on available ground water data from the most contaminated wells at the processing site, and only major exposure pathways have been thoroughly examined. If future data collection, decisions, or actions at this site cause conditions to change, other pathways will be evaluated in more detail.

This risk assessment follows the basic framework outlined by the U.S. Environmental Protection Agency (EPA) (1989a) for evaluating hazardous waste sites to assess potential health and environmental impacts. The risk assessment process consists of the following steps:

- Contamination characterization.
    - Selecting chemical data for the risk assessment.
    - Comparing sample results with background data.
    - Selecting chemicals of potential concern.
    - Discussing contaminant fate and transport.

- Exposure assessment.
    - Characterizing exposure settings.
    - Identifying exposure pathways.
    - Identifying potentially exposed populations.
    - Quantifying exposures.

- Toxicity assessment.
    - Identifying toxicity values.
    - Evaluating noncarcinogenic effects of chemicals.
    - Evaluating carcinogenic effects of radionuclides and chemical carcinogens.

- Public health risk characterization.
    - Comparing toxicity ranges with predicted exposure ranges.
    - Combining risks across exposure pathways and multiple contaminants.
    - Characterizing noncarcinogenic and carcinogenic risks.

- Environmental risk.
    - Characterizing potential biota exposure pathways.
    - Identifying potential ecological receptors.
    - Evaluating environmental risk qualitatively.

This framework is incorporated in the methodology used to evaluate current human health risks at UMTRA Project sites and to estimate risks from potential future use of contaminated ground water or surface water near the former uranium processing site. A report describing this methodology is in preparation.

2.0 SITE DESCRIPTION

The Canonsburg site is in the southwestern corner of the borough of Canonsburg, Washington County, in southwestern Pennsylvania. The site lies approximately 20 miles (mi) (30 kilometers [km]) southwest of downtown Pittsburgh (Figure 2.1) in a mixed commercial/residential area and comprises approximately 30 acres (ac) (12 hectares [ha]). The Canonsburg site is bounded by Chartiers Creek to the west, north, and east and by Conrail railroad tracks to the south (Figure 2.2).

2.1 SITE BACKGROUND

In the early 1900s, the Standard Chemical Company developed a method to extract and concentrate radium from carnotite ore. The company established its radium processing facilities at Canonsburg, Pennsylvania, and produced the first marketable quantities of radium in 1913. The company ceased processing operations in the early 1920s (DOE, 1983a,b).

The Vitro Manufacturing Company purchased the Canonsburg facility in 1933 to extract uranium, vanadium, and radium from various ores, concentrates, and residues. From 1942 until the facility's closing in 1957, the operations focused on producing uranium concentrates. The only customer during this period was the U.S. Government. The uranium, and other rare metals, were extracted from both company owned and government-owned ores, concentrates, and residues. Ores, concentrates, and scrap materials were brought from a number of Atomic Energy Commission (AEC) installations to the Canonsburg site for uranium recovery. All solid process wastes were stored temporarily on the Canonsburg site. The liquid wastes were discharged into the former swamp in Area C, which subsequently drained into Chartiers Creek. The swamp has since been filled in (DOE, 1983a,b).

On November 1, 1953, the U.S. Government and the Vitro Corporation entered into a contract requiring Vitro to process certain government-owned materials. The contract required Vitro to store the residues from this operation until November 1, 1955, because the AEC believed the residues might contain recoverable uranium. After attempts by the AEC to identify commercial interest in the material, the uranium in the residue was deemed "unrecoverable" and the AEC approved the transfer of 11,600 tons (10,500 tonnes) of material to the Burrell site, which is about 50 mi (80 km) northeast of the Canonsburg site. This material contained approximately 6 tons (5.4 tonnes) of uranium oxide and was transported to the Burrell site during late 1956 and early 1957.

Recovery operations at the Vitro plant ceased by 1957. Vitro stored the remaining residues and processing wastes on the site. Vitro's final source-material license expired, and in May 1961, Vitro applied to the AEC for another source-material license. On June 21, 1961, the AEC granted Vitro a license for storage of up to 23 tons (21 tonnes) of uranium contained in approximately 4500 tons (4080 tonnes) of material.

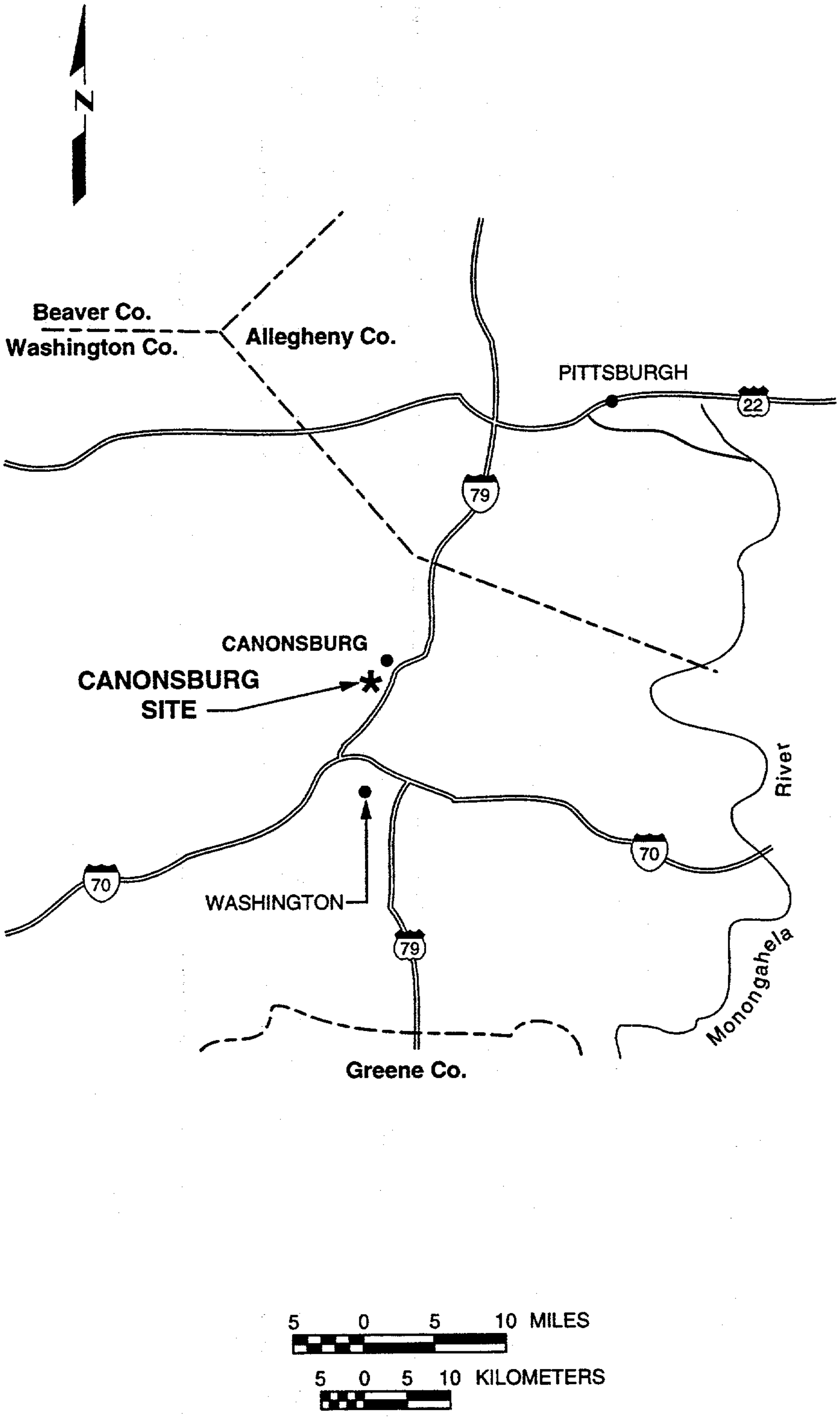


FIGURE 2.1
LOCATION OF THE CANONSBURG, PENNSYLVANIA, SITE

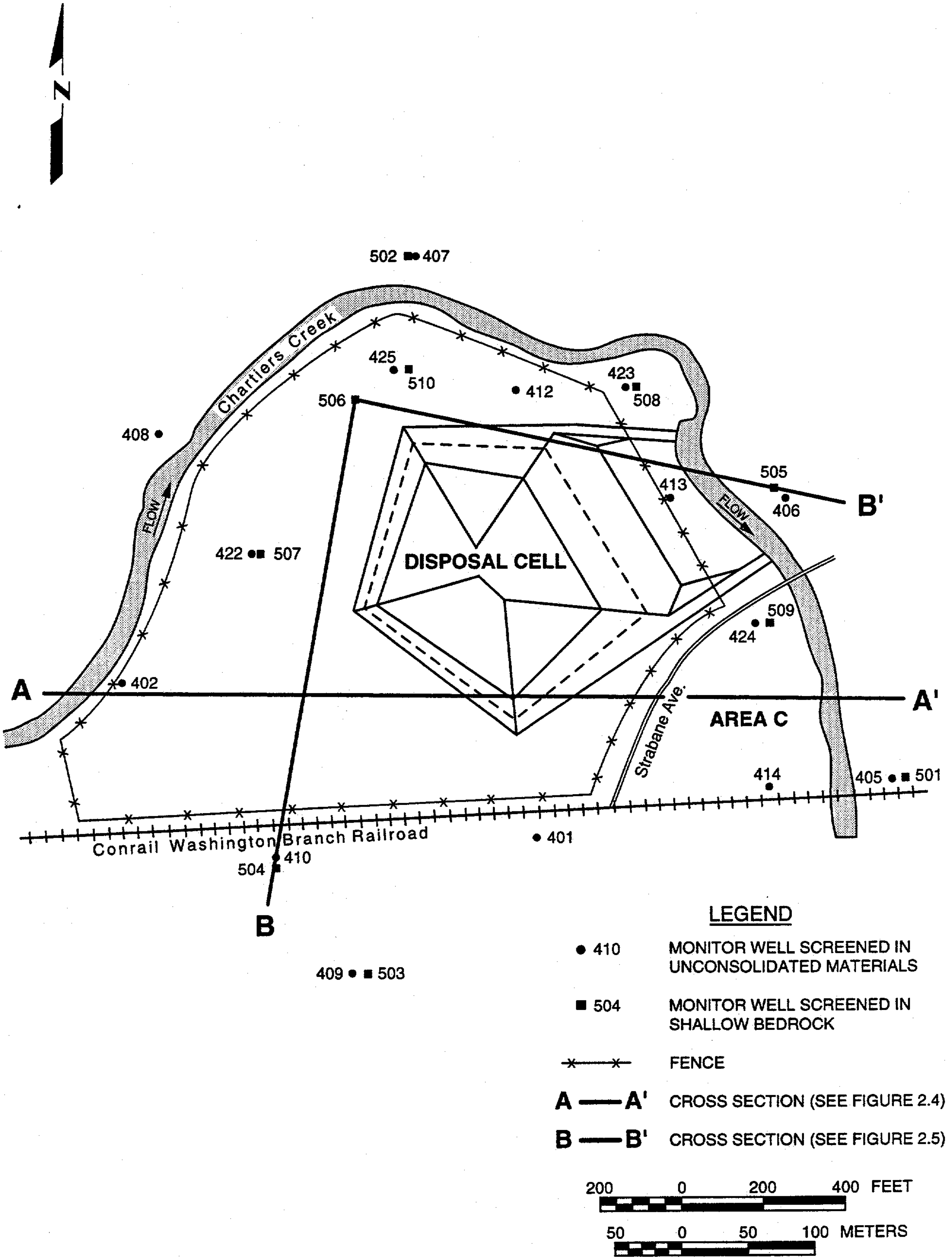


FIGURE 2.2
SITE MAP SHOWING LOCATION OF MONITOR WELLS AT THE CANONSBURG, PENNSYLVANIA, SITE

The real property was sold to developers in 1962, while Vitro retained title to the uranium-containing materials. Before 1964, an effort was made to decontaminate the immediate plant area, and all contaminated material was moved to a main stockpile of uranium-bearing material located in Area A. In 1965, the commonwealth of Pennsylvania granted Vitro a permit to move this pile to area C, where it was buried beneath a relatively impermeable layer of slag and covered by clean fill. Vitro's source-material license was then terminated, and the Canonsburg site was developed into the Canon Industrial Park in 1966, as depicted in Figure 2.3.

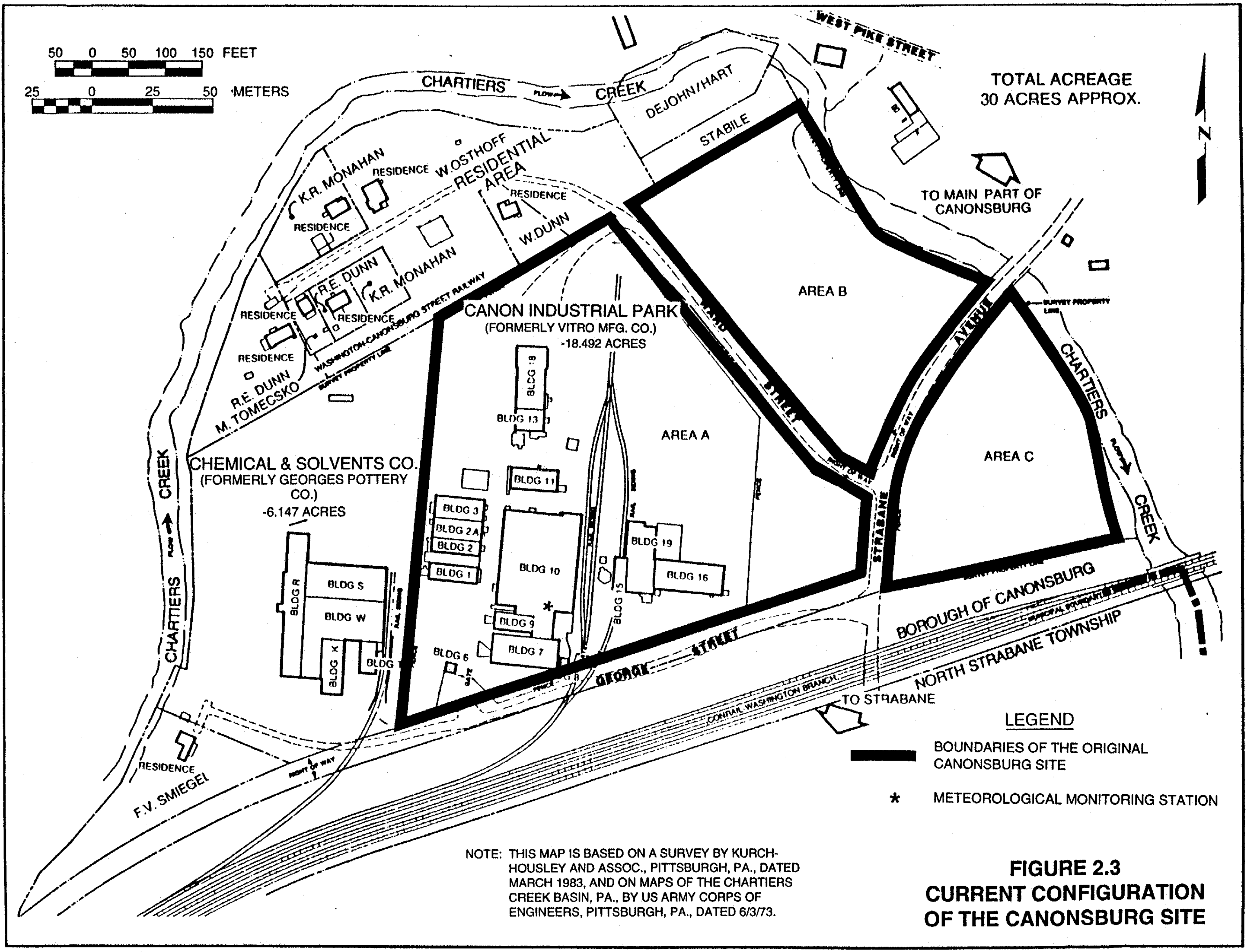
On November 8, 1979, the DOE designated the Canonsburg site as eligible for remedial action under the UMTRCA. Effective September 5, 1980, the DOE and the commonwealth of Pennsylvania entered into a cooperative agreement under the UMTRCA, setting forth the terms and conditions for a DOE and commonwealth cooperative remedial action effort (DOE, 1983a, 1983b). In 1982, the commonwealth of Pennsylvania acquired the Canonsburg site in accordance with the cooperative agreement between the state and the DOE (Licensing Implementation Plan, 1992).

Between 1984 and 1986, contaminated soils and materials (including those from Area C) were stabilized in a permanent disposal cell (Figure 2.2). Approximately 172,000 cubic yards (yd^3) (132,000 cubic meters [m^3]) of contaminated materials were stabilized in the disposal cell, which covers approximately 6 ac (2.4 ha) of the site (MK-Ferguson, 1986; Licensing Implementation Plan, 1992). The eastern toe of the cell was placed on fill material above the existing grade. The remainder of the site was evenly and smoothly graded to provide adequate site drainage and was revegetated with native grasses (DOE, 1983b). As shown in Figure 2.2, fencing was installed around the majority of the site, including Areas A and B. Area C, southeast of the designated disposal site, is not fenced and is being evaluated for public use.

The site is being monitored according to the Surveillance and Maintenance Plan for the Canonsburg site (DOE, 1992). The site will remain in the post-stabilization, prelicensing status until the U.S. Nuclear Regulatory Commission (NRC) issues a license for long-term surveillance and maintenance under the provisions of 10 CFR Part 40. The general license becomes effective for the Canonsburg site after the NRC concurs with the completion of the surface remedial action and approves the long-term surveillance plan. Upon licensing, ownership of the site, with the exception of Area C, will transfer from the commonwealth of Pennsylvania to the U.S. Government under the oversight of the DOE. The state will retain ownership of Area C.

2.2 CLIMATE

The Canonsburg site is in the humid continental climatic region. This region experiences distinct seasons with seasonal variations slightly moderated by the Great Lakes and the Atlantic seaboard (DOE, 1983a).



NOTE: THIS MAP IS BASED ON A SURVEY BY KURCH-HOUSLEY AND ASSOC., PITTSBURGH, PA., DATED MARCH 1983, AND ON MAPS OF THE CHARTIERS CREEK BASIN, PA., BY US ARMY CORPS OF ENGINEERS, PITTSBURGH, PA., DATED 6/3/73.

FIGURE 2.3
CURRENT CONFIGURATION
OF THE CANONSBURG SITE

The average annual temperature at the Canonsburg site is 50 degrees Fahrenheit (°F) (10 degrees Celsius [°C]), based on on-site data collected from 1979 to 1981. Based on these data, the winter temperatures at the site range from -6° to 63°F (-21° to 17°C), with an average temperature of 28°F (-2°C); the summer temperatures range from 36° to 95°F (2° to 35°C), with an average temperature of 70°F (21°C). Summers are generally mild but frequently humid due to invasions of tropical air from the Gulf of Mexico. The winter months are brisk with occasional periods of extreme cold. Spring and fall are transitional seasons, with moderate-to-cool temperatures. Rapid and wide variations in day-to-day weather conditions are common during the spring and fall (DOE, 1983a).

Based on data from the Pittsburgh International Airport from 1941 to 1980, the average annual precipitation in the area is 38 inches. March and June are the wettest months, each averaging 3.8 inches, while February and November are the driest, each averaging 2.4 inches. The average annual snowfall in the site vicinity is 45 inches. The snow season typically occurs from October to May, with the heaviest snowfall in January (DOE, 1983a).

The Canonsburg site is situated in the east-to-west-oriented Chartiers Creek valley, which channels wind flows. As a result, the predominant wind direction is west-to-northwest. Cross-valley winds (north and south) are limited to periods of relatively high wind speeds typically occurring in the winter as northerly winds. The average annual wind speed as measured from 1979 to 1980 at the Canonsburg site was 4.7 mi (7.6 km) per hour (DOE, 1983a).

2.3 PHYSIOGRAPHIC SETTING

The Canonsburg site is in southwestern Pennsylvania where the geologic structural setting consists of subparallel folds with northeastern axis orientation. Landfilling and earth-moving activities have altered the topography of the Canonsburg site, originally a low-lying flood plain. The site lies in the Chartiers Creek basin along the creek's southern bank, approximately 15 mi (24 km) upstream from its confluence with the Ohio River.

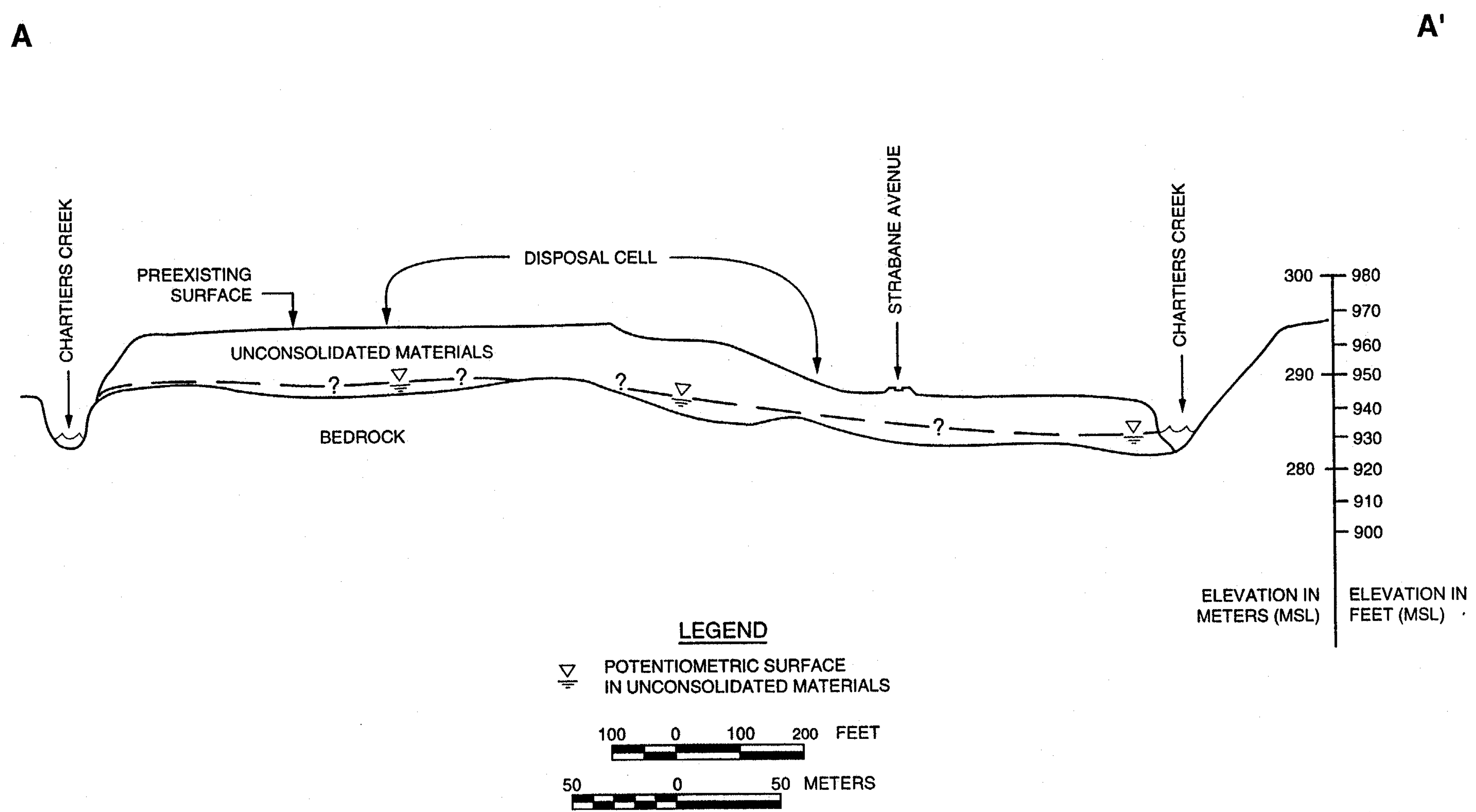
2.4 HYDROGEOLOGY

2.4.1 Geology

The Canonsburg site is on a sequence of unconsolidated materials overlying bedrock of the Pennsylvanian Casselman Formation (Figures 2.4 and 2.5).

Unconsolidated materials

The unconsolidated materials generally consist of up to 30 feet (ft) (9 meters [m]) of soil (sandy loam to silty clay loam), clay, alluvium, and fill material (cinders mixed with soil, stones/cobbles, and building rubble). The unconsolidated materials are heterogeneous beneath the site and do not form



MSL = MEAN SEA LEVEL

REDRAWN FROM DOE, 1983a

FIGURE 2.4
HYDROGEOLOGIC CROSS SECTION (A-A') AT THE CANONSBURG, PENNSYLVANIA, SITE

MAC: SITE/CAN/BRA/HYDROX-SEC(A-A')

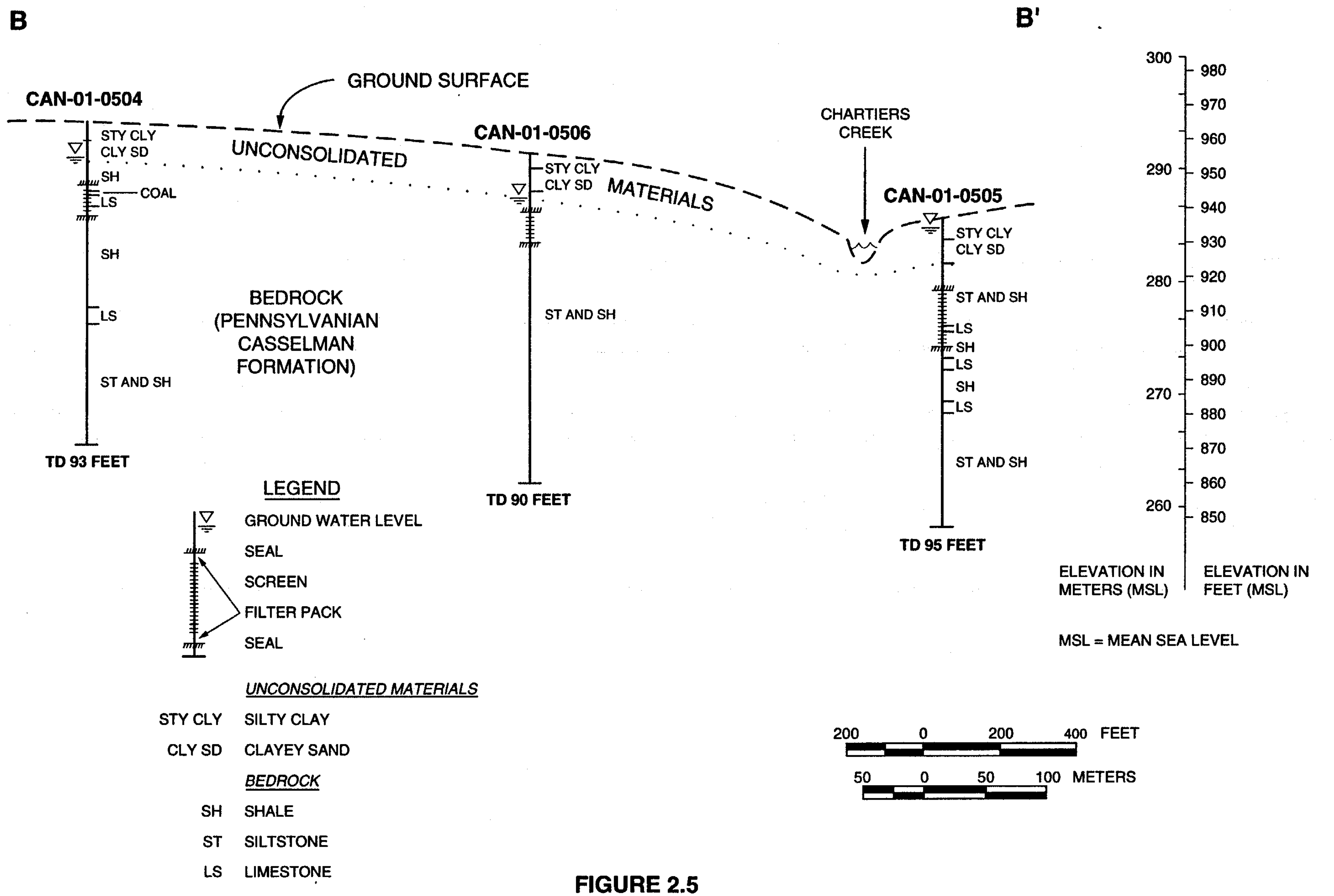


FIGURE 2.5
HYDROGEOLOGIC CROSS SECTION B-B' AT THE
CANONSBURG, PENNSYLVANIA, SITE

MAC: SITE/CAN/BRA/HYDROX-SEC(B-B')

discrete, continuous units. Also, the permeability is variable due to the types and placement of the materials.

Bedrock

The lithology of the bedrock to a depth of 95 ft (29 m), based on lithologic logs of monitor wells CAN-01-0504 through -0506, consists predominantly of gray siltstone and shale, with some interbedded limestone, and sparse coal seams (Figure 2.5). Shale near the bedrock surface is broken and weathered to thin brittle plates. The bedrock surface generally dips northeast at less than 1 degree. Fracturing was observed in core samples in the upper 5 to 20 ft (2 to 6 m) of the bedrock beneath the site. The interval of interest for evaluating potential bedrock contamination is the upper 25 ft (7 m) beneath the contact with the unconsolidated material, referred to as the "shallow bedrock." The shallow bedrock has been observed at the surface in the site vicinity.

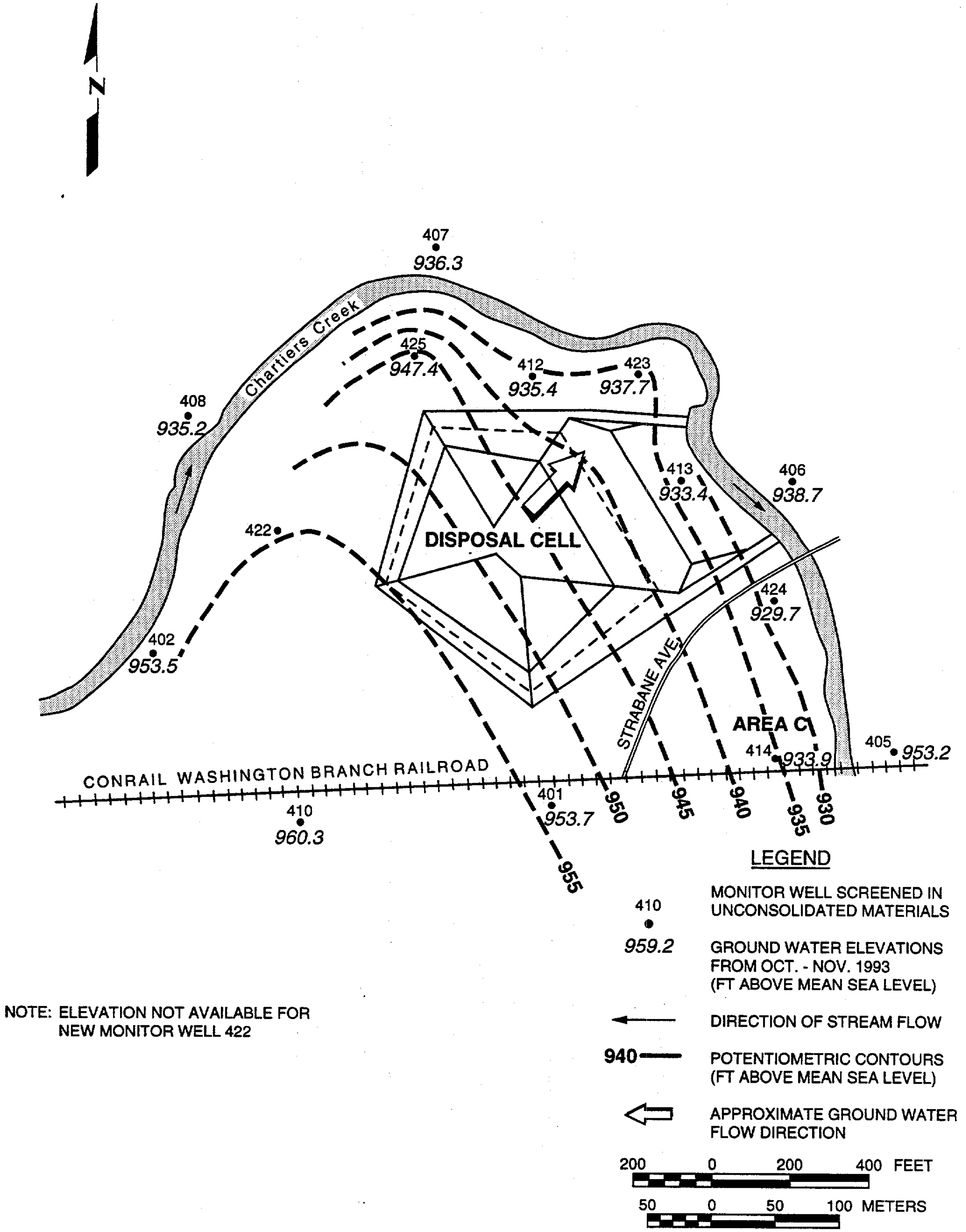
2.4.2 Hydrology

Ground water is present in two distinct units beneath the site: the unconsolidated materials and the bedrock. Hydraulic interconnection appears between the two lithologic units with a generally downward vertical gradient from the unconsolidated materials to the shallow bedrock. The dominant boundary condition for ground water movement in the unconsolidated materials and shallow bedrock is Chartiers Creek. This creek surrounds the site on the west, north, and east and is the normal discharge zone for the water table and shallow bedrock ground water systems. Minor gradient reversal in ground water flow may occur near the creek during periods of maximum flow, but this should not significantly impact potential contaminant migration.

Although ground water is present in the unconsolidated materials and shallow bedrock beneath the site, neither unit is considered as an aquifer. This is primarily because the materials are not ideal for aquifer formation, the source of recharge to the shallow units is limited, and sustained yield to a well from these units is probably lacking.

Unconsolidated materials

Ground water occurs in the unconsolidated materials under unconfined (water table) conditions. Depth to ground water in the unconsolidated materials ranges from 3 to 14 ft (0.9 to 4.3 m) beneath the ground surface. Figure 2.6 shows the configuration of the potentiometric surface and the approximate direction of ground water flow in this unit; because of discontinuities and heterogeneities of the materials, the degree of hydraulic interconnection between areas beneath the site and the exact flow direction may be variable. Ground water in the unconsolidated materials is a result of precipitation infiltrating the unit with downward migration toward contact with the shallow bedrock. Water may perch on clay layers within the unit or on the shallow bedrock. Lateral continuity of ground water in this unit has not been definitively determined.



NOTE: ELEVATION NOT AVAILABLE FOR NEW MONITOR WELL 422

FIGURE 2.6
POTENTIOMETRIC SURFACE MAP FOR THE UNCONSOLIDATED MATERIALS AT THE CANONSBURG, PENNSYLVANIA, SITE

Transmissivity, based on aquifer pumping tests in well 26, averaged 3.22 square centimeters per second (cm^2/s) in the unconsolidated materials (DOE, 1983a), which, along with the estimated saturated thickness of 10 ft (3 m), a porosity of 0.2, and a gradient of 0.027, results in an approximate ground water velocity of 1.4×10^{-3} cm/s (4 ft per day).

<u>Bedrock</u>

Ground water occurs in the underlying shallow bedrock under semiconfined conditions. Figure 2.7 shows the potentiometric surface configuration and the approximate ground water flow direction in the shallow bedrock unit; because of discontinuities and the accumulation of ground water in fractured and weathered zones, the degree of hydraulic interconnection between areas beneath the site and the exact flow direction may be variable. Ground water in the shallow bedrock results from water infiltration from above into zones of secondary porosity where the shale bedrock is weathered or fractured. Lateral continuity of ground water in this unit has not been definitively determined. Some ground water appears to be present in deeper zones in the bedrock associated with limestone or more porous zones. This ground water is probably not related to surface infiltration due to intervening shale layers acting as aquitards, but is a result of ground water underflow. Transmissivity, based on aquifer pumping tests in well 303R, ranged from 0.167 to 3.94 cm^2/s in the shallow bedrock (DOE, 1983a), which, along with an estimated saturated thickness of 20 ft (6 m), a porosity of 0.2, and a gradient of 0.016 results in an approximate ground water velocity range of 4.3×10^{-5} to 1.0×10^{-3} cm/s (0.1 to 3 ft per day).

2.5 SURFACE WATER

The Canonsburg site lies along the southern bank of Chartiers Creek (Figure 2.2), a meandering stream 75 to 100 ft (23 to 30 m) wide and about 10 ft (3 m) deep. Chartiers Creek drains an area of approximately 80 square miles (mi^2) (200 square kilometers [km^2]) upstream from the site and drains into the Ohio River 15 mi (24 km) downstream from the site. The average flow of Chartiers Creek past the site is 90 to 130 cubic feet per second (ft^3/s) (2.5 to 3.7 cubic meters per second [m^3/s]).

2.6 LAND USE

A 1-mi (1.6-km) radius around the site encompasses four municipalities: the borough of Canonsburg, the borough of Houston, Chartiers Township, and North Strabane Township.

The primary land use in the site vicinity is residential. The closest residences are approximately 80 to 100 ft (24 to 30 m) east of the site along Strabane Avenue and adjacent streets in the borough of Canonsburg. Residences are also directly south of the site in North Strabane Township, on Latimer Avenue, and west and southwest of the site in the borough of Houston.

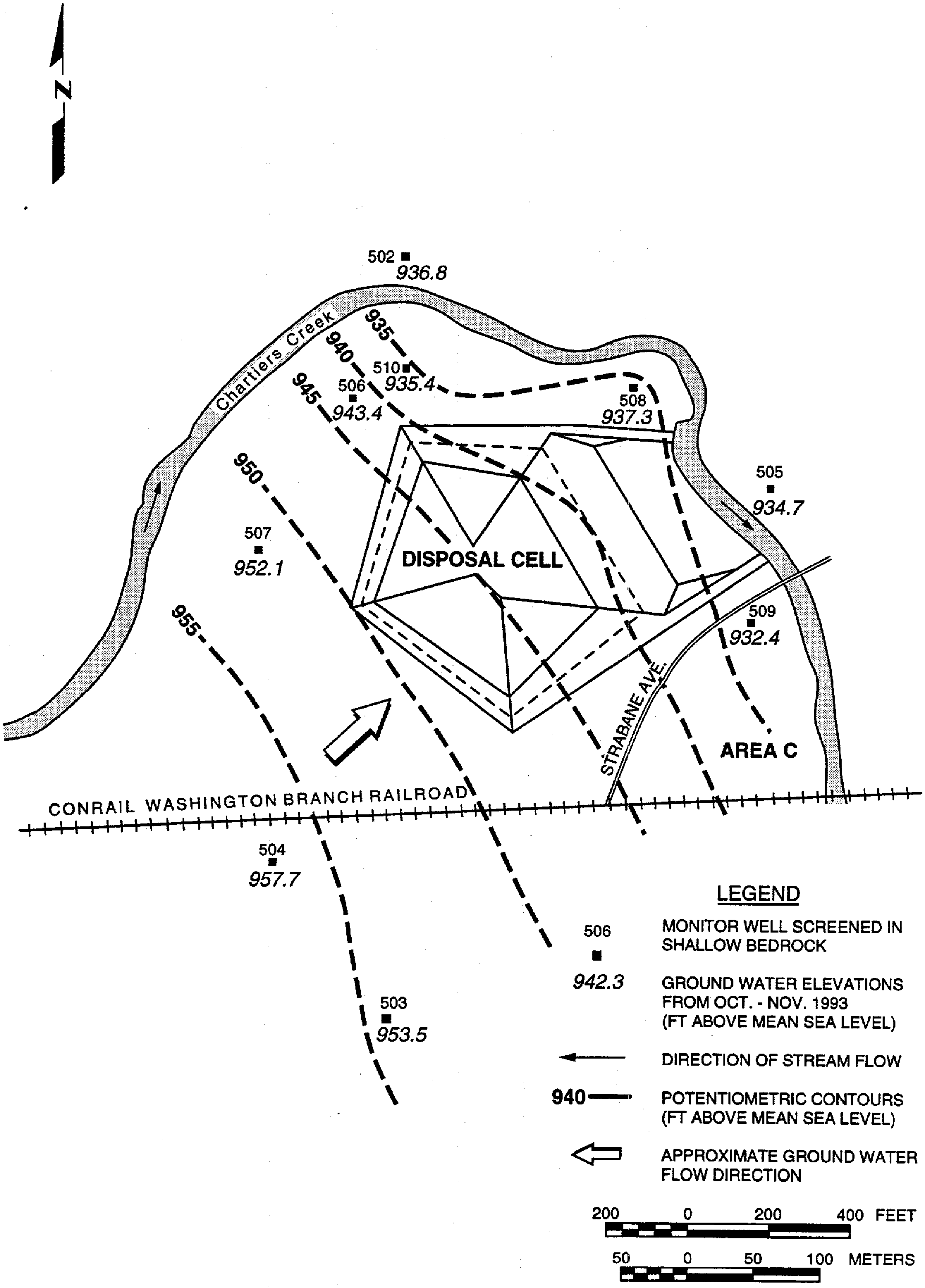


FIGURE 2.7
POTENTIOMETRIC SURFACE MAP FOR THE SHALLOW BEDROCK
AT THE CANONSBURG, PENNSYLVANIA, SITE

North of the site along West Pike Street is a commercial and light industrial area. Businesses in this area include a gas station, car wash, car repair shop, car dealerships, woodcrafting company, and a heating and cooling company. Residences are north of this commercial/industrial area on Pike Street. A light industrial area is also located southwest of the site. Undeveloped areas are primarily northwest of the site in Chartiers Township and south of the site in North Strabane Township. Figure 2.8 shows the land uses within a 1-mile (1.6-km) site radius. This map, taken from the Final Environmental Impact Statement for the Canonsburg site (DOE, 1983a), was based on information obtained from maps and local surveys. Based on recent site visits in 1994, these land uses appear very similar to current land uses, with the possible addition of some new residential and commercial areas. Figure 2.9 shows the current land use zoning within this same area.

Based on 1990 data (Washington County Planning Commission, 1993), the populations of the municipalities in the site vicinity are as follows:

- Borough of Canonsburg - 9200
- Borough of Houston - 1445
- Chartiers Township - 7603
- North Strabane Township - 8157

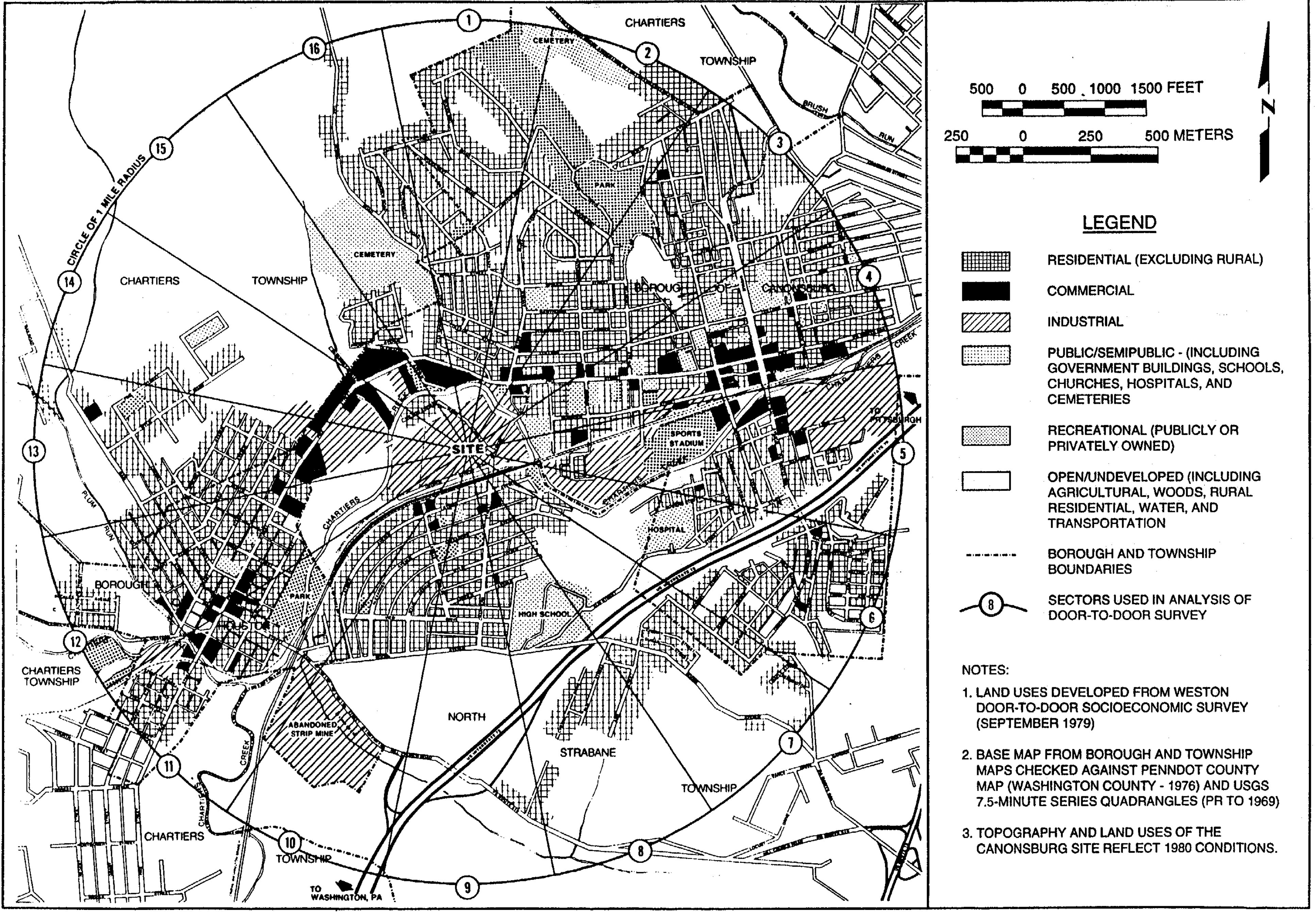
The population of Washington County has fluctuated, but has remained more than 200,000 for the past few decades. Based on data from 1990, the population for the county is 204,584 (Washington County Planning Commission, 1993).

The 1992-1993 Industrial Directory for Washington County lists 491 industries and businesses, which employ 19,980 persons. Washington County's resident civilian labor force was approximately 95,400 in 1991, with approximately 66,860 persons working in the county. By categories, the major employers in the county are steel (1989 employees), electronics (1789 employees), mining (1276 employees), and plastics (1212 employees) (Washington County Board of Commissioners, 1993). Manufacturing in Washington County has declined over the years, primarily in steel and glass and their supporting industries. However, employment has increased in the government, wholesale/retail trade, and service industries. The major manufacturing employer in Canonsburg is Cooper Power Systems, which employs approximately 1080 persons (Washington County Board of Commissioners, 1993).

Approximately 1590 farms are in Washington County, with an average size of 137 ac (55 ha). The main products are milk and dairy (Washington County Board of Commissioners, 1993).

2.7 WATER USE

Most residents of Canonsburg, Houston, North Strabane, and Chartiers, in the site vicinity, are connected to a municipal water supply system operated by the



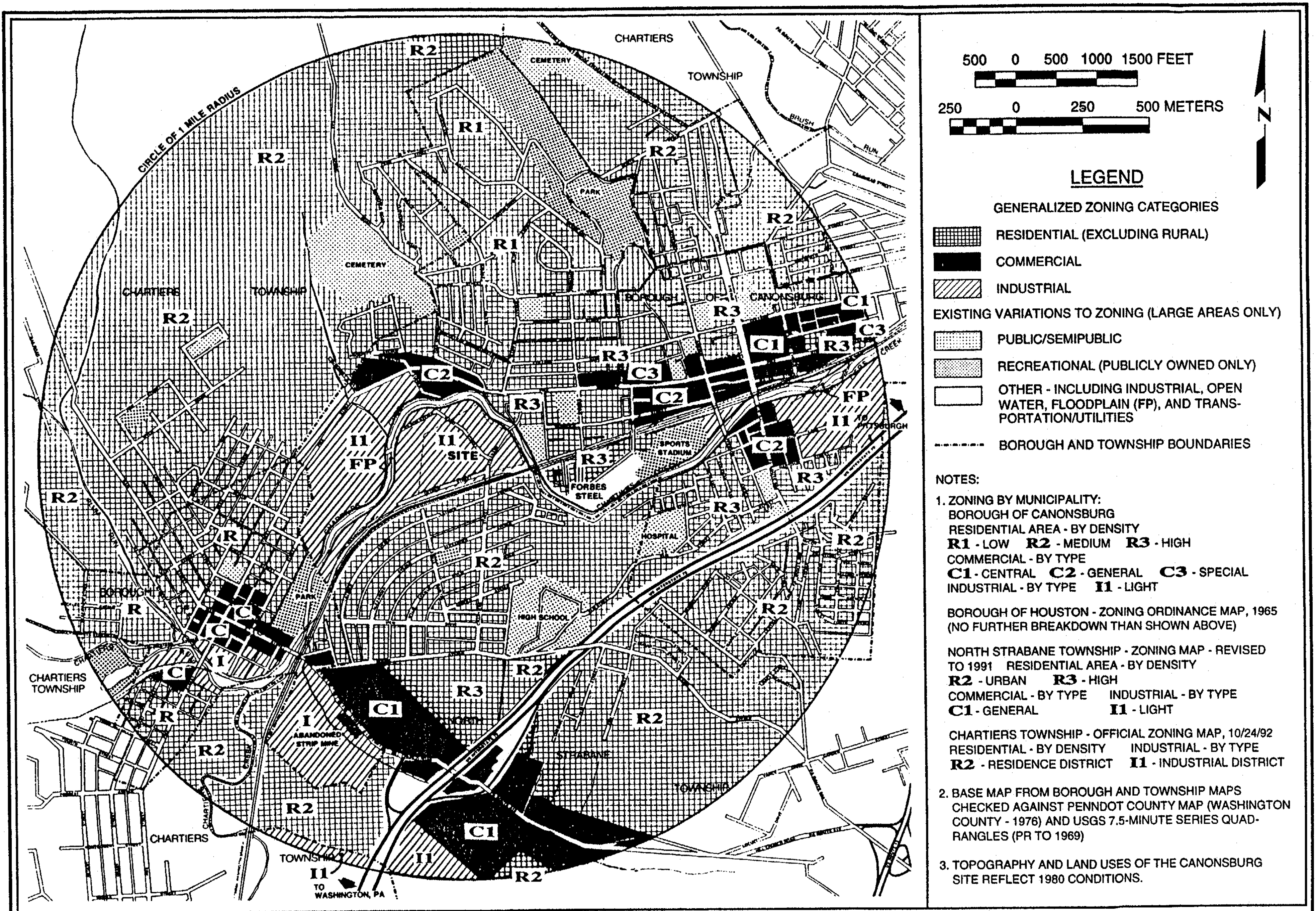
NOTES:

1. LAND USES DEVELOPED FROM WESTON DOOR-TO-DOOR SOCIOECONOMIC SURVEY (SEPTEMBER 1979)
2. BASE MAP FROM BOROUGH AND TOWNSHIP MAPS CHECKED AGAINST PENNDOT COUNTY MAP (WASHINGTON COUNTY - 1976) AND USGS 7.5-MINUTE SERIES QUADRANGLES (PR TO 1969)
3. TOPOGRAPHY AND LAND USES OF THE CANONSBURG SITE REFLECT 1980 CONDITIONS.

SOURCE: DOE, 1983a - FINAL ENVIRONMENTAL IMPACT STATEMENT

FIGURE 2.8
EXISTING LAND USES (1980) IN THE CANONSBURG SITE VICINITY

MAC: SITE/CAN/BRA/EXISTLANDUSES



LEGEND

GENERALIZED ZONING CATEGORIES

▦ RESIDENTIAL (EXCLUDING RURAL)

■ COMMERCIAL

▨ INDUSTRIAL

EXISTING VARIATIONS TO ZONING (LARGE AREAS ONLY)

░ PUBLIC/SEMIPUBLIC

▒ RECREATIONAL (PUBLICLY OWNED ONLY)

☐ OTHER - INCLUDING INDUSTRIAL, OPEN WATER, FLOODPLAIN (FP), AND TRANSPORTATION/UTILITIES

-·-·- BOROUGH AND TOWNSHIP BOUNDARIES

NOTES:

1. ZONING BY MUNICIPALITY:
   BOROUGH OF CANONSBURG
   RESIDENTIAL AREA - BY DENSITY
   R1 - LOW **R2** - MEDIUM **R3** - HIGH
   COMMERCIAL - BY TYPE
   C1 - CENTRAL **C2** - GENERAL **C3** - SPECIAL
   INDUSTRIAL - BY TYPE **I1** - LIGHT

   BOROUGH OF HOUSTON - ZONING ORDINANCE MAP, 1965
   (NO FURTHER BREAKDOWN THAN SHOWN ABOVE)

   NORTH STRABANE TOWNSHIP - ZONING MAP - REVISED TO 1991 RESIDENTIAL AREA - BY DENSITY
   R2 - URBAN **R3** - HIGH
   COMMERCIAL - BY TYPE INDUSTRIAL - BY TYPE
   C1 - GENERAL **I1** - LIGHT

   CHARTIERS TOWNSHIP - OFFICIAL ZONING MAP, 10/24/92
   RESIDENTIAL - BY DENSITY INDUSTRIAL - BY TYPE
   R2 - RESIDENCE DISTRICT **I1** - INDUSTRIAL DISTRICT

2. BASE MAP FROM BOROUGH AND TOWNSHIP MAPS CHECKED AGAINST PENNDOT COUNTY MAP (WASHINGTON COUNTY - 1976) AND USGS 7.5-MINUTE SERIES QUADRANGLES (PR TO 1969)

3. TOPOGRAPHY AND LAND USES OF THE CANONSBURG SITE REFLECT 1980 CONDITIONS.

SOURCE: DOE, 1983a - FINAL ENVIRONMENTAL IMPACT STATEMENT

FIGURE 2.9
LAND USE ZONING IN THE CANONSBURG SITE VICINITY

MAC: SITE/CAN/BRA/LANDUSEZONING

Pennsylvania-American Water Company. The Monongahela River, located east of the site, supplies the water for the system. There are two water intake stations: in Aldridge and in Pittsburgh, Pennsylvania. The Aldridge plant can treat about 60 million gallons (230 million liters [L]) of water per day, and the Pittsburgh plant can treat 80 million gallons (300 million L) of water per day (Taylor, 1994). Washington District residents use approximately 10 million gallons (38 million L) of water daily.

In April 1994, a water use survey was conducted within a 1-mi (1.6-km) radius of the Canonsburg site. The purpose of the survey was to verify locations and status of domestic well information listed in previous surveys (DOE, 1983a), either provided by the Pennsylvania Geologic Survey (PGS, 1994) or obtained from personal communications with local residents. From this water use survey, approximately 16 wells were identified within a 1-mi (1.6-km) site radius. Of these wells, 1 was in use, 11 were not in use, and 4 were abandoned. Figure 2.10 shows the locations of the 12 wells that were not abandoned. Seven of these wells are upgradient of the site and, thus, would not be affected by any potentially migrating site-related contaminants. The remaining five wells are potentially downgradient of the site. Of these five wells, only one is in use. This well is approximately 400 ft (122 m) north of the site and is used for washing cars, mixing cement, and watering the garden. Although the well's depth is unknown, based on its construction, it appears to be a shallow well finished in the unconsolidated unit. Because this well is on the opposite side of Chartiers Creek relative to the site, it is not expected to be influenced by any ground water flow from the site. The ground water from this location most likely flows toward the site and discharges into Chartiers Creek.

Figure 2.10 also shows the locations of five wells situated immediately outside the 1-mi (1.6-km) radius. These wells are used for drinking as well as all other domestic purposes. Three of these wells are just over 1 mi (1.6 km) south of the site. The municipal water supply does not service houses further south of this area; thus, individuals residing in this area most likely use well water. These wells are upgradient of the site and thus would not be affected by any potentially migrating contamination from the site. An additional two wells are approximately 1.3 miles (2.1 km) north of the site. Houses further north of this area also are not serviced by the municipal water supply system, and these residents also most likely use well water. Due to the distance from the site and the fact that these wells are located crossgradient, rather than downgradient, of the site, any ground water contamination potentially migrating from the site is not expected to affect ground water in this area.

Chartiers Creek, which flows along the western, eastern, and northern boundaries of the site, is designated by the commonwealth of Pennsylvania for the maintenance and propagation of fish species and protection of additional flora and fauna indigenous to a warm water habitat (PADER, 1992). Local residents use the creek for fishing, swimming, and wading. Children have also been observed playing in the creek and on its banks. The types of fish found in the creek include carp, catfish, and bluegill (Templeton, 1993).

FIGURE 2.10
DOMESTIC WELL LOCATIONS IN THE CANONSBURG, PENNSYLVANIA, SITE VICINITY

3.0 EXTENT OF CONTAMINATION

Figure 2.2 is a map of the Canonsburg processing/disposal site showing the locations of the disposal cell, the DOE monitor well network, and other features mentioned in this discussion. Ground water is found at the site in unconsolidated near-surface materials and in the underlying bedrock. Filtered water quality data from 22 monitor wells were used to characterize background ground water and the nature and extent of ground water contamination at the site. Unfiltered water quality data are available for only one sampling round (October 1993) and for a limited number of constituents. For water samples from those wells used in this risk assessment, these data are generally consistent with the filtered data. Therefore, unfiltered ground water data were not used for this risk assessment. However, for samples from other wells, some parameters indicated higher concentrations in unfiltered than in filtered water samples. Water quality data for unfiltered samples from six surface water locations were used to evaluate surface water quality. Table 3.1 provides monitor well and surface water sampling site information, including the formations of completion and locations of monitor wells, years sampled, sampling rounds, and well depths.

Because of the wide variety of ore types processed at the Canonsburg site, different extraction processes were used. No information is available concerning the use of organic solvents in an extraction process at the site and ground water has not been screened for organic constituents. Additional sampling and analyses would be needed to rule out the possibility of organic contamination.

3.1 BACKGROUND GROUND WATER QUALITY DATA SUMMARY

Background ground water quality is defined as ground water quality that would exist at this site if uranium processing had not occurred. Statistical and geochemical analyses have evaluated background ground water quality at the Canonsburg site.

Monitor wells 401, 409, and 410, completed in the near-surface, unconsolidated materials, were evaluated as potential background wells. Monitor well 410 was most appropriate for estimating background levels in the unconsolidated material because it was completed in fill material that is characteristic of the site. Monitor well 409, on the other hand, is located off of the site and completed in unconsolidated alluvium and soils with different characteristics. Monitor well 401 was not used because while the chemistry of ground water in well 401 is basically similar to that in well 410, the concentrations of the radionuclides thorium-230 and polonium-210 are slightly higher than in well 410. Because no historical ground water quality data exist for well 401, the possibility of site-related contamination could not be ruled out. Therefore, monitor well 401 was not included in the determination of background values.

Monitor wells 503 and 504 were considered potential background wells for the bedrock unit. Monitor well 503 is a deep well (112.9 ft [34.4 m]) screened in a

Table 3.1 Monitor well and surface water sampling information for the Canonsburg site

Well number	Location	Years sampled	Number of rounds	Screen interval (ft)
Unconsolidated materials				
Background wells				
401	south of disposal cell	1986, 1993	2	7.5-12.2
409	southwest of disposal cell	1993	1	18.3 (a)
410	southwest of disposal cell	1986-1993	16	11.4-16.0
Downgradient wells				
405	across river from disposal cell	1993	1	14.0 (a)
406	across river from disposal cell	1993	1	14.0 (a)
407	across river from disposal cell	1993	1	20.0 (a)
408	across river from disposal cell	1993	1	21.0 (a)
412	north of disposal cell	1986-1993	15	14.3-19.3
413	northeast of disposal cell	1986-1993	15	7.0-12.0
414	southeast of disposal cell (Area C)	1986-1993	16	4.5-14.5
422	east of disposal cell	1993	dry	18.0-23.0
423	north of disposal cell	1993	1	8.0-13.0
424	east of disposal cell (Area C)	1993	1	12.0-17.0
425	north of disposal cell	1993	1	12.5-17.5
Bedrock				
Background wells				
503	southwest of disposal cell	1993	1	112.9 (a)
504	southwest of disposal cell	1986-1993	16	19.9-24.9
Downgradient wells				
502	across river from disposal cell	1993	1	82.3 (a)
505	across river from disposal cell	1986-1993	16	25.4-35.4
506	northwest of disposal cell	1986-1993	16	21.0-26.0
507	west of disposal cell	1993	1	38.0-43.0
508	north of disposal cell	1993	1	27.0-32.0
509	east of disposal cell (Area C)	1993	1	29.5-34.5
510	north of disposal cell	1993	1	32.0-37.0

Table 3.1 Monitor well and surface water sampling information for the Canonsburg site (Concluded)

Well number	Location	Years sampled	Number of rounds	Screen interval (ft)
Surface water - Chartiers Creek				
Downstream locations				
602	east of site, north of railroad	1989-1993	9	
603	east of site, south of RR	1993	1	
604	east of site, north of Strabane Ave	1993	1	
605	north of site	1993	1	
606	north of site	1993	1	
Upstream location				
601	southwest of site, N of railroad	1989-1993	9	

(a) Total depth (ft)

limestone unit and, thus, is not representative of ground water conditions on the site. Therefore, monitor well 504 was selected to represent background bedrock ground water conditions at Canonsburg.

A trilinear plot of the background water from the two units (Figure 3.1) shows that ground water in monitor well 504 has a mixed anionic composition with roughly equal amounts of chloride, sulfate, and bicarbonate. Calcium is the dominant cation. Conversely, the ground water from background well 410 has a mixed cationic composition with roughly equal amounts of sodium and calcium and slightly less magnesium. Sulfate, with slightly less bicarbonate and chloride, dominates the anionic composition of this ground water. As can be seen from the concentration versus time plots (Figure 3.2 a, b, c, and d), the pH, alkalinity, sulfate concentrations, and total dissolved solids (TDS) are much higher in the bedrock background ground water. Conversely, iron and manganese concentrations are higher in ground water from the shallow unconsolidated unit than from the deeper bedrock unit (Figure 3.3 a and b).

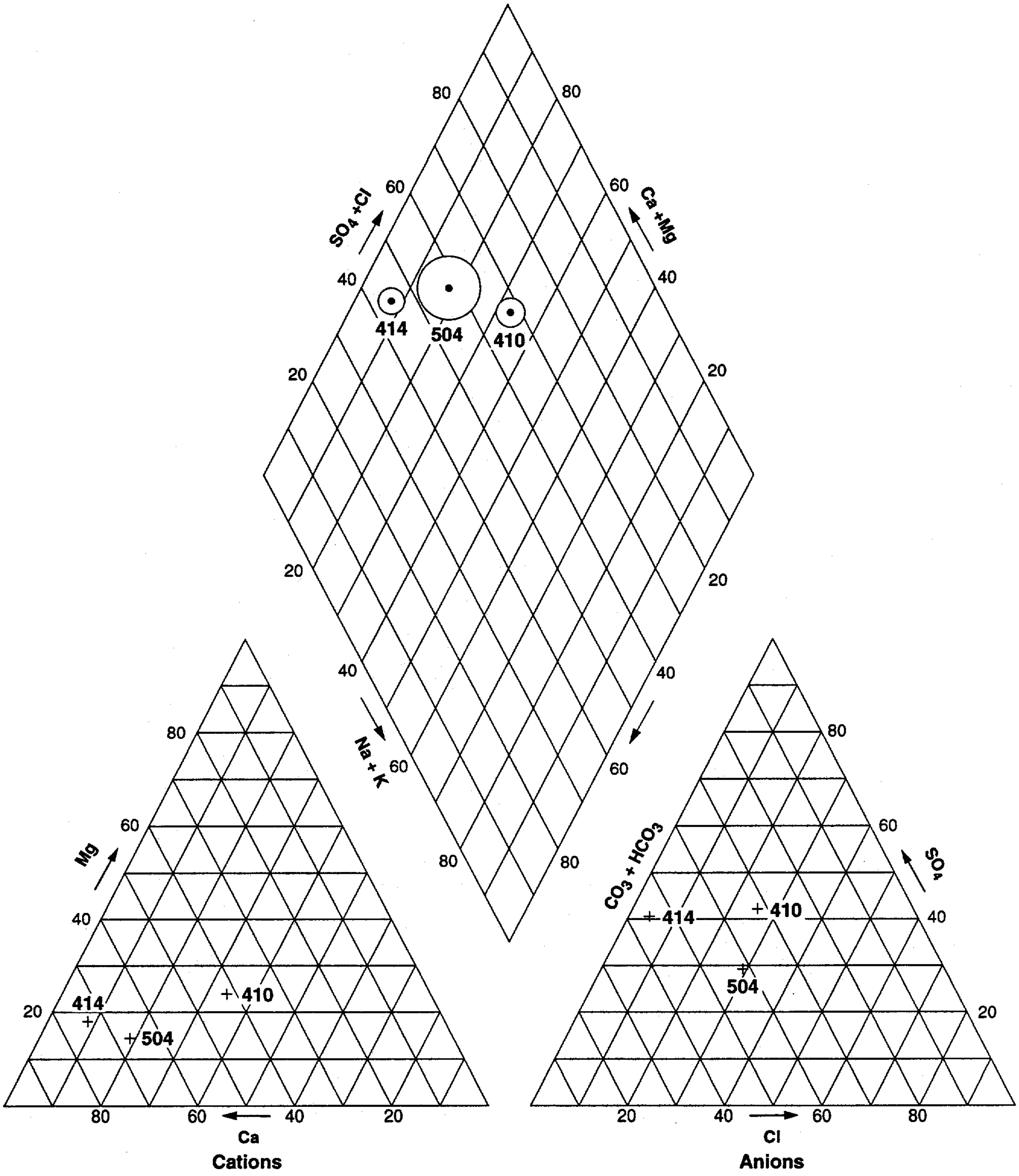
3.2 MAGNITUDE AND EXTENT OF SITE-RELATED GROUND WATER CONTAMINATION

Geochemical and statistical analyses of the available chemical data from the unconsolidated and bedrock units suggest that many major, minor, and trace constituents are elevated in some downgradient wells relative to background ground water.

3.2.1 Unconsolidated materials

Wells completed in the unconsolidated material with the highest levels of site-related contamination are 412, 413, and 414 (Figures 3.4 and 3.5). Wells 412 and 413 are within the restricted zone and, as discussed Section 2.4, contamination in these wells is not expected to migrate to potentially accessible ground water areas. Monitor wells 414 and 424 are in Area C, southeast of the disposal cell. One round of ground water samples was collected from monitor well 424, within 2 weeks after the well was completed, and analyzed for inorganic constituents. Comparison of water quality data from monitor wells 414 and 424 indicates that monitor well 414 shows higher levels of some constituents (boron, potassium, manganese, molybdenum, uranium, lead-210, radium-226, and thorium-230) than are seen in monitor well 424. Conversely, monitor well 424 shows higher levels of other constituents (notably, ammonium, arsenic, calcium, chloride, iron, sodium, sulfate, and radium-228) (Table 3.2). Because only one round of data is available from monitor well 424, these results need to be verified by future sampling. For this reason, and because Area C is being considered for public use, discussion of contamination will focus on monitor well 414.

A trilinear diagram (Figure 3.1) can illustrate some of the major elemental differences between background ground water from upgradient monitor well 410 and contaminated ground water from downgradient well 414 in



% of Total MEQ/L
4 Samples

LEGEND

NUMBER	*TDS*	*WELL NAME*
504	829	BACKGROUND WELL
414	380	DOWNGRADIENT WELL
410	420	BACKGROUND WELL

2000 0 2000 mg/L per INCH

FIGURE 3.1
TRILINEAR PLOT SHOWING ANION-CATION COMPOSITION OF BACKGROUND WELLS 410 AND 504 AND DOWNGRADIENT WELL 414 CANONSBURG, PENNSYLVANIA, SITE

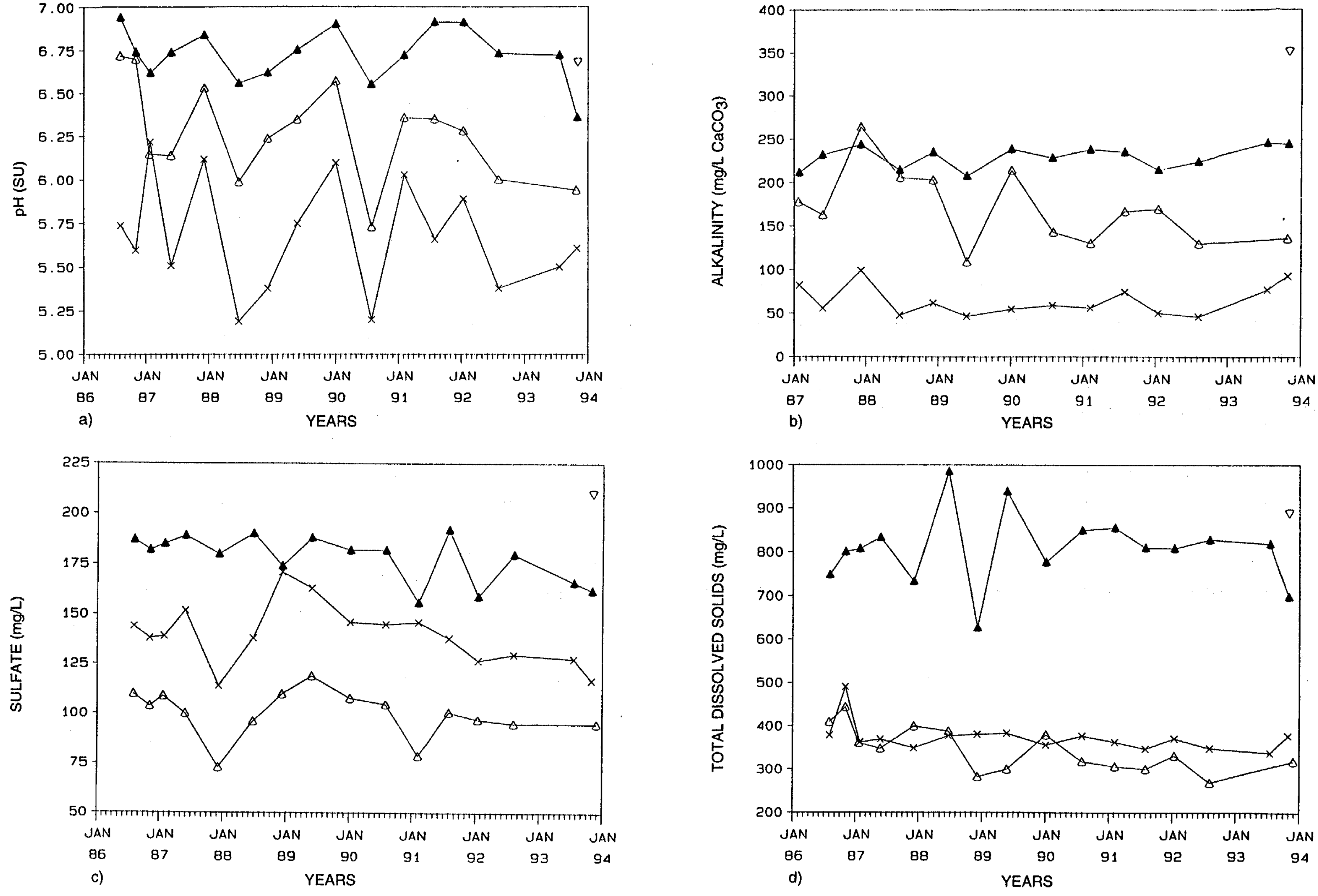


FIGURE 3.2
GROUND WATER PARAMETER VERSUS TIME PLOTS OF WELLS
410, 414, 504, AND 509
CANONSBURG, PENNSYLVANIA, SITE

MAC: SITE/CAN/BRA/GWVSTIME1

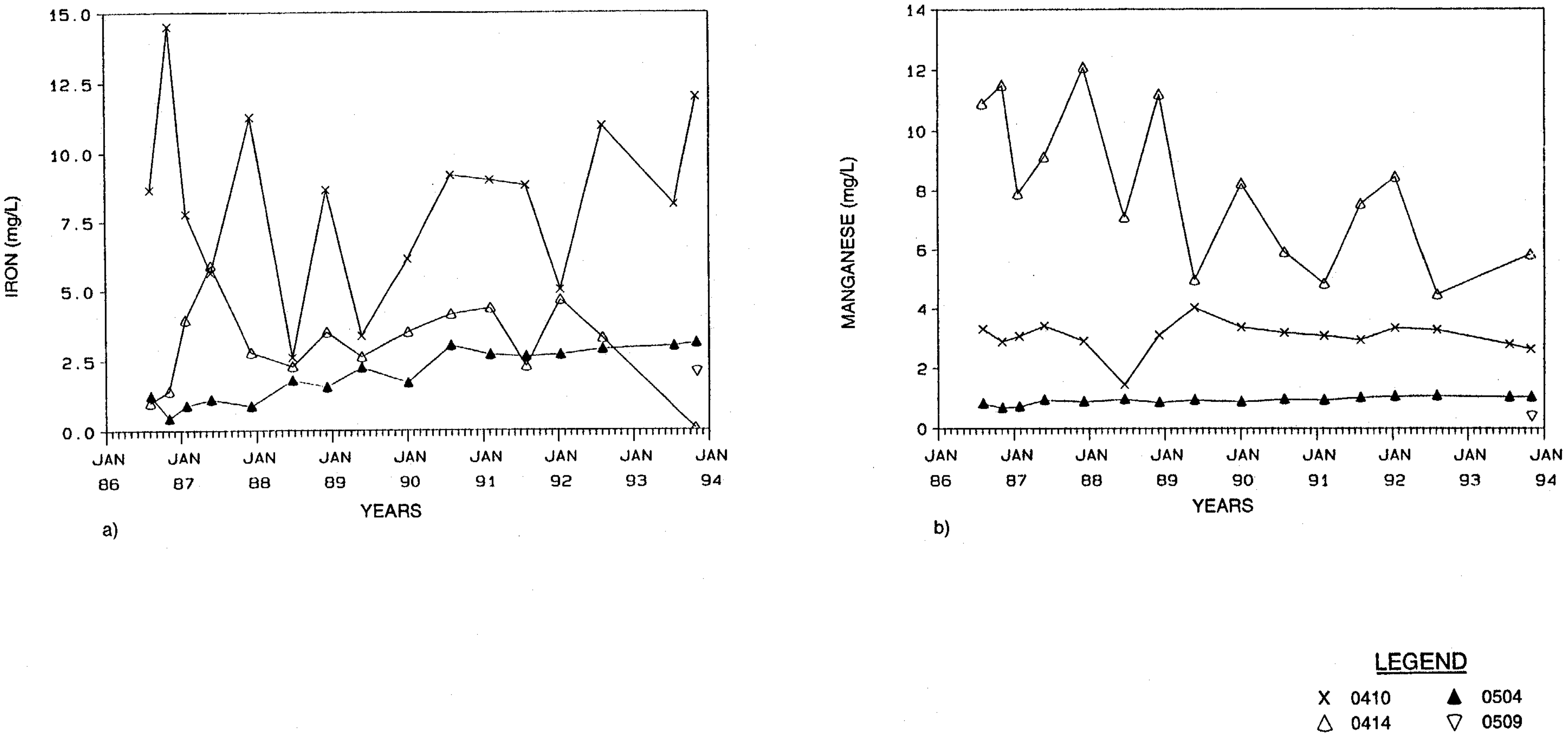


FIGURE 3.3
GROUND WATER PARAMETER VERSUS TIME PLOTS OF WELLS
410, 414, 504, AND 509
CANONSBURG, PENNSYLVANIA, SITE

MAC: SITE/CAN/BRA/GWVSTIME2

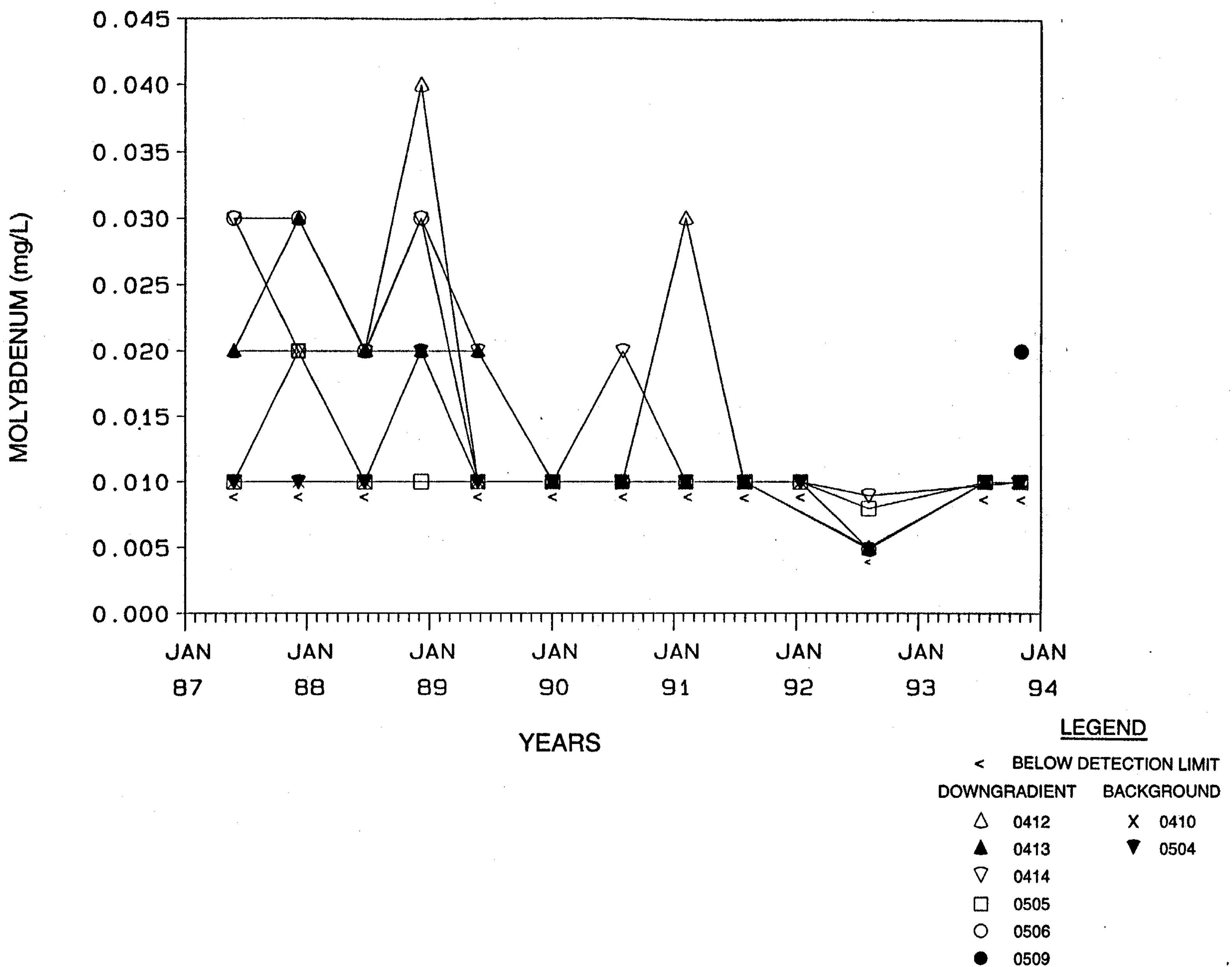


FIGURE 3.4
MOLYBDENUM VERSUS TIME PLOT FOR BACKGROUND WELLS 410 AND 504
AND DOWNGRADIENT WELLS 412, 413, 414, 505, 506, AND 509
CANONSBURG, PENNSYLVANIA, SITE

MAC: SITE/CAN/BRA/GWVSTIME3A

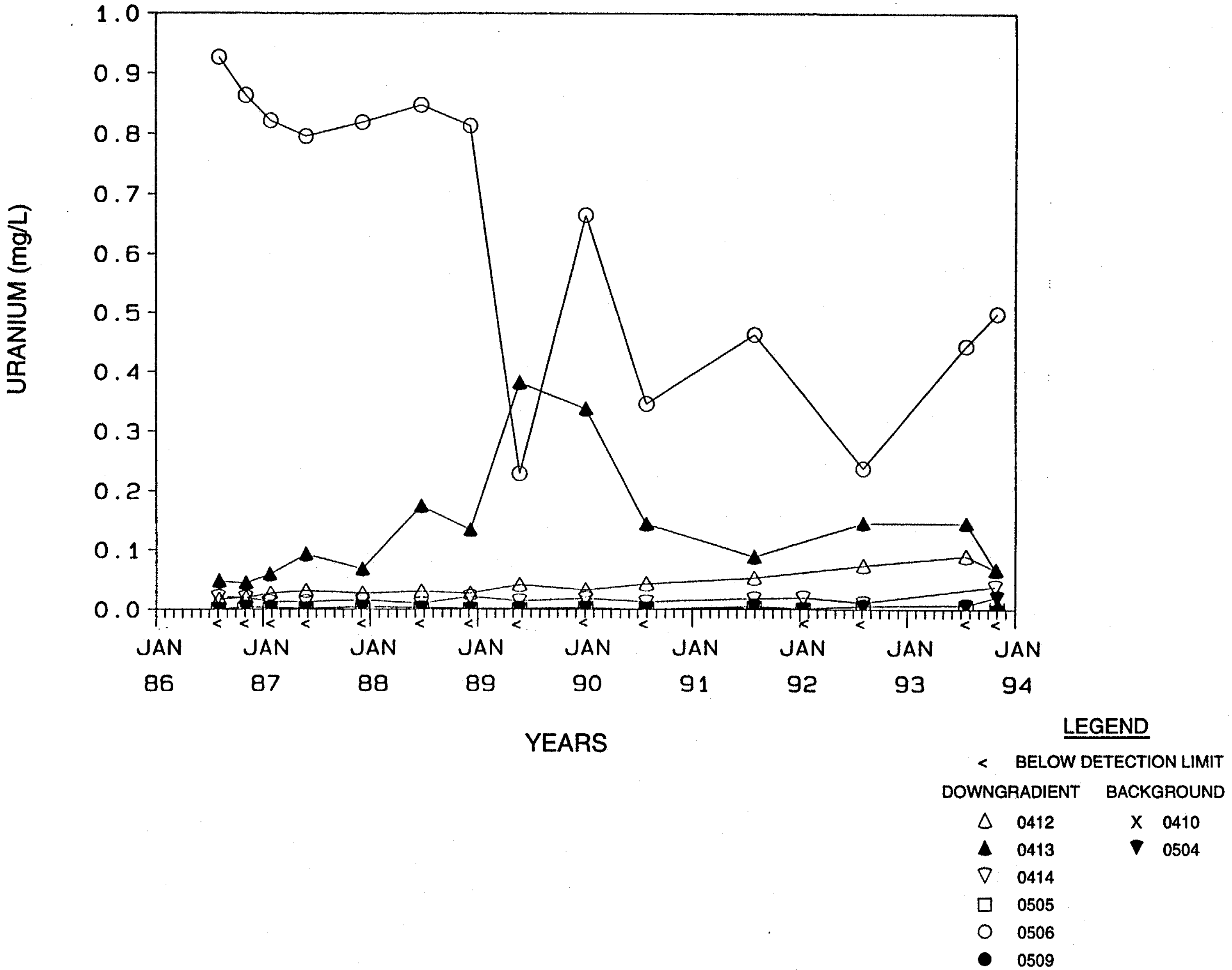


FIGURE 3.5
URANIUM VERSUS TIME PLOT FOR BACKGROUND WELLS 410 AND 504
AND DOWNGRADIENT WELLS 412, 413, 414, 505, 506, AND 509
CANONSBURG, PENNSYLVANIA, SITE

MAC: SITE/CAN/BRA/GWVSTIME4

unconsolidated materials. As is clear from this diagram, the contaminated ground water of the shallow unconsolidated unit is relatively more calcium and bicarbonate-rich and chloride-poor than the background ground water from monitor well 410. Concentration versus time plots (Figures 3.2, 3.3, 3.4, and 3.5) show elevated levels of manganese, molybdenum, and uranium in monitor well 414 relative to background. Note that one component of the unconsolidated unit is iron slag, which was used as fill material (DOE, 1983b). This material contains high concentrations of iron and manganese and its presence in the subsurface could strongly affect iron and manganese concentrations in the ground water. Table 3.2 is a statistical summary of ground water data from background and select downgradient wells in the unconsolidated materials for filtered water samples.

3.2.2 Bedrock unit

Of the downgradient bedrock wells, only 505 and 506 have data from more than one sampling round. Well 505 does not show any signs of contamination. Uranium concentrations in well 506 have been consistently high since sampling began in 1986 (Figure 3.5). This monitor well was installed in an area containing contaminated material that was not put into the disposal cell (this material is in a separate covered area), apparently resulting in the locally elevated concentrations of uranium. Monitor well 510 was installed just downgradient from well 506 to verify a possible local source of contamination. The concentration of uranium in ground water from well 510 is low (less than the detection limit), indicating that the above assumption is probably correct. Also, the apparent lack of lateral hydraulic continuity of ground water in the shallow bedrock may be substantiated by these results, indicating that even with an elevated source area, migration of contaminants in this area is minimal. Based on data to date, contamination appears to have affected no other well in the bedrock unit. Comparing data from well 509, located in Area C, with data from background well 504, it appears that over time, concentrations in well 509 generally fall within the range of levels found in well 504. Thus, current data indicate that the bedrock unit is not contaminated except in the immediate area of monitor well 506. The site will continue to be monitored, and risks can be re-evaluated if there is any indication that contamination has migrated into the bedrock unit.

Summary of site-related contamination

After the extent of contamination was determined, 1986 through 1993 water quality data were evaluated to identify statistically those constituents elevated above background concentrations in the alluvial aquifer. Qualitative trend analysis of concentration versus time for all parameters indicated that pre-1988 data are generally inconsistent with, and have greater variability and number of anomalies than, data collected from 1988 through 1993 (TAC, 1994a). Moreover, the recent data are considered to be more representative of current ground water conditions. For these reasons, when possible, data from sampling events in 1988 through 1993 were preferentially used in the statistical

Table 3.2 Summary of filtered ground water quality data from the unconsolidated materials at Canonsburg (1986-1993)

Parameter	Above detection[a]	Minimum	Median[b]	Maximum
Inorganics			mg/L	
Aluminum				
Background[c]	4/7	0.03	0.03	0.30
Downgradient[d]	5/7	<0.05	0.08	0.30
Well 424[e]	0/1	-	<0.05	-
Ammonium[f,g]				
Background	1/6	<0.06	-	0.10
Downgradient	5/5	0.35	0.80	1.30
Well 424	1/1	-	12.0	-
Antimony				
Background	0/2	<0.003	-	<0.003
Downgradient	0/2	<0.003	-	<0.003
Well 424	NA	-	-	-
Arsenic				
Background	1/7	<0.001	-	<0.01
Downgradient	3/7	<0.001	-	<0.01
Well 424	1/1	-	0.008	-
Barium				
Background	2/2	0.10	0.20	0.30
Downgradient	2/2	0.10	0.15	0.20
Well 424	NA	-	-	-
Beryllium				
Background	0/2	<0.005	-	<0.01
Downgradient	0/2	<0.005	-	<0.01
Well 424	NA	-	-	-
Boron[g]				
Background	4/7	0.03	0.03	0.20
Downgradient	6/7	<0.10	0.23	0.39
Well 424	0/1	-	<0.2	-
Bromide				
Background	1/1	0.10	-	0.10
Downgradient	0/1	<0.10	-	<0.10
Well 424	1/1	-	0.2	-
Cadmium				
Background	0/5	<0.001	-	<0.001
Downgradient	0/5	<0.001	-	<0.001
Well 424	0/1	-	<0.001	-

Table 3.2 Summary of filtered ground water quality data from the unconsolidated materials at Canonsburg (1986-1993) (Continued)

Parameter	Above detection[a]	Minimum	Median[b]	Maximum
		mg/L		
Calcium[f,g]				
Background[c]	11/11	39.4	43.6	50.1
Downgradient[d]	10/10	70.0	74.0	92.8
Well 424[e]	1/1	-	96.7	-
Chloride[f]				
Background	11/11	36.0	43.0	51.9
Downgradient	10/10	2.10	3.85	7.20
Well 424	1/1	-	136	-
Chromium[f]				
Background	1/6	<0.01	-	0.04
Downgradient	1/6	<0.01	-	0.05
Well 424	0/1	-	<0.01	-
Cobalt				
Background	1/5	0.03	-	<0.05
Downgradient	0/5	<0.03	-	<0.05
Well 424	0/1	-	<0.05	-
Copper				
Background	1/2	<0.02	-	0.02
Downgradient	1/2	<0.02	-	0.02
Well 424	NA	-	-	-
Cyanide[f]				
Background	0/5	<0.01	-	<0.01
Downgradient	2/5	<0.01	-	0.01
Well 424	NA	-	-	-
Fluoride				
Background	7/7	0.10	0.14	0.20
Downgradient	7/7	0.14	0.19	0.30
Well 424	1/1	-	0.1	-
Iron[f]				
Background	11/11	2.63	8.68	12.0
Downgradient	10/10	0.07	3.40	4.66
Well 424	1/1	-	22.3	-
Lead[f]				
Background	0/11	<0.001	-	<0.01
Downgradient	0/10	<0.001	-	<0.01
Well 424	0/1	-	<0.003	-

Table 3.2 Summary of filtered ground water quality data from the unconsolidated materials at Canonsburg (1986-1993) (Continued)

Parameter	Above detection[a]	Minimum	Median[b]	Maximum
		mg/L		
Magnesium[f]				
Background	11/11	14.1	15.3	17.0
Downgradient	10/10	9.45	10.3	12.6
Well 424	1/1	-	26.3	-
Manganese[f,g]				
Background[c]	11/11	1.47	3.12	4.05
Downgradient[d]	10/10	4.50	6.52	11.2
Well 424[e]	1/1	-	6.43	-
Mercury				
Background	0/2	<0.0002	-	<0.0002
Downgradient	0/2	<0.0002	-	<0.0002
Well 424	NA	-	-	-
Molybdenum[f,g]				
Background	1/11	<0.004	-	0.02
Downgradient	5/10	0.009	-	0.03
Well 424	0/1	-	<0.01	-
Nickel				
Background	2/5	<0.01	-	0.05
Downgradient	1/5	<0.01	-	<0.04
Well 424	0/1	-	<0.04	-
Nitrate[f]				
Background	1/10	<0.10	-	<1.0
Downgradient	2/10	<0.10	-	1.2
Well 424	0/1	-	<1.0	-
Phosphate				
Background	1/3	<0.01	-	0.20
Downgradient	1/3	<0.01	-	0.20
Well 424	1/1	-	0.40	-
Potassium[f,g]				
Background	11/11	0.97	1.2	2.5
Downgradient	10/10	1.82	2.1	4.6
Well 424	1/1	-	3.2	-
Selenium[f]				
Background	0/11	<0.001	-	<0.005
Downgradient	0/10	<0.001	-	<0.005
Well 424	0/1	-	<0.005	-

Table 3.2 Summary of filtered ground water quality data from the unconsolidated materials at Canonsburg (1986-1993) (Continued)

Parameter	Above detection[a]	Minimum	Median[b]	Maximum
			mg/L	
Silica				
Background	3/3	6.0	6.8	13.8
Downgradient	3/3	3.9	5.0	11.6
Well 424	1/1	-	12.1	-
Silver				
Background	0/2	<0.01	-	<0.01
Downgradient	0/2	<0.01	-	<0.01
Well 424	NA	-	-	-
Sodium[f]				
Background[c]	11/11	38	43.9	50.1
Downgradient[d]	10/10	5.9	7.83	17.5
Well 424[e]	1/1	-	157	-
Strontium[f,g]				
Background	2/3	<0.10	0.10	0.13
Downgradient	3/3	0.20	0.29	0.30
Well 424	1/1	-	0.32	-
Sulfate[f]				
Background	11/11	117	138	171
Downgradient	10/10	79	99	119
Well 424	1/1	-	210	-
Sulfur				
Background	0/1	<0.10	-	<0.10
Downgradient	0/2	<0.10	-	<0.10
Well 424	NA	-	-	-
Thallium[f]				
Background	0/6	<0.01	-	<0.10
Downgradient	0/6	<0.01	-	<0.10
Well 424	NA	-	-	-
Tin				
Background	1/2	<0.005	-	0.011
Downgradient	0/2	<0.005	-	<0.005
Well 424	NA	-	-	-
Uranium[f,g]				
Background	2/10	<0.001	-	0.003
Downgradient	9/9	0.01	0.02	0.04
Well 424	0/1	-	<0.001	-

Table 3.2 Summary of filtered ground water quality data from the unconsolidated materials at Canonsburg (1986-1993) (Continued)

Parameter	Above detection[a]	Minimum	Median[b]	Maximum
			mg/L	
Vanadium[f]				
Background	2/10	<0.001	-	0.02
Downgradient	2/9	<0.001	-	0.02
Well 424	0/1	-	<0.01	-
Zinc				
Background	7/7	0.033	0.079	0.157
Downgradient	6/7	<0.005	0.014	0.051
Well 424	0/1	-	<0.005	-
Radionuclides			pCi/L	
Lead-210				
Background[c]	1/1	1.1	-	1.1
Downgradient[d]	2/2	ND	2.5	5.0
Well 424[e]	NA	-	-	-
Polonium				
Background	1/1	0.10	-	0.10
Downgradient	2/2	ND	0.05	0.10
Well 424	NA	-	-	-
Radium-226[f]				
Background	6/6	ND	0.105	0.30
Downgradient	5/5	ND	0.10	0.70
Well 424	1/1	-	0.2	-
Radium-228[f]				
Background	6/6	ND	0.60	1.2
Downgradient	5/5	ND	1.15	2.3
Well 424	1/1	-	3.8	-
Thorium-230				
Background	2/2	ND	0.70	1.4
Downgradient	3/3	ND	0.10	0.7
Well 424	1/1	-	0.2	-

[a] Above detection = Number of samples with detectible concentration/total number of samples.

[b] Median is the 50th percentile of the data. The median cannot be calculated if 50 percent or more of the data are below detection. For parameters having only one round at sampling data, the single reported value is listed in the median column.

[c] DOE well 410 was used as background.

[d] DOE well 414 is located in Area C and was used as the downgradient well.

[e] Monitor well 424 is in Area C and is indicative of downgradient conditions but, with only one sampling round, could not be included in the statistical analysis. The single value for each parameter from this well is reported in the median column.

[f] Data collected from 1988 through 1993 are summarized for these parameters. For all other parameters, all available data from 1986 through 1993 are summarized.

[g] Concentrations are statistically elevated in well 414 above background.

NA - not applicable.

ND - not detected.

evaluation over pre-1988 data. For many parameters, however, a limited number of sampling rounds from 1988 through 1993 did not allow for valid statistical comparisons. In these cases, data from all sampling events from 1986 through 1993 were used.

For each constituent, a Mann-Whitney test was conducted at the 0.05 level of significance. A significant Mann-Whitney test result indicates higher concentrations, on average, in the samples from well 414 than those in background well 410. Table 3.2 is a summary of 1986 through 1993 water quality data in the alluvial aquifer. Those constituents for which only data from 1988 through 1993 were used are identified. Table 3.2 also identifies constituents statistically elevated above background levels.

3.3 CONTAMINANTS OF POTENTIAL CONCERN

The data presented in Sections 3.1 and 3.2 were used to compile a list of contaminants of potential concern for the assessment of human health or environmental risks at the Canonsburg site. In general, a contaminant was placed on the list of contaminants of potential concern if it was detected in excess of background levels as measured in upgradient monitor wells and if the site is a possible source for the contaminant.

Table 3.3 presents the list of contaminants of potential concern for ground water. The contaminants listed in column 1 represent those contaminants detected in the unconsolidated material in Area C (represented by well 414) that were statistically elevated from upgradient levels in the unconsolidated material (represented by well 410). These contaminants were further screened for their potential to affect human health, in order to develop a final list of contaminants of potential concern for human health. Several constituents were screened out because they are essential nutrients present at levels within the nutritional ranges even when added to expected dietary intake. These constituents include calcium and potassium. Ammonium, boron, and strontium were eliminated as contaminants of potential concern based on low toxicity and/or intakes present at normal dietary levels. Although ammonium is not considered a dietary component, it is produced in the human body at levels exceeding 4000 milligrams (mg) per day (Summerskill and Wolpert, 1970), over 3 orders of magnitude more than would be expected from the ingestion of the maximum ammonium levels in well 414 (1.3 milligrams per liter [mg/L]). Thus, the levels of ammonium in well 414 are not likely to be associated with adverse health effects.

Based on the screening, manganese, molybdenum, and uranium were chosen as final contaminants of potential concern for the human health assessment. Also, because uranium decays to radioactive progeny, Section 6.0 will evaluate the longer-lived radioactive isotopes of the uranium decay series (represented by lead-210, polonium-210, radium-226, and thorium-230). These seven constituents form the basis of the human health risk assessment for the unconsolidated material at the Canonsburg site.

Table 3.3 Contaminants of potential concern in ground water

Contaminant levels exceeding background	Contaminant levels in nutritional range	Contaminants of low toxicity and/or high dietary range	Contaminants of potential concern for human health
Ammonium	Calcium	Ammonium	Manganese
Boron	Potassium	Boron	Molybdenum
Calcium		Strontium	Uranium[a]
Manganese			
Molybdenum			
Potassium			
Strontium			
Uranium			

[a] The longer-lived radioactive isotopes of the uranium decay series are represented by radium-226, lead-210, polonium-210, and thorium-230. These radionuclides are evaluated as contaminants of potential concern.

Note: Based on data from well 414 located in the unconsolidated material in Area C.

Because ecological impacts differ from effects on human health, the complete list of contaminants was considered for the ecological evaluation in Section 7.0. In addition, due to other ecological-specific considerations, the ecological evaluation also assessed contaminants from wells 412 and 413 that exceeded background levels. Additional contaminants evaluated in the ecological assessment as a result of the inclusion of these two wells were arsenic, chloride, magnesium, sodium, and sulfate.

Some constituents (ammonium, arsenic, calcium, chloride, iron, sodium, sulfate, and radium-228) were observed at higher levels in ground water from monitor well 424 than 414 (Table 3.2). These constituents could potentially be included in the list presented in column 1 in Table 3.3 if analytical results of the only sampling round from monitor well 424 were used, without further verification, to identify contaminants of potential concern. Ammonium, calcium, chloride, and sodium would be screened out from this list, because the levels at which they were detected are within either nutritional or normal dietary ranges, even when added to expected dietary intake (Gilman et al., 1990). Sulfate would be screened out because it is not toxic at detected levels (210 mg/L) (EPA, 1992a). Potential presence of arsenic, iron, and radium-228 at these levels in well 424 needs to be further evaluated.

3.4 CONTAMINANT FATE AND TRANSPORT

At the Canonsburg site, ground water occurs in near-surface unconsolidated materials (including fill material) and in the underlying bedrock. As contaminants migrate through the ground water system, they interact with natural chemical variations in ground water at the site and with the matrix materials. These interactions will produce variations in contaminant concentrations that are not simply the result of physical dispersion. Contaminant interactions are strongly dependant on Eh and pH conditions, ionic strength (generally indicated by TDS), and the speciation of the elements of concern in ground water.

Water from background well 410 completed in the unconsolidated material shows pH in the range of 5.4 to 6.2 and redox potentials near 300 millivolts (mV). Water from downgradient well 414, also completed in the unconsolidated material, shows pH in the range of 5.7 to 6.7 and redox potentials near 400 mV. The downgradient well has a slightly higher pH and a slightly higher redox potential, but both waters are mildly acidic and oxidizing.

In contrast, water in the bedrock system, in addition to having substantially higher TDS, is reducing (Eh near 0 mV) and has a more variable pH. The pH ranges from near 8.5 in well 505, completed in the bedrock unit across Chartiers Creek east of the site, to between 6.5 and 7.0 in background well 504, completed in the bedrock unit at the same location as background well 410. Ground water from downgradient well 414 (January 1991 sampling round), completed in the unconsolidated material, was modeled using the geochemical code PHREEQE (Parkhurst et al., 1980) to predict which species of the contaminants of concern might be present in ground water at the site. Information for some species was taken from Brookins (1988). Table 3.4 presents results of the model.

Manganese

Manganese concentrations ranging from 4.85 to 12.1 mg/L have been observed in downgradient monitor well 414. These values are significantly higher than those observed in background well 410, which range from 1.47 to 3.42 mg/L (Figure 3.3). Water from both wells is mildly oxidizing (redox potentials near 300 mV), with pH values between 5 and 6. Under these conditions, modeling with the geochemical code PHREEQE (Parkhurst et al., 1980) suggests that Mn^{2+} accounts for more than 90 molar percent of manganese species present (Table 3.4). Mn^{2+} is relatively mobile and the major decrease in manganese concentration will likely be adsorption onto matrix materials and dilution as ground water discharges into the adjacent Chartiers Creek. This creek is the primary discharge point for the shallow ground water system on the site.

Water from monitor well 505, completed in the bedrock ground water system, is relatively more reducing (redox potentials near 0 mV) and has a higher pH (near 8.5) compared with well 414 (pH near 6). If there is flow from the shallow ground water table to the bedrock ground water system, creation of solid precipitates could become an important mechanism for attenuation of manganese in the plume. Modeling with PHREEQE (Parkhurst et al., 1980) indicates that mixing with the higher pH water in the lower unit could more strongly stabilize Fe and Mn oxides and hydroxides in the aquifer matrix, and these metals would tend to be adsorbed or precipitated. An increase in pH

Table 3.4 **Stable species of constituents of concern in the ground water system at the Canonsburg, Pennsylvania, UMTRA Project site at Eh = 300 mV and pH = 6.3 (conditions observed in downgradient monitor well 414, completed in the unconsolidated materials, during the January 1991 sampling round)**

Contaminant of potential concern	Common name	Identity of species in ground water	Approximate molar percentage
Manganese	Manganese ion	Mn^{2+}	92
	Manganese sulfate	$MnSO_{4\ AQ}$	5
	Manganese bicarbonate	$MnHCO_3{}^+$	3
Molybdenum	Molybdate	$MoO_4{}^{2-}$	100
Uranium	Uranyl dicarbonate	$UO_2(CO_3)_2{}^{2-}$	63
	Uranyl carbonate	$UO_2CO_{3\ AQ}$	34
	Uranyl tricarbonate	$UO_2(CO_3)_3{}^{4-}$	3
Lead-210	Lead carbonate	$PbCO_{3\ AQ}$	49
	Lead bicarbonate	$PbHCO_3{}^+$	26
	Lead ion	Pb^{2+}	21
	Lead sulfate	$PbSO_{4\ AQ}$	5
Thorium-230[a]	Thorium hydroxide	$Th(OH)_3{}^+$	Dominant
Polonium-210[a]	Polonium ion	Po^{2+}	100
Radium-226 and Radium-228[a]	Radium ion	Ra^{2+}	100

[a] Information from Brookins (1988).

accompanied by the high alkalinity of the bedrock water could result in precipitation of the mineral rhodochrosite ($MnCO_3$) and manganese attenuation.

Molybdenum

In samples taken since 1987, molybdenum occurs in concentrations from near the detection limit to 0.02 mg/L in background well 410 (Figure 3.4) and from near the detection limit to 0.03 mg/L in downgradient well 414. Samples taken in August 1986 are high for all wells sampled. Values reported for both background well 410 and downgradient well 414 are 0.20 mg/L during that sampling round. Modeling with PHREEQE (Parkhurst et al., 1980) indicates that molybdenum occurs in these waters as the molybdate species MoO_4^{2-} (Table 3.4). This species becomes relatively mobile in water with pH values above 5 (Brookins, 1988). Thus, the primary mechanisms for decreasing molybdenum concentrations will be dilution and dispersion as ground water discharges into Chartiers Creek. Coprecipitation with and adsorption on iron oxides and hydroxides may be a secondary mechanism for removing molybdenum from ground water, particularly if contamination is transported into the bedrock unit.

Uranium

Uranium concentrations of 0.01 to 0.04 mg/L in downgradient well 414 (Figure 3.5) are significantly higher than those in background well 410 (below detection to 0.003 mg/L). Modeling with PHREEQE (Parkhurst et al., 1980) predicts that various uranyl carbonates are the dominant uranium species in solution (Table 3.4). These species are relatively stable in mildly oxidizing and alkaline solutions such as water in the upper ground water system at the Canonsburg site. Thus, the major reduction in uranium concentrations at the site will occur by dilution as ground water discharges into Chartiers Creek. Adsorption on iron and manganese oxides and hydroxides could also be important in removing uranium from the ground water. If uranium were to migrate from the unconsolidated unit to the bedrock system, more reducing conditions could stabilize the mineral uraninite in the system and uranium would be precipitated.

Radium-226 and radium-228

In data from 10 sampling dates for downgradient well 414, radium-226 is above detection only on October 28, 1993, with a value of 0.7 ± 0.5 picocuries per liter (pCi/L) for the filtered sample. Background well 410 also shows values below detection except on November 5, 1986, which shows a value of 2.1 ±0.6 pCi/L. Similarly, radium-228 is above detection in monitor well 414 only once in 10 sampling dates with a value of 2.3 ±1.0 pCi/L on August 1, 1991, and twice in monitor well 410 with a high value of 1.2 ± 1.0 on August 1, 1991. These values are not statistically different.

Radium is an alkaline-earth metal that shares many chemical characteristics with the more common alkaline-earth element barium. Like barium, radium forms a highly insoluble sulfate compound at pH values ranging from 3 to more than 12 (Brookins, 1988), but ion exchange reactions primarily are expected to control solution concentrations. Radium is more strongly adsorbed by clays and iron oxides/hydroxides than are strontium, calcium, and magnesium, suggesting that radium should be essentially immobile in ground water at the Canonsburg site.

Lead-210

Very little data are available for lead-210. Water from background well 410 was analyzed once in 1986 for lead-210 (filtered sample), with results reported as 1.1 ± 1.1 pCi/L, and once in 1993 (unfiltered sample), with results reported as 0.7 ± 1.5 pCi/L. For downgradient well 414, a single analysis in 1986 (filtered sample) shows 5.0 ± 1.2 pCi/L and an analysis in 1993 (unfiltered sample) shows 1.3 ± 1.5 pCi/L. Thus, lead-210 in downgradient well 414 is higher than background for a single analysis in 1986.

Processes affecting lead-210 in the ground water at the Canonsburg site are the same as those affecting lead in general. Modeling by PHREEQE (Parkhurst, et al., 1980) predicts that the dominant species in ground water from well 414 will be various carbonate species (Table 3.4). This water is not saturated with the lead carbonate mineral cerrusite, so it is unlikely that precipitation will remove lead. However, iron oxides and hydroxides are stable in the ground water matrix and these phases strongly adsorb lead. Therefore, lead contamination probably will not extend beyond the confines of the site.

Polonium-210

With only three sample dates reported, Polonium-210 was not detected at downgradient well 414. With two sample dates reported, background well 410 shows one concentration below detection and one at 0.2 ± 0.1 pCi/L.

Polonium-210 is produced by the beta decay of lead-210 (half-life equals 22 years) through the intermediate short-lived daughter bismuth-210 (half-life equals 5.02 days). Polonium-210 has a half-life of 138 days and decays to stable lead-206. Because lead-210 has a much longer half-life than bismuth-210 or polonium-210, the distribution of lead-210 primarily will control the distribution of polonium-210 at this site.

Thorium-230

As with lead-210, data are sparse for this constituent. Thorium-230 in downgradient well 414 is above detection for only one sampling date on which the values in the filtered sample (0.7 ± 0.3 pCi/L) were found to be higher than those in the unfiltered sample (0.5 ± 0.3 pCi/L). With only two sampling dates, background well 410 also has one sample with values that are above detection

(1.4 ± 0.3 pCi/L filtered and 0.3 ± 0.3 pCi/L unfiltered). These values are higher than those in downgradient well 414.

Whatever the source of thorium-230 in these wells, the highly insoluble $Th(OH)_4$ and ThO_2 (Brookins, 1988; Langmuir and Herman, 1980) dominate the Eh and pH ranges of ground water at Canonsburg. Therefore, it is likely that the Eh and pH conditions at the Canonsburg site will effectively immobilize thorium-230.

3.5 SURFACE WATER MONITORING

Surface water in Chartiers Creek has been monitored for several years in the site vicinity. Figure 3.6 shows the six sampling locations (601 through 606). Prior to the October 1993 ecological field survey, only locations 601 (upstream of the site) and 602 (adjacent to Area C) had been sampled. One to three filtered surface water samples were collected from these two locations during 1989 and 1990. One to four unfiltered surface water samples were collected from these locations from 1991 through 1993 (Table 3.5). Comparing the unfiltered data from location 601 with location 602 for the list of ground water constituents that exceeded background ground water quality in wells 412, 413, and 414 indicates no statistical differences in water quality between the two sites. Uranium was not detected (<0.001 mg/L) at either site. Five of the ground water constituents (ammonium, magnesium, manganese, sodium, and sulfate) were detected at the upstream location (601) at median concentrations equal to or greater than concentrations detected at the downstream location (602). For the other four constituents (calcium, chloride, molybdenum, and potassium), the concentrations detected at location 602 were higher than the upstream concentrations. However, the differences in concentrations between the two sites for these four constituents are minimal, ranging from 2 to 6 percent, and do not represent a statistically significant difference.

Surface water samples were collected in October 1993 at all sampling locations (601 through 606). Locations 603 through 606 were not sampled prior to this date. The samples collected in October 1993 were analyzed for a select list of constituents (chromium, iron, lead, manganese, molybdenum, selenium, sulfate, uranium, vanadium, and zinc). These constituents were chosen based on a preliminary screening of the ground water data prior to development of this risk assessment. Of these constituents, manganese, molybdenum, sulfate, and uranium were identified as exceeding background in ground water. An evaluation of the most recent surface water data (October 1993) for all sampling locations (see Section 7.0) indicates that uranium was not detected at any location, and sulfate was detected at the highest concentration at the upstream site (Table 3.5). For the other two constituents (manganese and molybdenum), the differences between the upstream concentrations and adjacent or downstream concentrations ranged from 10 to 47 percent, with the highest values detected at location 606. Although the surface water quality data base is limited, the available data suggest that ground water contamination from the site is not affecting the water quality of Chartiers Creek. However, acid mine drainage (the closest of several upstream mines is approximately 1 mi

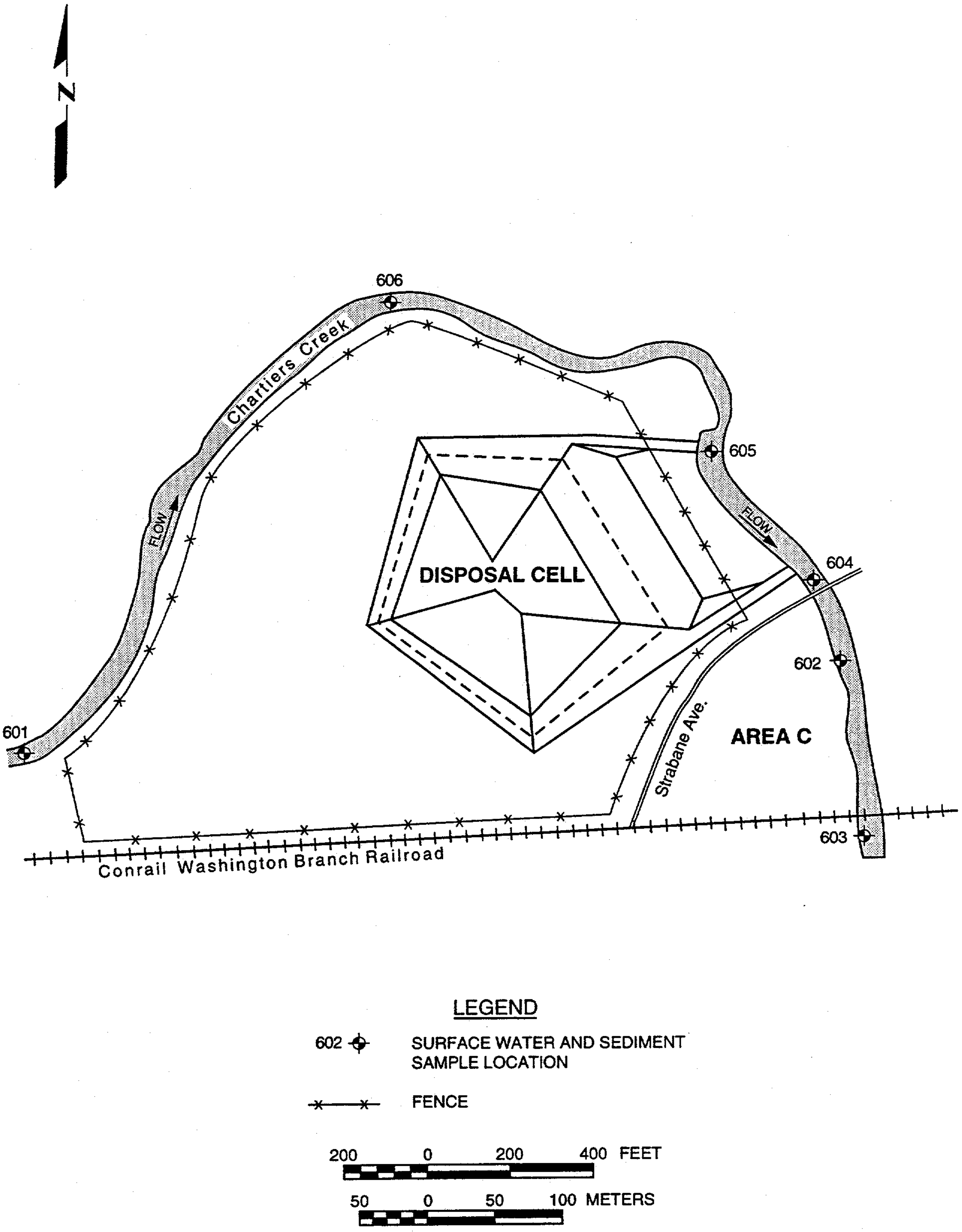


FIGURE 3.6
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS,
CANONSBURG, PENNSYLVANIA, SITE

Table 3.5 Summary of unfiltered water quality data from Chartiers Creek at Canonsburg (1989-1993)

Parameter[a]	Above detection[b]	Minimum	Median[c]	Maximum
Inorganic parameters			mg/L	
<u>Ammonium</u>				
Upstream	3/4	<0.06	0.25	0.8
602	3/4	<0.06	0.20	0.3
<u>Cadmium</u>				
Upstream	0/1	-	<0.001	-
602	0/1	-	<0.001	-
<u>Calcium</u>				
Upstream	5/5	80.1	83.0	112
602	5/5	80.0	86.7	116
<u>Chloride</u>				
Upstream	5/5	36	50.1	99
602	5/5	34	50.8	101
<u>Chromium</u>				
Upstream	0/2	<0.01	-	<0.01
602	0/2	<0.01	-	<0.01
Downstream[f]	0/4	<0.01	-	<0.01
<u>Cobalt</u>				
Upstream	0/1	-	<0.05	-
602	0/1	-	<0.05	-
<u>Cyanide</u>				
Upstream	1/4	<0.01	-	0.02
602	0/4	<0.01	-	<0.01
<u>Iron</u>				
Upstream	6/6	0.36	0.565	2.80
602	6/6	0.36	0.520	2.92
Downstream	4/4	0.57	0.650	0.74
<u>Lead</u>				
Upstream	2/6	<0.0015	-	0.009
602	3/6	0.0022	-	0.012
Downstream	2/4	<0.003	-	0.004
<u>Magnesium</u>				
Upstream	5/5	16.9	18.8	29.2
602	5/5	16.8	18.9	29.5
<u>Manganese</u>				
Upstream	6/6	0.13	0.155	0.20
602	6/6	0.12	0.155	0.22
Downstream	4/4	0.12	0.140	0.17

Table 3.5 Summary of unfiltered water quality data from Chartiers Creek at Canonsburg (1989-1993) (Continued)

Parameter[a]	Above detection[b]	Minimum	Median[c]	Maximum
		mg/L		
Molybdenum				
Upstream	6/6	0.04	0.080	0.22
602	6/6	0.04	0.085	0.17
Downstream	4/4	0.10	0.125	0.17
Nitrate				
Upstream	5/5	0.43	11.7	31.0
602	5/5	0.43	11.9	26.6
Potassium				
Upstream	5/5	3.6	6.5	10.4
602	5/5	3.3	6.8	10.2
Selenium				
Upstream	0/6	<0.0015	-	<0.05
602	0/6	<0.0015	-	<0.005
Downstream	0/4	<0.005	-	<0.005
Sodium				
Upstream	5/5	36.7	62	132
602	5/5	36.0	58	135
Sulfate				
Upstream	6/6	116	207.0	383
602	6/6	128	202.5	412
Downstream	4/4	248	262.0	276
Thallium				
Upstream	0/3	<0.01	-	<0.01
602	0/3	<0.01	-	<0.01
Uranium				
Upstream	1/5	<0.001	-	0.001
602	1/5	<0.001	-	0.002
Downstream	0/4	<0.001	-	<0.001
Vanadium				
Upstream	2/6	<0.0019	-	0.02
602	2/6	<0.0019	-	0.02
Downstream	4/4	0.01	0.025	0.03
Zinc				
Upstream	1/1	-	0.045	-
602	1/1	-	0.199	-
Downstream	4/4	0.040	0.047	0.064

Table 3.5 Summary of unfiltered water quality data from Chartiers Creek at Canonsburg (1989-1993) (Concluded)

Parameter[a]	Above detection[b]	Minimum	Median[c]	Maximum
Radiological parameters			pCi/L	
Radium-226				
Upstream	4/4	ND	0.12	0.90
602	4/4	ND	0.0	0.12

[a] Data were available from sampling events as early as 1989. All sampling events were used in this summary.

[b] Above detection = Number of samples with detectable concentration/total number of samples.

[c] Median is the 50th percentile of the data. The median cannot be calculated if 50 percent or more of the data are below detection. For parameters for which only one sampling round was available, the one reported value is listed in the median column.

[d] Upstream sampling location 601 was used as background. Sampling data from 1989 through 1993 were available for this location.

[e] Sampling location 602 was the only downstream location for which sufficient historical data were available.

[f] Sampling locations 603, 604, 605, and 606 were also considered to be downstream. These locations were sampled only during the October 1993 sampling round, and these samples were analyzed for only 10 inorganic parameters.

(1.6 km) southwest of the site) and industrial and municipal discharges (FBDU, 1982; Newport, 1973) affect water quality in Chartiers Creek . Concentrations of sulfate, iron manganese, and TDS are elevated in surface water at both upstream and downstream sampling locations (Table 3.5).

Sediment samples were collected at all surface water sampling locations (601 through 606) in October 1993. Table 3.6 is a statistical summary of the sediment sampling data. Rainfall and snowmelt may have carried both dissolved and suspended metal constituents along surface drainages from the site to Chartiers Creek. Metal constituents transported as dissolved species would have been diluted after discharging to the creek. Alternatively, dissolved species could have adsorbed to sediments or been concentrated by biota, processes that are both dependent on biochemical and geochemical conditions. Constituents transported from the site that were sorbed onto soil particles may have been deposited as sediments. Variations in geochemical conditions or biological action could also release constituents adsorbed onto sediments into surface waters. Thus, deposited sediments could act as a source of site-related surface water contamination. However, as discussed further in Section 7.0, no evidence suggests that this is occurring now.

Table 3.6 Summary of sediment data from Chartiers Creek at Canonsburg (1993)

Parameter[a]	Above detection[b]	Minimum	Median[c]	Maximum
Inorganic parameters			mg/L	
Chromium				
Upstream[d]	1/1	-	96	-
Downstream[e]	5/5	22	69	189
Iron				
Upstream	1/1	-	37,400	-
Downstream	5/5	26,200	56,600	105,000
Lead				
Upstream	1/1	-	80.8	-
Downstream	5/5	0.42	49.5	53.7
Manganese				
Upstream	1/1	-	1,410	-
Downstream	5/5	590	1,900	2,820
Molybdenum				
Upstream	1/1	-	33	-
Downstream	5/5	2	16	96
Selenium				
Upstream	0/1	-	<0.5	-
Downstream	1/5	<0.5	<0.5	0.7
Uranium				
Upstream	1/1	-	2.0	-
Downstream	5/5	1.6	2.0	2.6
Vanadium				
Upstream	1/1	-	42	-
Downstream	5/5	22	41	126
Zinc				
Upstream	1/1	-	252	-
Downstream	5/5	90	204	268

[a] Data were available from a single sampling round in October 1993.

[b] Above detection = Number of samples with detectable concentration/total number of samples.

[c] Median is the 50th percentile of the data. The median cannot be calculated if 50 percent or more of the data are below detection. When data were available from only one sampling round, the single value is reported in the median column.

[d] Upstream sampling location 601 was used as background.

[e] Sampling locations 602, 603, 604, 605, and 606 were combined as downstream.

4.0 EXPOSURE ASSESSMENT

This section discusses and estimates the type and magnitude of exposures to the chemicals of potential concern present at the Canonsburg site. The exposure routes evaluated in this section are based on potential contact with ground water, surface water, and sediment at the site or in the site vicinity.

4.1 POTENTIALLY EXPOSED POPULATION

Ground water contaminated by uranium processing at the Canonsburg site is not currently used. The source of drinking water for residents in the site vicinity is the Monongahela River as supplied by the Pennsylvania-American Water Company. As shown in Figure 2.9, a number of residents within a 1-mile (1.6-km) site radius have domestic wells. However, most of these wells have broken pumps or are not in use. Residents located slightly beyond 1 mile (1.6 km) north and south of the site use the ground water for drinking purposes, and one well approximately 400 ft (120 m) north of the site is used for domestic purposes other than drinking. However, contaminated ground water from the site does not appear to have migrated to off-site locations. Thus, contamination from the site is not expected to affect these residents (see Sections 2.4 and 2.7).

Because there are no current human receptors of contaminated ground water, this assessment assumes a future ground water use scenario. In the future, a domestic well could be installed in the unconsolidated material in Area C, creating the potential for exposure through drinking, bathing, and irrigation. This assumption is made because Area C is the only portion of the site available for future public use. The exposure point in this area will be based on data from well 414. Although wells from other areas of the site (i.e., well 412 and 413) have higher levels of some contaminants, data from these wells were not used in this assessment because no one is anticipated to use the ground water in this area. This portion of the site will be in DOE possession, and development of this area will not be permitted (TAC, 1994b). Currently, the ground water in this area discharges to Chartiers Creek. Based on available data, it appears that contamination has not migrated to the bedrock or under the creek (see Section 2.4).

The future scenario evaluates domestic ground water uses consistent with current water uses by the population in the region. The potentially exposed population includes residents of the following age groups: children (1 to 10 years old and 6 to 12 years old) and adults (11 to 65 years old). These age groups were selected for the following reasons:

- Survey data for population variables such as age, weight, and daily water intake are available for these age groups.

- Toxicological variables are similar within these age groups, including responsiveness of sensitive subgroups to the contaminants of concern, consistent intake to body weight ratios, and similar toxicokinetics.

- Potential exposures to nearby populations may occur in surface waters near the site because ground water in the unconsolidated material at the site discharges into Chartiers Creek. Local residents (adults and older children) could use these waters for wading, swimming, or fishing.

4.2 EXPOSURE PATHWAYS

An exposure pathway describes the course a chemical takes from a source to an exposed organism. Exposure can occur only if there is a source of contamination, a point of contact with a population or individual, and a route of exposure (e.g., water ingestion). This assessment evaluates both ground water and surface water/sediment pathways. Figure 4.1 presents a conceptual model of the potential ground water and surface water/sediment exposure pathways that may occur at the Canonsburg site. The following subsections discuss these pathways in more detail.

4.2.1 Ground water

Although it is unlikely that ground water in the site vicinity will be used in the future for drinking purposes because of the existing public water supply system, this risk assessment will assess hypothetical future use of the ground water in the unconsolidated material. Water in the region is primarily used for household purposes such as drinking, cooking, and bathing. Another use typical of the region that could indirectly lead to human exposure is irrigation of garden vegetables. The conceptual model (Figure 4.1) presents the potential ground water exposure routes that could result from these uses and includes drinking water ingestion, dermal absorption, and garden produce ingestion.

Drinking water ingestion

Drinking water ingestion is generally the most significant exposure route for ground water contaminated with metals. For this evaluation, drinking water consumption includes water used for drinking and for food preparation (e.g., reconstituted juice, soup, rice, and beans). For comparing relative pathway significance, Table 4.1 presents a screening level assessment of drinking water intake for adults. These screening calculations are based on the estimated 95th percentile of the constituent concentrations measured at well 414.

Dermal absorption

Dermal absorption is the process by which chemicals coming into contact with the skin are absorbed into the blood vessels near the skin's surface. Some

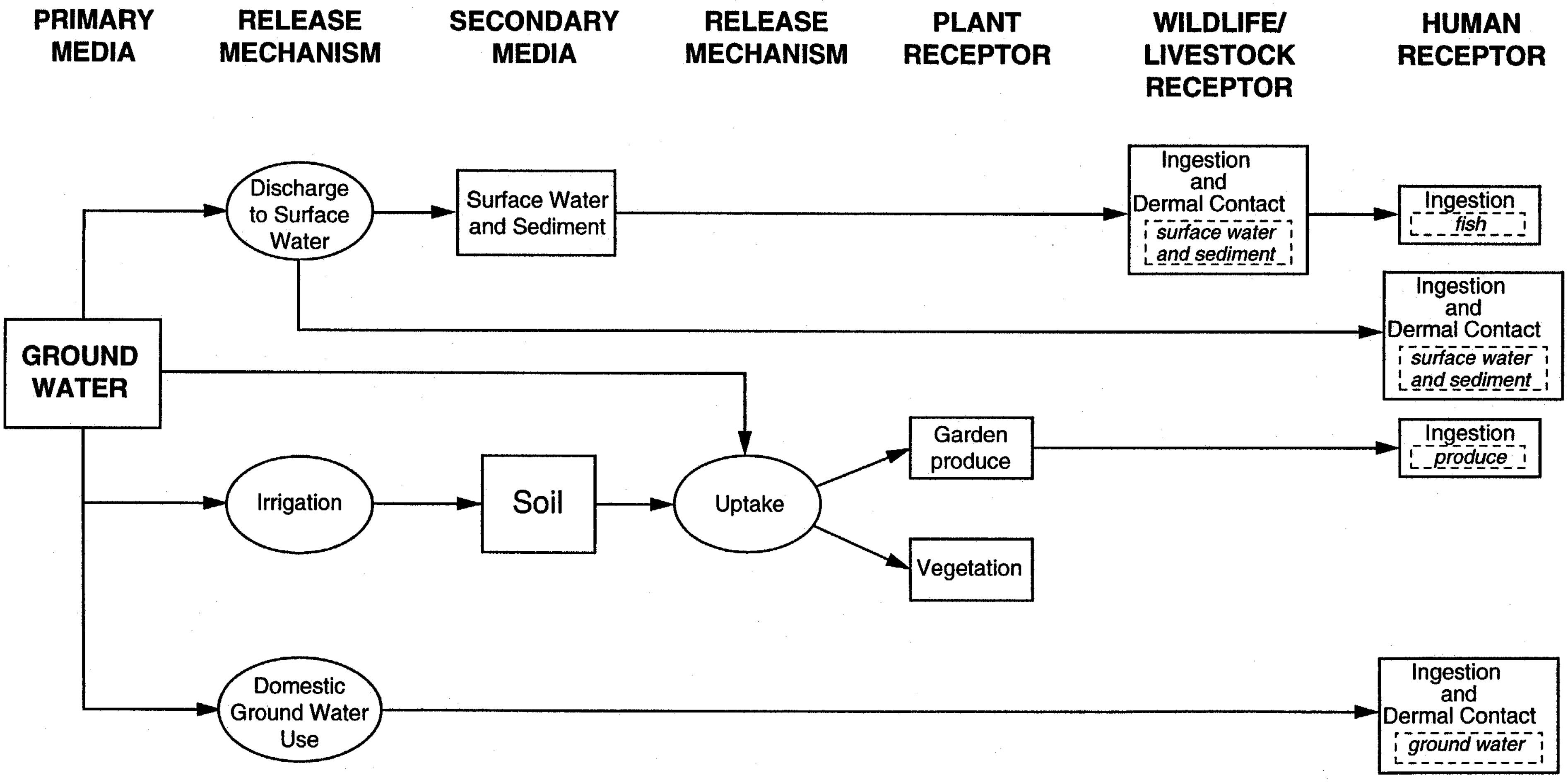


FIGURE 4.1
CANONSBURG CONCEPTUAL MODEL

MAC: SITE/CAN/BRA/CONCEPTMOD

Table 4.1 Exposure dose calculations and equation definitions for ground water ingestion and dermal contact for the future hypothetical adult scenario, Canonsburg, Pennsylvania, UMTRA Project site

Contaminant of potential concern	Cw	Ground water exposure doses (mg/kg-day) Ingestion	Dermal contact	Ratio of dermal: ingestion[a]
Noncarcinogenic effects (mg/L)				
Manganese	10	3E-01	5E-04	0.002
Molybdenum	0.027	7E-04	1E-06	0.002
Uranium	0.033	9E-04	2E-06	0.002
Carcinogenic effects (pCi/L)				
Uranium	23[b]	5E+05[c]	9E+02[c]	0.002

Equation definitions for exposure dose calculations

Ingestion of ground water

Chemicals: Chronic daily intake (mg/kg-day) $= \dfrac{Cw \times IRw \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi per lifetime) $= Cw \times IRw \times EF \times ED$

Dermal contact with ground water

Chemicals: Chronic daily intake (mg/kg-day) $= \dfrac{(Cw \times SA \times Pc \times Cf) \times ET \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi per lifetime) $= Cw \times SA \times Pc \times Cf \times ET \times EF \times ED$

Where:

Cw = Contaminant concentration in ground water (upper 95th percentile) (mg/L or pCi/L).
IRw = Ingestion rate for water (L per day) (2 L per day for an adult) (EPA, 1989a).
EF = Exposure frequency (350 days per year) (EPA, 1991).
ED = Exposure duration (30 years for an adult) (EPA, 1989a).
BW = Body weight (70 kilograms [kg] for an adult) (EPA, 1989a).
AT = Averaging time (365 days x ED for noncarcinogens) (EPA, 1989a).
SA = Skin surface area (19,400 cm^2; based on 50th percentile total body surface area) (EPA, 1989a).
Pc = Dermal permeability constant (0.001 cm per hour) (EPA, 1989a).
Cf = Conversion factor (0.001 liters per cubic centimeter [L/cm^3]).
ET = Exposure time (0.2 hour per day) (EPA, 1989a).

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[a] Ratio of the dermal absorption exposure dose to the ground water ingestion dose.
[b] Uranium-234 and uranium-238 combined; 1 mg uranium is assumed to equal 686 pCi.
[c] Units are pCi per lifetime.

mg/kg-day = milligrams per kilogram per day.

compounds are absorbed easily, although metals do not possess the chemical properties conducive to skin absorption.

To evaluate this exposure route, a screening calculation was performed to determine if the dermal absorption dose would be significant compared with the drinking water ingestion dose for the contaminants of potential concern. Because chemical-specific absorption factors are not available for the contaminants of potential concern, they are assumed to be absorbed across the skin at the same rate as water. This assumption will probably overestimate any potential contribution from dermal absorption.

Table 4.1 provides the results of the screening. Although the dermal dose is an absorbed dose, whereas the drinking water ingestion dose is a total dose of which only some percentage will be absorbed, the very low contribution of dermal absorption, 0.2 percent, is assumed to be insignificant compared with drinking water ingestion. Based on these results, the dermal absorption exposure route is eliminated from a more detailed evaluation.

Ingestion of ground water-irrigated garden produce

The garden produce ingestion route could not be evaluated for its relative significance to the drinking water ingestion route. Although the intake from ground water-irrigated produce ingestion is not likely to be greater than the exposure dose from drinking water ingestion, the incremental contribution could be significant. There are currently no literature values that could be used to estimate this pathway contribution. However, the UMTRA Ground Water Project is currently conducting plant uptake studies for irrigated vegetables and grasses. The results of these studies will be included in the National Environmental Policy Act (NEPA) document and ground water compliance strategy planning for this site.

In addition to ground water irrigation, plant roots may be in direct contact with contaminated ground water. Because fruit trees (apple and cherry) grow wild in the vicinity, there is a potential for uptake of contaminants into these fruits, leading to human exposure. This exposure pathway also cannot be estimated at this time.

Summary

The results of the ground water pathway screening analyses indicate that drinking water ingestion is the dominant pathway. Section 4.4 further evaluates this pathway probabilistically.

4.2.2 Surface water/sediment

The surface water/sediment exposure pathway is considered due to the potential access of nearby residents to Chartiers Creek, which receives ground water discharge from the unconsolidated material beneath the site. Individuals have access to the creek for swimming or wading in the summer. The creek also is used for fishing. For these reasons, the surface water and sediment in the creek were selected for a detailed exposure evaluation. The conceptual model (Figure 4.1) presents the potential surface water and sediment exposure routes that could result and includes incidental surface water ingestion, dermal absorption from surface water, incidental sediment ingestion, and fish ingestion. Children aged 6 to 12 years are considered the subpopulation most likely to play in the creek, and adults are considered the subpopulation most likely to fish and subsequently consume their catch.

Incidental ingestion of surface water

Incidental surface water ingestion could occur when children swim or wade in Chartiers Creek. It is assumed that a child may visit the creek every day during the summer to swim or wade, incidentally ingesting a few tablespoons of water on each visit. Table 4.2 presents the results for this exposure route, which is further evaluated in Section 6.0.

Dermal contact with surface water

The dermal contact exposure route for surface water was evaluated for the same scenario discussed under incidental ingestion of surface water. A child's total body surface area is assumed to contact surface water while swimming in the creek. Dermal exposure was evaluated for swimming rather than wading because more skin surface area would contact water while swimming. Dermal contact with surface water leads to a potential exposure route from dermal absorption, although metals generally do not absorb well across the skin. Because chemical-specific absorption factors are not available for the contaminants of concern, they were assumed to absorb across the skin at the same rate as water. This assumption probably overestimates any potential contribution from dermal absorption. Table 4.2 presents the results for this exposure route. This table shows that contributions from dermal absorption are approximately 20 percent of the incidental surface water ingestion dose for the selected contaminants of concern. Based on these results, the dermal absorption from surface water route is further evaluated in Section 6.0.

Incidental ingestion of sediments

Children swimming or wading in Chartiers Creek may also be exposed to contaminants of potential concern through the incidental ingestion of sediments. Table 4.3 presents the equation and assumptions for this exposure route. The doses from this exposure route exceed those estimated for incidental ingestion of surface water. Section 6.0 further evaluates the incidental ingestion of sediments exposure route.

Table 4.2 Exposure dose calculations and equation definitions for incidental surface water ingestion and dermal contact by children in Chartiers Creek, Canonsburg, Pennsylvania, UMTRA Project site

Contaminant of potential concern	Csw	Surface water exposure doses (mg/kg-day) Ingestion	Dermal contact	Ratio of dermal: surface water ingestion[a]
Noncarcinogenic effects (mg/L)				
Manganese	0.17[b]	5E-05	1E-05	0.2
Molybdenum	0.17[b]	5E-05	1E-05	0.2
Uranium	ND	NA	NA	NA
Carcinogenic effects (pCi/L)				
Uranium	ND	NA	NA	NA

Equation definitions for exposure dose calculations

Incidental Ingestion of surface water

Chemicals: Chronic daily intake (mg/kg-day) $= \dfrac{Csw \times IRsw \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi per lifetime) $= Csw \times IRsw \times EF \times ED$

Dermal contact with surface water

Chemicals: Chronic daily intake (mg/kg-day) $= \dfrac{(Csw \times SA \times Pc \times Cf) \times ET \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi per lifetime) $= Csw \times SA \times Pc \times Cf \times ET \times EF \times ED$

Where:

Csw = Contaminant concentration in surface water (maximum concentration) (mg/L or pCi/L).
IRsw = Incidental ingestion rate for surface water (0.05 L/day for 6- to 12-year-old children) (EPA, 1989a).
EF = Exposure frequency (90 days; 3 months per year for 7 days per week).
ED = Exposure duration (7 years for 6 to 12 year old children).
BW = Body weight (38.3 kg; based on 90th percentile body weight for 6- to 12-year-old male children) (EPA, 1989b).
AT = Averaging time (365 days x ED for noncarcinogens) (EPA, 1989a).
SA = Skin surface area (10,937 cm^2 for 6- to 12-year-old children; based on 50th percentile total body surface area) (EPA, 1989b).
Pc = Dermal permeability constant (0.001 cm per hour) (EPA, 1989a).
Cf = Conversion factor (0.001 liters per cubic centimeter [L/cm^3]).
ET = Exposure time (1 hour per day).

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[a] Ratio of the dermal absorption exposure dose to the surface water ingestion dose.
[b] Based on maximum detected value in surface water (sampling location 606).

mg/kg-day = milligrams per kilogram per day.

Table 4.3 Exposure dose calculations and equation definitions for incidental sediment ingestion by children in Chartiers Creek, Canonsburg, Pennsylvania, UMTRA Project site

Contaminant of potential concern	Csd (mg/L)	Sediment ingestion exposure doses (mg/kg-day)
Noncarcinogenic effects		
Manganese	2820[a]	2E-03
Molybdenum	96[b]	6E-05
Uranium	2.6[a]	2E-06
Carcinogenic effects	(pCi/L)	
Uranium	1784[c]	112[d]

Equation definitions for exposure dose calculations

Incidental ingestion of sediment

Chemicals: Chronic daily intake (mg/kg-day) $= \dfrac{Csd \times Cf \times IRsd \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi per lifetime) $= Csd \times Cf \times IRsd \times EF \times ED$

Where:

Csd = Contaminant concentration in sediment (maximum concentration) (mg/L or pCi/L).
Cf = Conversion factor (10^{-6} milligrams per kilogram [mg/kg]).
IRsd = Incidental ingestion rate for sediment (100 mg per day for 6- to 12-year-old children) (EPA, 1989a).
EF = Exposure frequency (90 days per year; 3 months per year for 7 days per week).
ED = Exposure duration (7 years for 6- to 12-year-old children).
BW = Body weight (38.3 kg; based on 90th percentile body weight for 6- to 12-year-old male children) (EPA, 1989b).
AT = Averaging time (365 days x ED for noncarcinogens) (EPA, 1989a).

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[a] Based on maximum detected value in sediment (sampling location 604).
[b] Based on maximum detected value in sediment water (sampling location 605).
[c] Uranium-234 and uranium-238 combined; 1 mg uranium is assumed to equal 686 pCi.
[d] Units are pCi per lifetime.

mg/kg-day = milligrams per kilogram per day.

Fish ingestion

The commonwealth of Pennsylvania designated Chartiers Creek for the maintenance and propagation of fish species and protection of additional flora and fauna indigenous to a warm water habitat (PADER, 1992). Fish found in the creek include carp, catfish, and bluegill (Templeton, 1993). The ingestion of fish, which may have accumulated site-related constituents, is a potential exposure route for residents who use the creek for fishing.

Table 4.4 presents the results of the screening-level evaluation for the fish ingestion exposure route. To evaluate this exposure route, chemical-specific bioconcentration factors (BCF) are needed to estimate fish tissue levels. A BCF for fish was not available in the literature for molybdenum. For manganese, assuming a BCF of 150 for fish, an intake rate higher than that estimated for the surface water ingestion route was calculated. Based on these results, the fish ingestion exposure route is further evaluated in Section 6.0.

4.3 EXPOSURE CONCENTRATIONS

The exposure concentration of a contaminant in ground water is defined as the concentration contacted by an individual over the period of exposure being considered. Estimates of contaminant concentrations are based on ground water data collected from monitoring wells after surface remediation was completed at the site. In this evaluation, the contaminant concentrations are assumed to be at steady state although actual contaminant concentrations (and therefore potential exposures) are expected to decrease with time because surface remediation has been completed at the site. Nonetheless, these estimates are reasonable for chronic exposure soon after surface remediation. (Chronic exposure for noncarcinogens is considered to be exposure for any period longer than 7 years).

For the unconsolidated material, exposure concentrations are evaluated as a probability of occurrence based on 1988 to 1993 ground water quality data from monitor well 414. The probability distribution selected for each contaminant reflected, to the extent possible, the same mean, standard deviation, and shape observed in actual water quality data. For constituents showing an obvious trend over time, the theoretical distribution is centered around the more recently observed concentrations. Because relatively little data are available on which to determine shape, the normal distribution was assumed unless strongly contradicted by the data. The data sets for manganese, molybdenum, and uranium were all determined to reasonably fit a normal distribution. The lower tail of the distribution was truncated at 0 mg/L, and the upper tail of the distributions was truncated at the 99th percentile. For every contaminant, the upper truncated concentration was higher than the maximum observed concentration in the water quality data. The software package @ RISK (Palisade Corp., 1992) was used to generate the probability curves for the contaminants of potential concern. Figures 4.2 through 4.4 show the results.

Table 4.4 **Exposure dose calculations and equation definitions for ingestion of fish from Chartiers Creek by adults, Canonsburg, Pennsylvania, UMTRA Project site**

Contaminant of potential concern	Csw	BCF	Fish ingestion exposure doses (mg/kg-day)	Ratio of fish ingestion:surface water ingestion[a]
Noncarcinogenic effects (mg/L)				
Manganese	0.17	150[b]	9E-03	180
Molybdenum	0.17	NTA	NC	NC
Uranium	ND	NA	NA	NA
Carcinogenic effects (pCi/L)				
Uranium	ND	NA	NA	NA

Equation definitions for exposure dose calculations

Ingestion of fish

Chemicals: Chronic daily intake (mg/kg-day) $= \frac{Cf \times IR \times EF \times ED \times FI}{BW \times AT}$

Radionuclides: Lifetime intake (pCi per lifetime) $= Cf \times IR \times EF \times ED \times FI$

$$Cf = Csw \times BCF$$

Where:

Cf = Contaminant concentration in fish (milligrams per kilogram [mg/kg]).
IR = Ingestion rate of fish (0.054 kg per day for an adult) (EPA, 1991).
EF = Exposure frequency (350 days per year) (EPA, 1991).
ED = Exposure duration (30 years for an adult) (EPA, 1989a).
FI = Fraction ingested from contaminated source (0.5 unitless).
BW = Body weight (70 kg for an adult) (EPA, 1989a).
AT = Averaging time (365 days x ED for noncarcinogens) (EPA, 1989a).
Csw = Contaminant concentration in surface water (maximum concentration)(mg/L).
BCF = Bioconcentration factor (chemical-specific; unitless).

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[a] Ratio of the fish ingestion dose to the surface water ingestion dose.
[b] BCF based on study on minnows (AQUIRE, 1992); converted from dry to wet weight assuming 75% moisture in fish tissue (EPA, 1993).

ND — not detected in surface water.
NTA — not available.
NA — not applicable, since uranium was not detected in surface water.
NC — could not be calculated.
mg/kg-day = milligrams per kilogram per day.

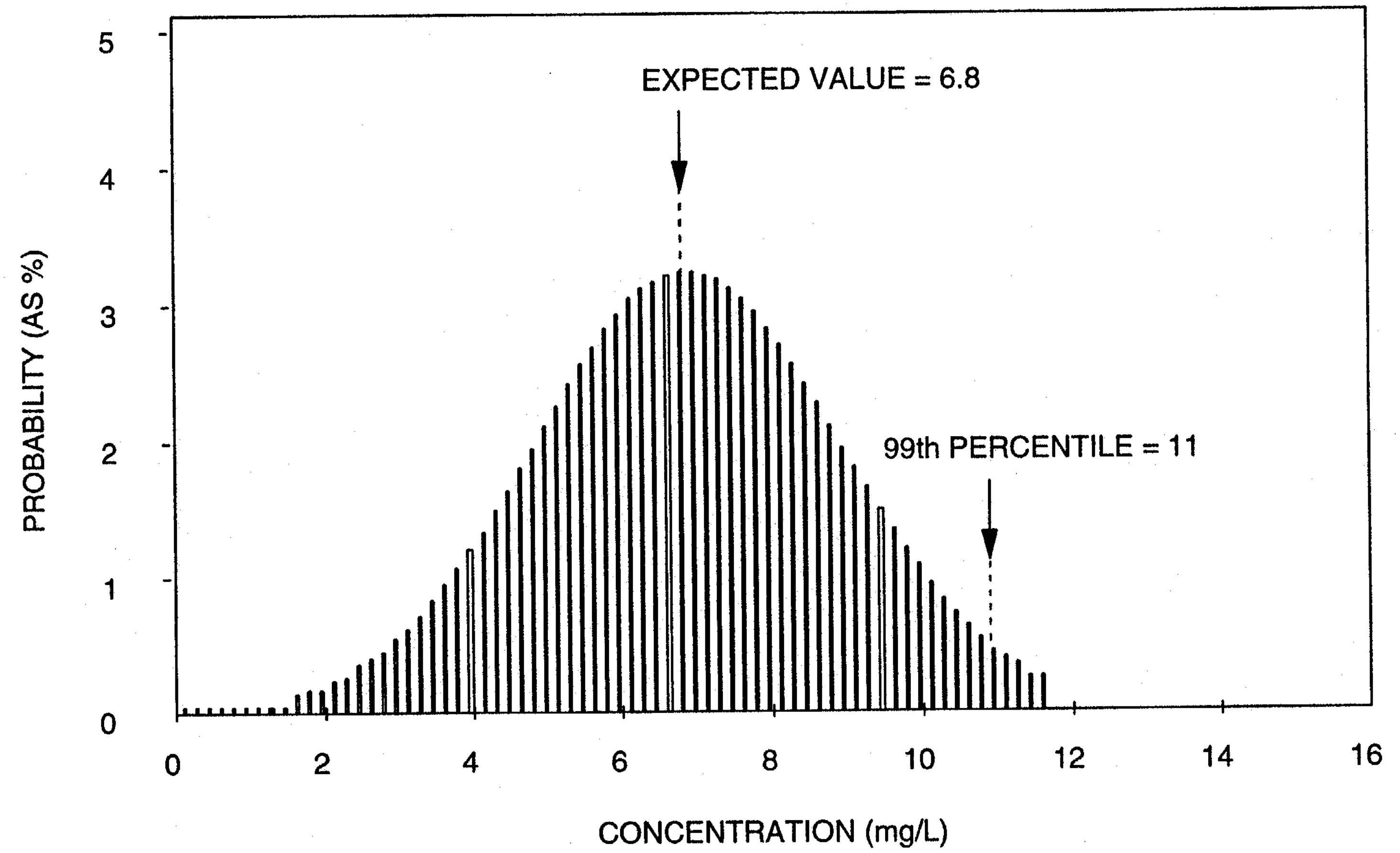

FIGURE 4.2
PROBABILITY DISTRIBUTION OF MANGANESE CONCENTRATIONS FOR THE UNCONSOLIDATED MATERIAL
CANONSBURG, PENNSYLVANIA, SITE

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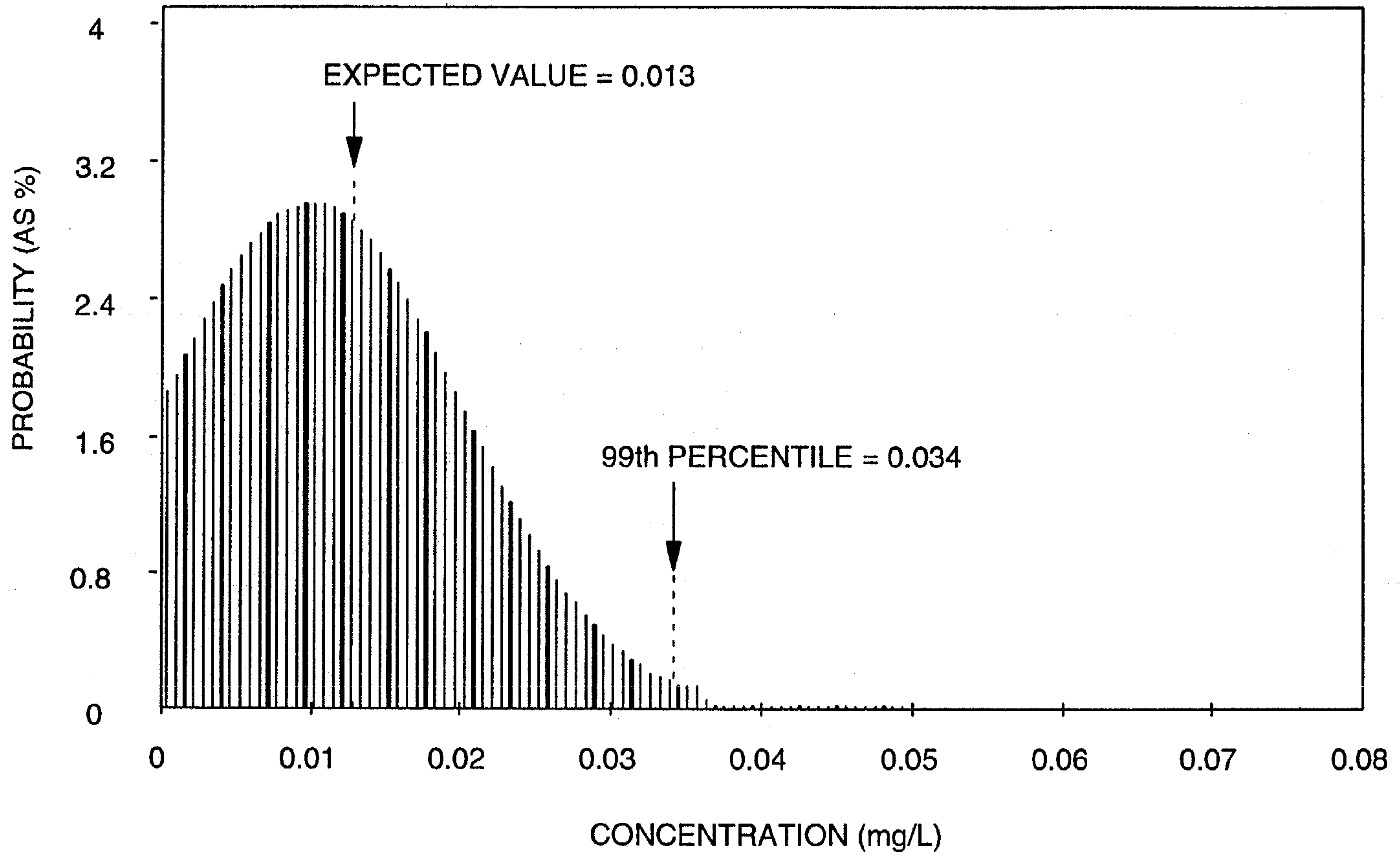

FIGURE 4.3
PROBABILITY DISTRIBUTION OF MOLYBDENUM CONCENTRATIONS FOR THE UNCONSOLIDATED MATERIAL CANONSBURG, PENNSYLVANIA, SITE

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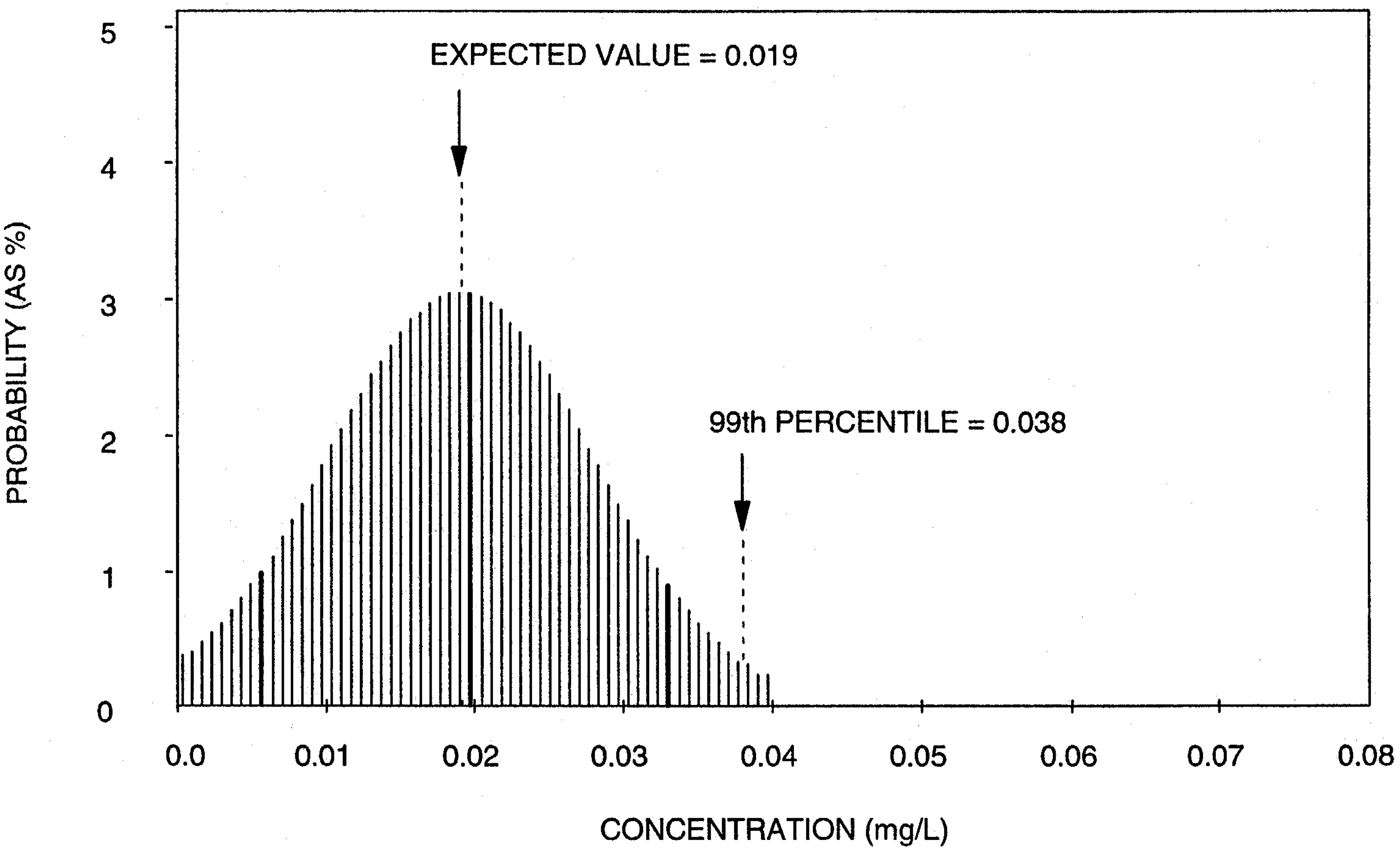


FIGURE 4.4
PROBABILITY DISTRIBUTION OF URANIUM CONCENTRATIONS FOR THE UNCONSOLIDATED MATERIAL CANONSBURG, PENNSYLVANIA, SITE

4.4 ESTIMATION OF GROUND WATER INGESTION INTAKE

Within the population of future residents, individuals are expected to vary in their water consumption habits, stable body weight, and length of residence time in the potential contamination zone. Consequently, health risks associated with ground water consumption will vary among members of this population. To adequately describe the range of potential risks to a potential future population ingesting water from the unconsolidated layer, naturally occurring variability in daily intake and body weight were incorporated in this assessment through probability distributions; these distributions were generated from the U.S. public health and census documents. All distributions were truncated at the upper and lower 0.01 percentile. Within the hypothetical population, values disallowed through this truncation may occur with a probability of less than 1 in 10,000.

All of the chemical contaminants of potential concern were evaluated for potential noncarcinogenic effects. In order to evaluate noncarcinogenic effects, exposure to contaminants was estimated as a chronic average daily intake on a body weight basis. Chronic daily intakes were calculated using the following equation:

$$\begin{array}{c}\text{Chronic}\\ \text{daily}\\ \text{intake}\\ \text{(mg/kg-day)}\end{array} = \frac{\begin{array}{c}\text{Water concentration}\\ \text{(mg/L)}\end{array} \times \begin{array}{c}\text{Ingestion rate}\\ \text{(L per day)}\end{array} \times \begin{array}{c}\text{Exposure duration}\\ \text{(years)}\end{array} \times \begin{array}{c}\text{Exposure frequency}\\ \text{(days per year)}\end{array}}{\begin{array}{c}\text{Averaging time}\\ \text{(days)}\end{array} \times \begin{array}{c}\text{Body weight}\\ \text{(kg)}\end{array}}$$

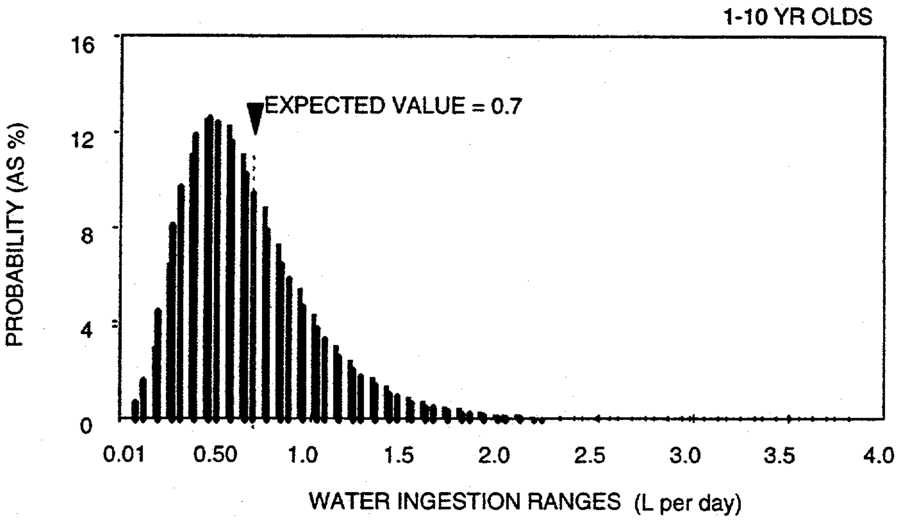
where mg/kg-day = milligrams per kilogram per day.

Potential carcinogenicity of radionuclides is thought to increase with total intake over time and, thus, is not averaged over a lifetime as for chemical carcinogens. Also, body weight is relatively insignificant in determining risk from exposure. Intake of a radionuclide is therefore quantified as total exposure to radioactivity throughout the residency period of an individual:

$$\begin{array}{c}\text{Lifetime intake}\\ \text{(pCi per lifetime)}\end{array} = \begin{array}{c}\text{Concentration}\\ \text{(pCi/L)}\end{array} \times \begin{array}{c}\text{Ingestion rate}\\ \text{(L per day)}\end{array} \times \begin{array}{c}\text{Exposure duration}\\ \text{(years)}\end{array} \times \begin{array}{c}\text{Exposure frequency}\\ \text{(days per year)}\end{array}$$

Average daily water intake (L per day)

Lognormal probability distributions were used to describe variations in average daily tap water intake among members of the population (Roseberry and Burmaster, 1992). These distributions were developed from data collected during the 1977-78 National Food Consumption Survey conducted by the U.S. Department of Agriculture. During the survey, total tap water consumption during a 3-day period was recorded for 26,081 survey participants nationwide (Figure 4.5).



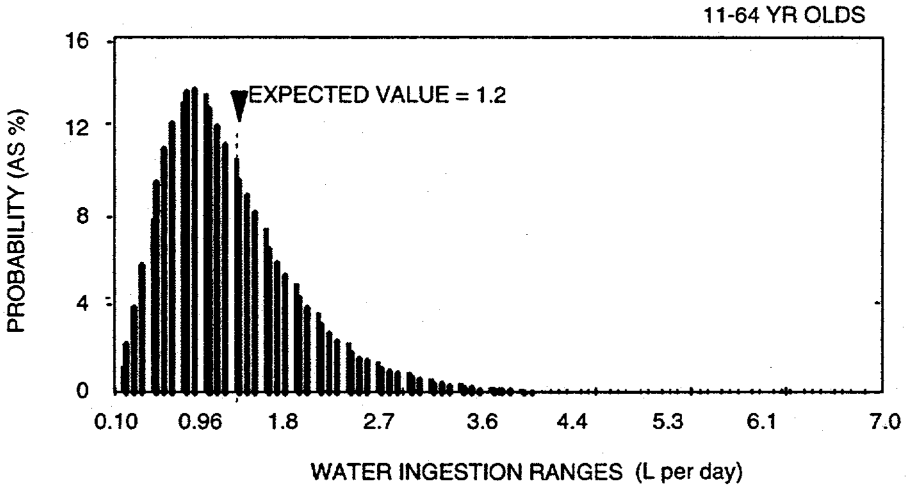


FIGURE 4.5
PROBABILITY DISTRIBUTIONS FOR TAP WATER INGESTION RATES

Exposure frequency (days per year)

An exposure frequency of 350 days per year was assumed for adults and children (EPA, 1991).

Exposure duration (years)

Children are the receptors of concern evaluated for the noncarcinogenic effects of the contaminants of concern. A 10-year exposure duration was assumed for 1- to 10-year-old children.

For carcinogens such as uranium and other radionuclides, risk is cumulative. For the evaluation of carcinogens, an exposure duration of 30 years was assumed, based on a national upper-bound time (90th percentile) spent at one residence (EPA, 1989a).

Body weight (kg)

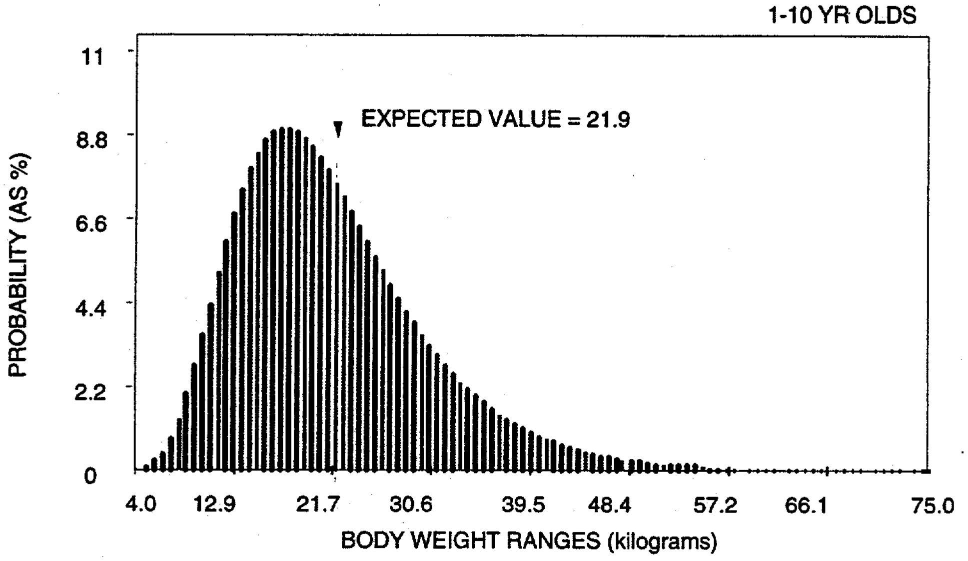
Between 1976 and 1980, the National Health and Nutrition Survey collected extensive national data on the weights of males and females by age. These data were used to develop lognormal probability distributions for body weight by age and by gender. The distributions for males and females were then combined using census data on the national ratio of males and females within each age group (Figure 4.6).

Averaging time (days)

When evaluating potential noncarcinogenic effects from longer-term exposures, intakes are averaged over the period of exposure. Thus, in evaluating the noncarcinogenic effects of the contaminants of concern, an averaging time of 3650 days (i.e., 10 years x 365 days) was used for children.

Intake distributions

Using the exposure concentration distributions discussed in Section 4.3 and the intake parameter distributions described in this section, total intake distributions were simulated for the receptor populations. The 1- to 10-year-old age group consistently showed the highest intake-to-body weight ratios and is therefore the most conservative age group to evaluate for noncarcinogenic risk. Figures 4.7 through 4.9 present simulated intake distributions for 1- to 10-year-old children for manganese, molybdenum, and uranium, respectively. Figure 4.10 shows the total lifetime intake estimate used to calculate carcinogenic risk for uranium.



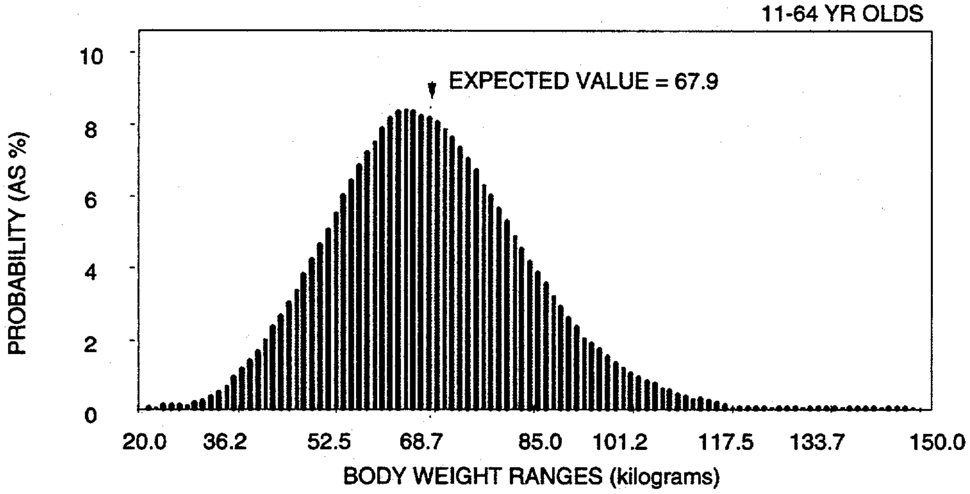


FIGURE 4.6
PROBABILITY DISTRIBUTIONS FOR BODY WEIGHT

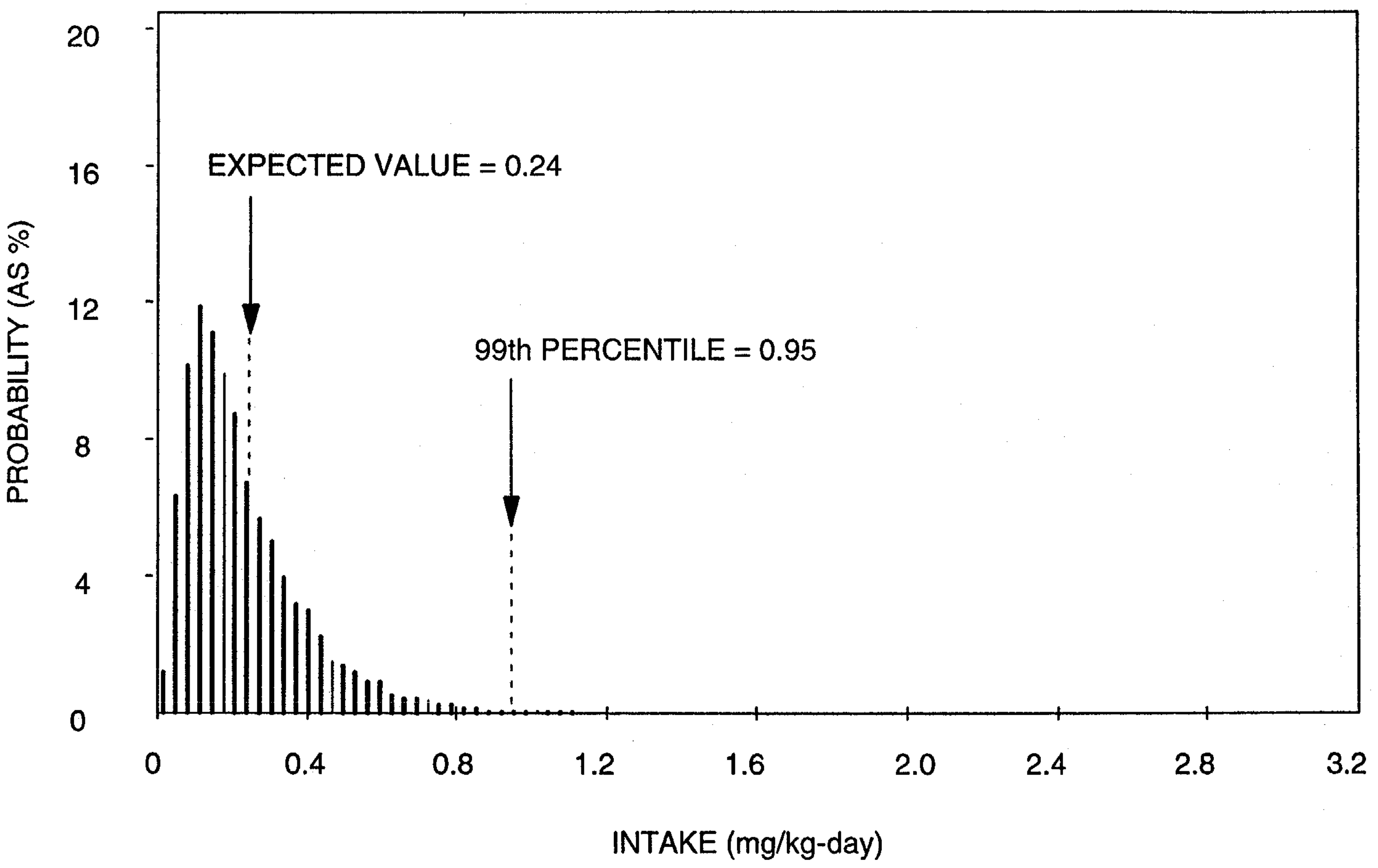


FIGURE 4.7
PROBABILITY DISTRIBUTION OF MANGANESE EXPOSURE TO CHILDREN BASED ON GROUND WATER INGESTION CANONSBURG, PENNSYLVANIA, SITE

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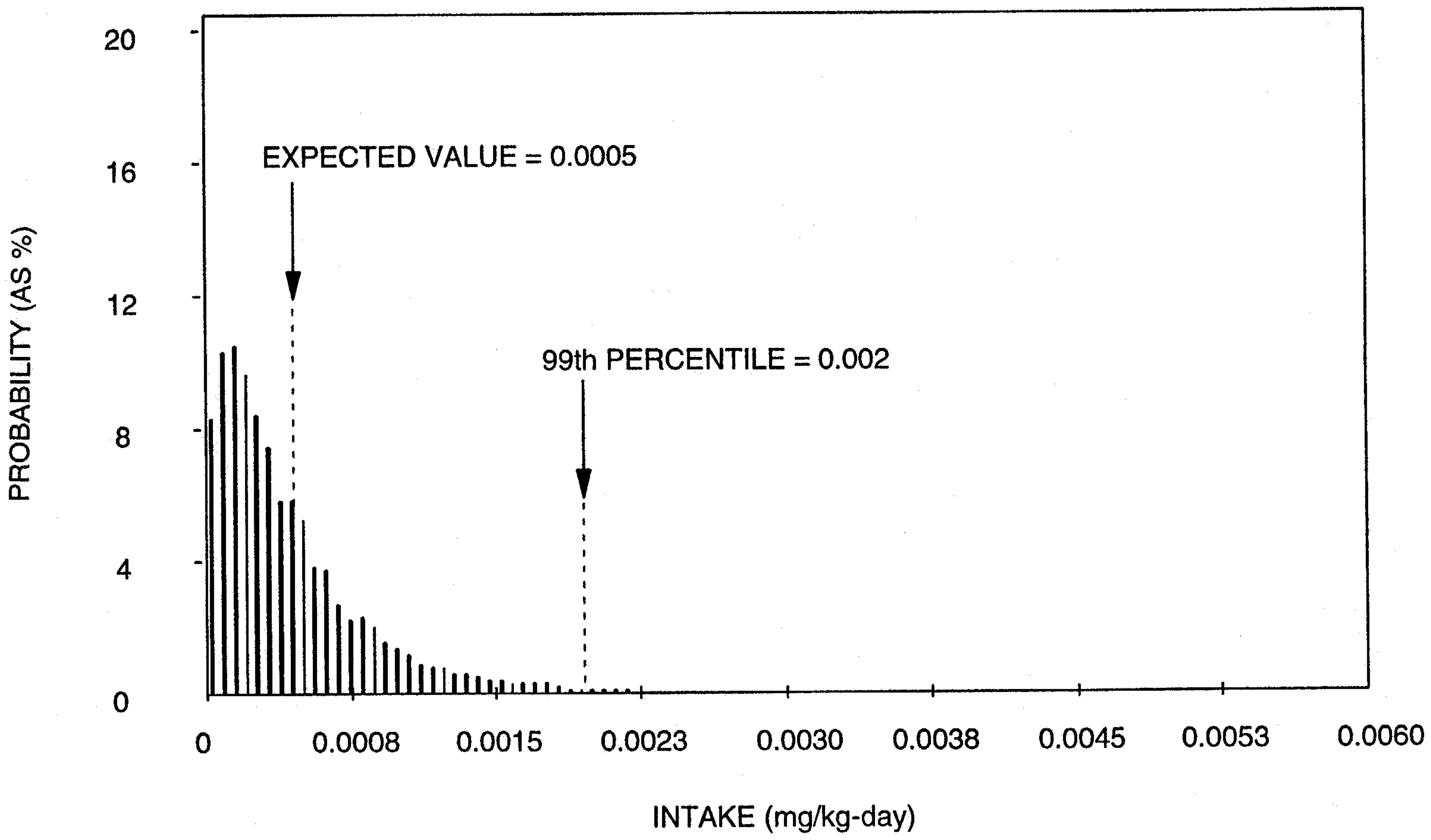

FIGURE 4.8
PROBABILITY DISTRIBUTION OF MOLYBDENUM EXPOSURE TO CHILDREN BASED ON GROUND WATER INGESTION CANONSBURG, PENNSYLVANIA, SITE

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MOLYEXP

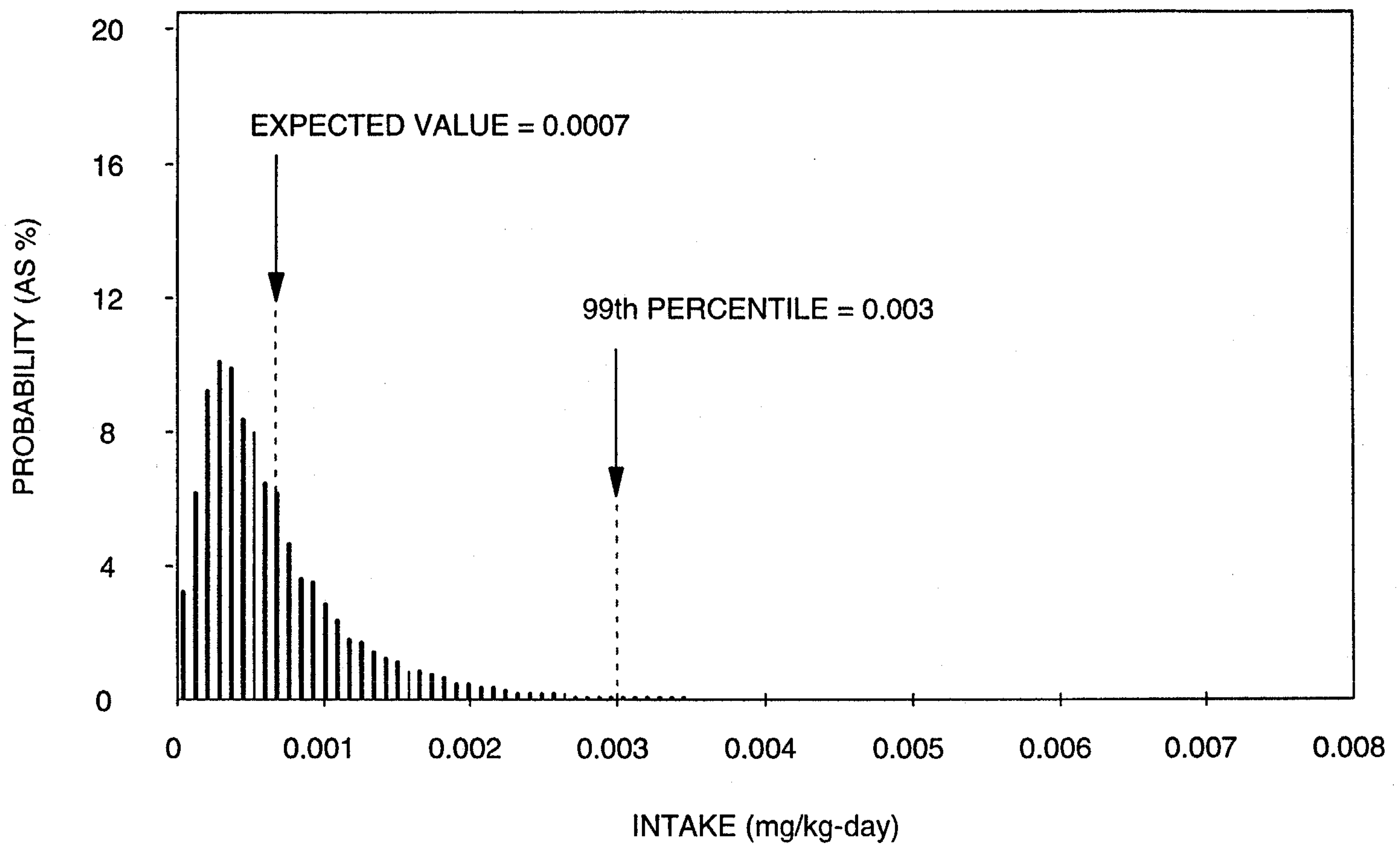

FIGURE 4.9
PROBABILITY DISTRIBUTION OF URANIUM EXPOSURE TO CHILDREN BASED ON GROUND WATER INGESTION
CANONSBURG, PENNSYLVANIA, SITE

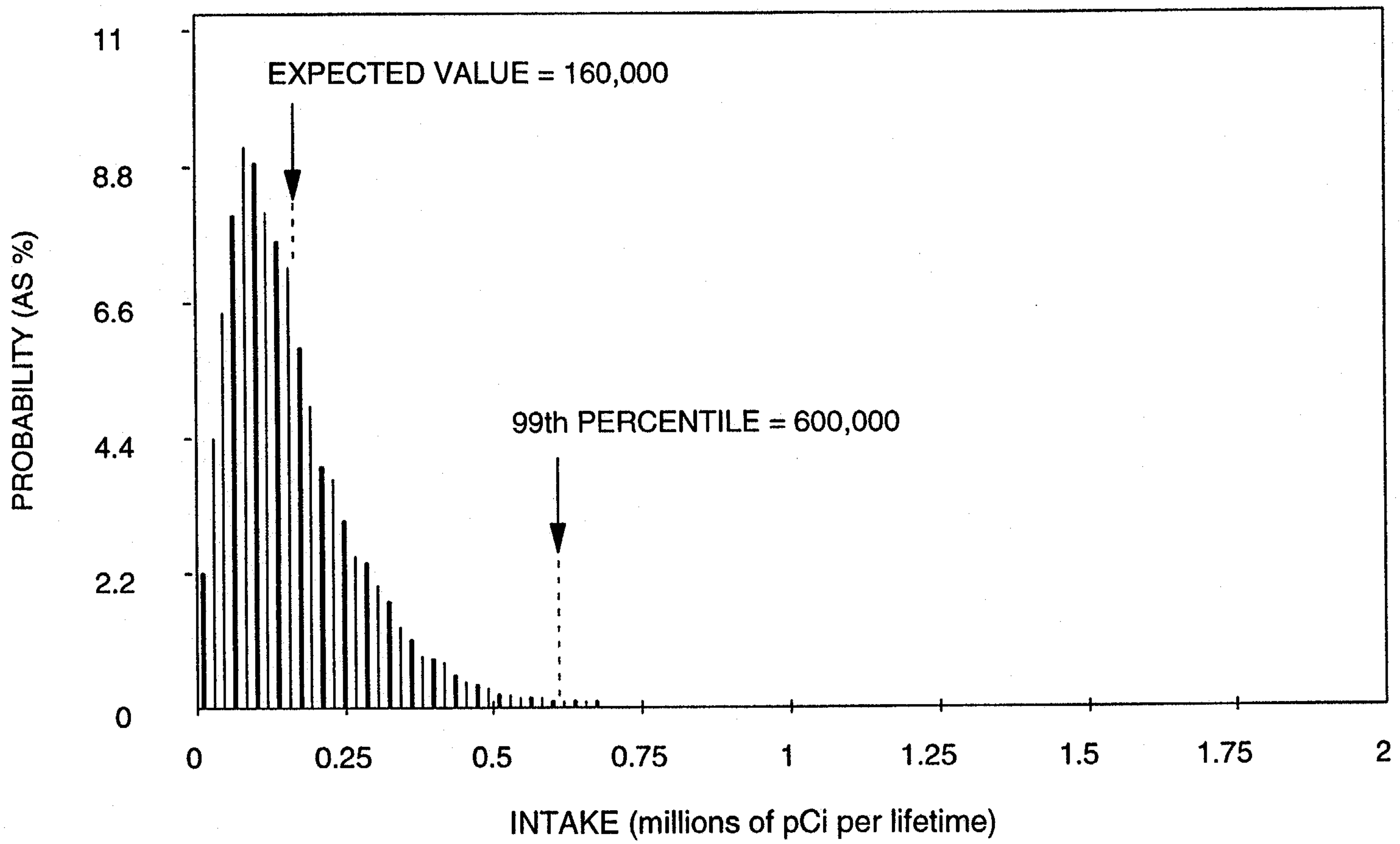

FIGURE 4.10
PROBABILITY DISTRIBUTION OF URANIUM EXPOSURE OVER A LIFETIME BASED ON GROUND WATER INGESTION
CANONSBURG, PENNSYLVANIA, SITE

4.5 EXPOSURE ASSESSMENT UNCERTAINTIES

A number of potential sources of uncertainty may arise in all phases of the exposure assessment, including the following more significant sources:

- Uncertainties resulting from a lack of thorough environmental sampling (ground water, surface water, and sediment) data, which could lead to an underestimation or overestimation in the exposure analysis.

- Uncertainties arising from the assumption that the ground water contaminant sources at the site have reached a steady state and that contaminant concentrations at the exposure point will remain constant for chronic periods of exposure (generally longer than 7 years). Because the major source of contamination at the Canonsburg site has been encapsulated on the site, the assumption of a constant source may lead to an overestimation of risk.

- Uncertainties associated with the use of filtered ground water samples. The results of exposure assessment presented in this document are based on filtered (0.45-micron) ground water samples. Therefore, the potential loss of certain ground water constituents as a consequence of filtration represents an additional source of uncertainty.

- Uncertainties associated with the incremental contribution from ingesting ground water-irrigated produce and wild fruit. The drinking water pathway is considered the major determinant of exposure in this risk assessment. The incremental contribution from the ground water-irrigated produce and wild fruit ingestion pathway could not be estimated here; however, the contribution could be significant.

- Uncertainties associated with the relationship of an applied dose (used here) and an absorbed or effective dose for dermal absorption.

- Uncertainties associated with the exclusion of organic contaminants from consideration as a source of potential exposure. This document evaluates exposures only to inorganic contaminants of ground water at the UMTRA Project site in Canonsburg. Potential organic contaminants related to uranium processing have not been considered.

- Uncertainties associated with differing sensitivities of subpopulations such as diabetics and the elderly.

Despite these uncertainties, using probability distributions that incorporate all definable sources of variability should provide a representative picture of the potential range of exposures.

5.0 TOXICITY ASSESSMENT

Several contaminants that could adversely affect human health and the environment have been detected in ground water at the Canonsburg site. This section summarizes the toxicological effects of the chemical contaminants and the carcinogenic potentials of the radionuclides.

The following source materials were used in developing these toxicological profiles, when available: EPA's Integrated Risk Information System (IRIS); the Agency for Toxic Substances and Disease Registry Toxicological Profiles published by the Department of Health and Human Services; the *Handbook on the Toxicology of Metals* (Friberg et al., 1986); and peer-reviewed scientific literature cited when these review documents were not available. By basing toxicity information on the standardized review documents cited above, the evaluation of risks at UMTRA Project sites should be consistent with evaluations at other sites.

The toxicity profiles presented here focus on drinking water source material in humans, whenever available, and include animal information only when human data are not available. Widely spaced dotted lines represent animal information on the toxicity range graphs. Where uncertainty exists regarding the beginning or end of a range of exposures that produces specific toxic effects, closely spaced dots are used at the appropriate end of the line that denotes range.

5.1 CONTAMINANT TOXICITY SUMMARIES

The following summaries address the basic toxicokinetics and toxicity of the contaminants of potential concern at the Canonsburg site based on the contaminant screening discussed in Section 3.3. The contaminants of potential concern are manganese, molybdenum, and uranium and its decay products (radium-226, lead-210, polonium-210, and thorium-230). Although these contaminants have a wide range of toxic effects depending on the exposure levels, the following discussions will focus on toxic effects observed in the exposure range most relevant to contamination at this site.

5.1.1 Manganese

<u>Absorption</u>

Following ingestion, manganese absorption is homeostatically controlled. The rate of absorption depends on both the amount ingested and tissue levels of manganese. In adult humans, approximately 3 to 4 percent of dietary manganese is absorbed (Saric, 1986). Manganese can be absorbed following exposure by inhalation, ingestion, and dermal contact. In humans, available data indicate that only 3 percent of an ingested dose of manganese chloride is absorbed (Mena et al., 1969). Iron and other metals influence the rate of absorption. In states of iron deficiency, manganese is actively absorbed from the intestine. Individuals with anemia can absorb more than twice the percentage of an ingested dose. However, in states of excess iron, absorption of manganese is by diffusion only (Saric, 1986). High levels of dietary calcium and phosphorus have been shown to increase the requirements for manganese in several species (Lönnerdal et al., 1987). Manganese in water appears to be more efficiently absorbed than manganese in foodstuff (EPA, 1994a).

Tissue accumulation and clearance

Manganese is widely distributed throughout the body, with the highest concentrations found in the liver, kidney and, to a lesser extent, the hair. The biological half-life in humans is 2 to 5 weeks, depending on body stores. Manganese readily crosses the blood-brain barrier and is cleared from the brain more slowly than from other tissues (Goyer, 1991). Although normal concentrations in the brain are low, manganese may accumulate under conditions of excessive absorption due to the longer half-life of manganese in the brain (National Research Council, 1973).

Absorbed manganese is rapidly cleared from the blood and concentrates in mitochondria. Initial concentrations are greatest in the liver. Manganese penetrates the placental barrier in all species and is more uniformly distributed throughout the fetus than in adult tissues. It is secreted into milk.

Absorbed manganese is almost totally secreted in bile and reabsorbed from the intestine as necessary to maintain body levels. Excess manganese is eliminated in the feces; urinary excretion is negligible (Goyer, 1991; Saric, 1986).

Environmental sources of manganese

Food constitutes the major source of manganese intake for humans. The highest manganese concentrations are found in plants, especially wheat and rice. Drinking water generally contains less than 0.1 mg/L. Manganese levels in soil range from 1 to 7000 mg/kg, with an average of 600 to 900 mg/kg. Mining and natural geological background variation can contribute to this variability. Manganese bioaccumulates in marine mollusks up to 12,000-fold, and there is evidence for toxic effects in plants (phytotoxicity) and plant bioaccumulation. The Illinois Institute for Environmental Quality recommends criteria of 1 to 2 mg/kg for manganese in soil and 200 mg/kg in plants (Saric, 1986).

Differences in nutritional habits can explain variations in manganese intake. The intake will be higher in populations with cereals and rice as main food sources than where meat and dairy products make up a larger part of the diet. The average daily intake is estimated to be between 2.0 and 8.8 mg per day (0.03 and 0.13 mg/kg-day) (EPA, 1994a), but intakes as high as 12.4 mg (about 0.2 mg/kg-day) have been reported in countries with high cereal intake (Saric, 1986).

Drinking water generally results in an intake of less than 0.2 mg (0.003 mg/kg-day), although some mineral waters can increase this amount more than threefold (Saric, 1986). One study from Greece reported drinking water concentrations of manganese in excess of 2 mg/L, which would result in daily intakes from 0.06 to 0.07 mg/kg-day (EPA, 1994a).

Manganese toxicity

Manganese is an essential nutrient. Estimated safe and adequate daily dietary intakes for adults range from 0.03 to 0.07 mg/kg-day (Saric, 1986). The EPA no-observed-adverse-effect level for drinking water is set at 0.005 mg/kg-day while the lowest-observed-adverse-effect level is 0.06 mg/kg-day. The EPA oral reference dose (RfD) for drinking water is 0.005 mg/kg-day, based on the endpoint of central nervous system effects. The oral RfD for food ingestion is 0.14 mg/kg-day, based on a level at which no adverse effects were observed. Manganese in drinking water appears to be potentially more bioavailable, i.e., more readily absorbed, than manganese in dietary food sources. This would result in toxic effects with lower ingested doses of manganese in drinking water than in food (EPA, 1994a).

Inhalation of manganese in industrial settings has provided the largest source of data on chronic manganese toxicity. These data indicate that excess manganese can result in a central nervous system disorder manifested by symptoms of irritability, difficulty in walking, speech disturbances, and compulsive behavior that may include running, fighting, and singing. With continued exposure, this condition can progress to a mask-like face, retropulsion or propulsion, and a Parkinson-like syndrome. These effects are largely irreversible, although some recovery may occur when exposure ceases (DHHS, 1992). Metal chelating agents are ineffective in treatment, but L-dopa has been effective (Goyer, 1991), suggesting that manganese produces a functional deficit in the central nervous system.

Limited information is available on the effects of manganese ingestion. Because effects from drinking water seem to differ from those from food sources, only water consumption studies will be considered here. A Japanese study of 25 people drinking well water with manganese concentrations of 14 mg/L (0.4 mg/kg-day estimated intake) reported symptoms of intoxication, including a mask-like face, muscle rigidity and tremors, and mental disturbances. Two cases (8 percent) of death were reported among intoxicated people. A Greek study of more than 4000 individuals drinking water with manganese concentrations varying from 0.081 to 2.3 mg/L (estimated intake at 2 L/day for a 70-kg individual range from 0.002 to 0.07 mg/kg-day) showed varying degrees of neurological effects in those drinking from 0.007 to 0.07 mg/kg-day, but no effects in those drinking less than 0.005 mg/kg-day (Kondakis et al., 1989).

The chemical form of manganese has complex effects on its toxicity. Although more soluble forms are more readily absorbed from the gastrointestinal tract, they also appear to be more rapidly cleared. Exposure to insoluble forms results in lower manganese absorption, but higher chronic tissue levels and therefore greater toxicity (EPA, 1994a). Limited information is available on the effects of various forms of manganese.

Few data are available on manganese toxicity in infants, but infants probably will be more susceptible to toxicity due to greater absorption and greater penetration into the central nervous system (EPA, 1994a; Saric, 1986).

Figure 5.1 summarizes manganese toxicity.

5.1.2 Molybdenum

Absorption

Absorption of molybdenum in the gastrointestinal tract depends on the species of the metal. Both inorganic and hexavalent forms such as molybdenum trioxide, sodium molybdate, and ammonium molybdate are readily absorbed from both food and water, unlike molybdenite. Human absorption rates of 40 to 70 percent have been observed for soluble forms of molybdenum (Tipton et al., 1969; Robinson et al., 1973; Alexander et al., 1974).

Tissue accumulation and clearance

In humans, the highest concentrations of molybdenum occur in the liver, kidneys, and adrenals (Casarett and Doull, 1991). With normal dietary intake, molybdenum levels in the body slowly increase until approximately age 20, when they begin to decline steadily. The principal route of excretion in humans is in the urine. Human studies indicate the biological half-life in humans is considerably longer than in animals and may be as long as 2 weeks (Rosoff and Spencer, 1964).

Environmental sources of molybdenum

The occurrence of natural molybdenum is in combination with other metals, including uranium, lead, iron, cobalt, and calcium. Native soil concentrations can vary by as much as 2 orders of magnitude, from 0.1 to 10 mg/kg, leading to large variations in the molybdenum concentrations in plant materials. Natural concentrations in ground water have been reported from 0.00011 to 0.0062 mg/L. Human dietary intake of molybdenum is estimated at 0.05 to 0.24 mg/day (0.0007 to 0.003 mg/kg-day). The contribution of drinking water is estimated to range from 0 to 95 percent. The nutritional range of intake for molybdenum is from 0.0015 to 0.0054 mg/kg-day. No symptoms of molybdenum deficiency have been reported in humans. Nonetheless, molybdenum is an essential trace element that functions as a necessary constituent of several enzymes, including xanthine oxidase (which is involved in the metabolism of uric acid) and nitrate reductase (Friberg et al., 1986).

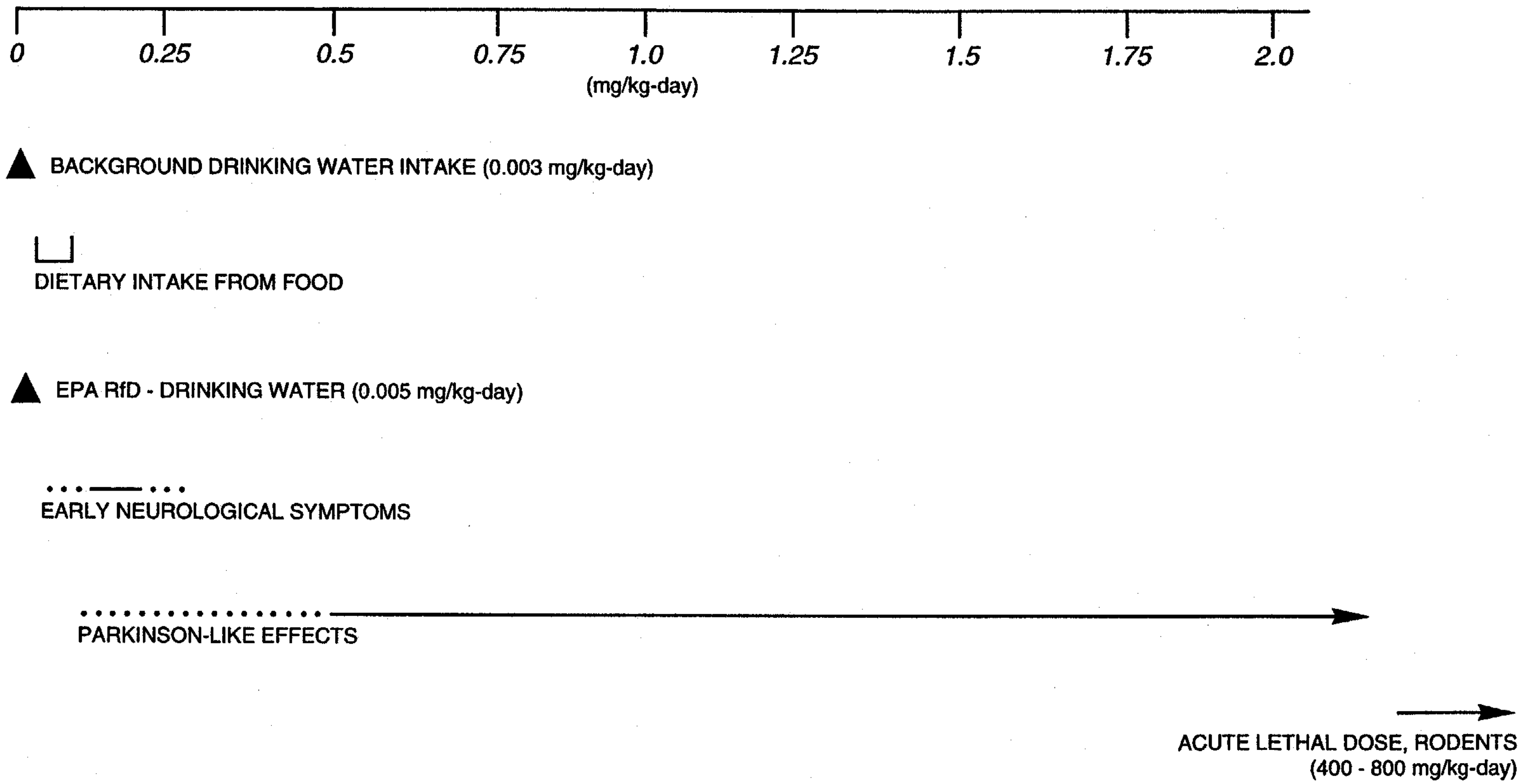

FIGURE 5.1
MANGANESE TOXICITY RANGES

Molybdenum toxicity

Acute effects of molybdenum have not been reported. No adverse health effects have been reported with chronic molybdenum intakes of less than 0.008 mg/kg-day. The primary toxicity of molybdenum is related to its interactions with copper and sulfur, leading to altered excretion patterns for these elements. Increased levels of molybdenum also increase the levels of xanthine oxidase, which is responsible for the production of uric acid. High levels of uric acid can accumulate in joints and lead to symptoms of gout and other joint disorders. The EPA oral RfD for molybdenum is 0.005 mg/kg-day, based on the endpoint of increased uric acid levels.

Intake of 0.008 to 0.022 mg/kg-day of molybdenum can produce mineral imbalance as a result of increased copper excretion. Excretion of copper is reported to double with molybdenum intakes at the upper end of this range. Copper is an essential nutrient important in many metabolic pathways, including the synthesis and function of hemoglobin. A copper deficiency resulting from excess excretion will impair the oxygen-carrying capacity of the blood, and severe copper deficiencies can lead to hypochromic microcytic anemia. In humans, gout-like symptoms and joint deformities have been reported in regions of Russia where elevated soil concentrations of molybdenum and subsequent increased molybdenum concentrations in food would lead to molybdenum intakes in the range of 0.14 to 0.21 mg/kg-day. Figure 5.2 summarizes the health effects of molybdenum as a function of dose.

5.1.3 Uranium

Naturally occurring uranium, present at UMTRA Project sites, consists of three radioactive isotopes: uranium-234, uranium-235, and uranium-238. More than 99 percent of natural uranium occurs in the form of uranium-238 (Cothern and Lappenbusch, 1983). Uranium-238 undergoes radioactive decay by emitting alpha particles to form uranium-234, thorium-230, radium-226, radon 222, polonium-210, and other radioisotopes. Figure 5.3 summarizes the radioactive decay chain of uranium-238 and uranium-234. Because all uranium isotopes in nature are radioactive, the hazards of a high uranium intake are from both its chemical toxicity and potential radiological damage. This section focuses on the chemical toxicity of natural uranium. Section 5.3 discusses the carcinogenic potential associated with exposure to radioactive isotopes of natural uranium.

Absorption

Absorption of uranium in the gastrointestinal tract depends on the solubility of the uranium compounds. The hexavalent uranium compounds, especially the uranyl salts, are water soluble, while tetravalent compounds generally are not (Weigel, 1983). Even with soluble compounds, only a small fraction is absorbed. Human gastrointestinal absorption rates of 0.76 to 7.8 percent have been determined (Wrenn et al., 1985).

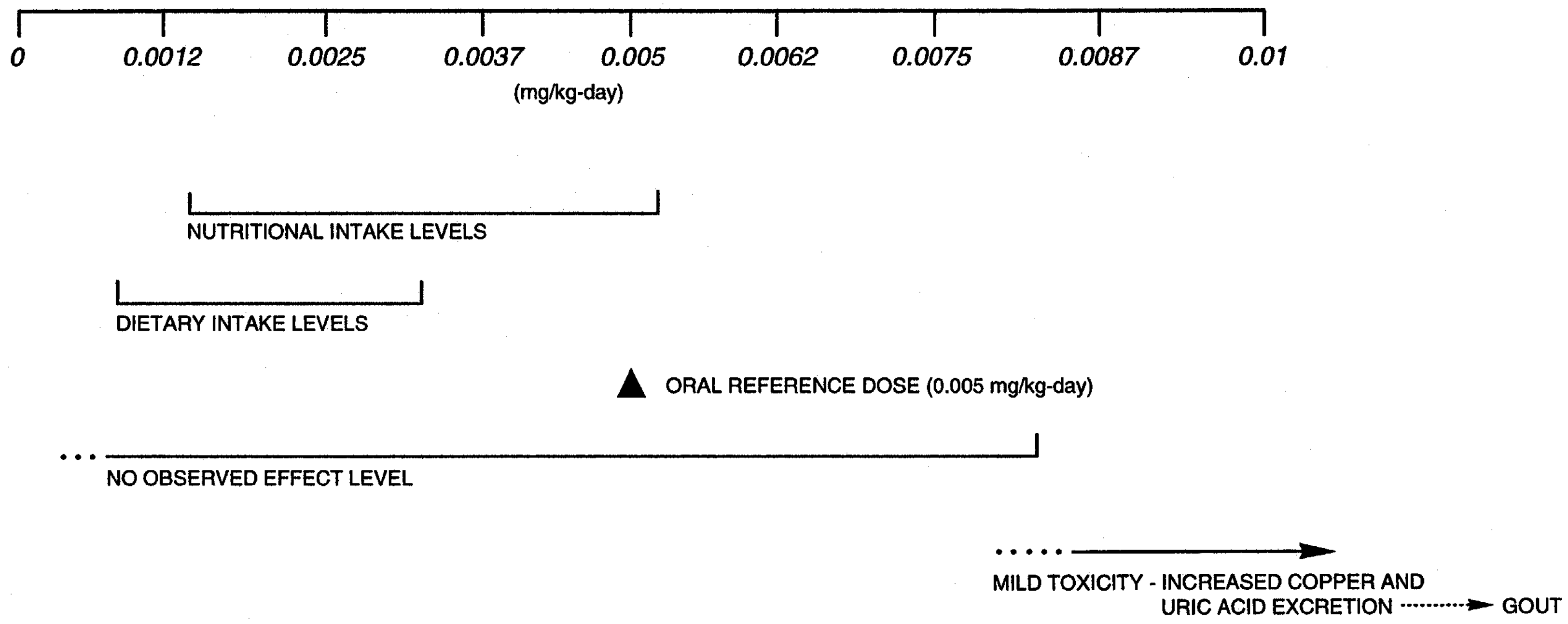

FIGURE 5.2
MOLYBDENUM TOXICITY RANGES

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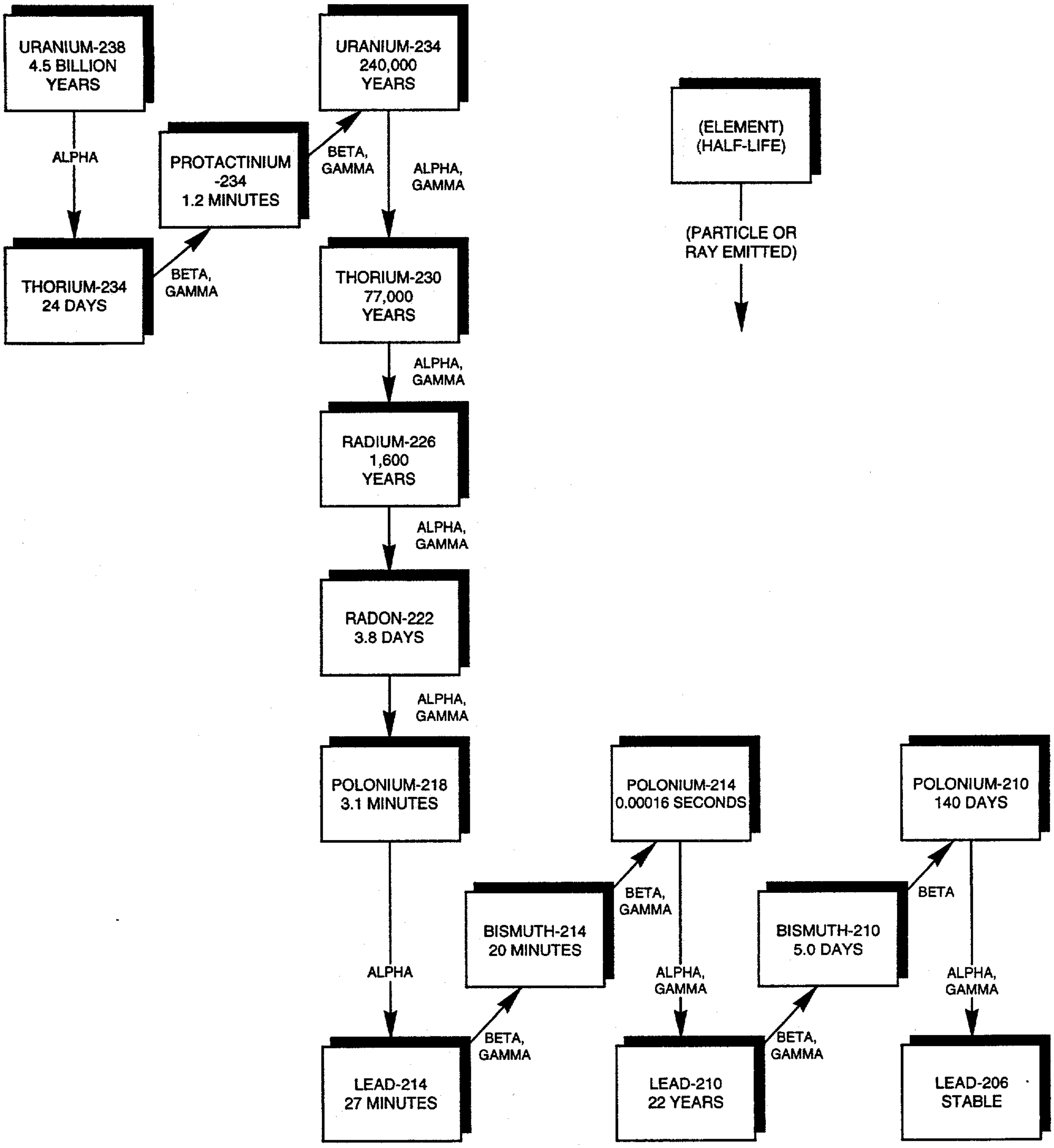


FIGURE 5.3
HALF-LIVES AND EMISSIONS FROM DECAY CHAIN OF URANIUM-238

MAC: SITE/CAN/BRA/HALFLIVES

Tissue accumulation and clearance

In humans exposed to background levels of uranium, the highest uranium concentrations were found in the bone, muscle, lung, liver, and kidney (Fisenne et al., 1988). Uranium retention in bone consists of a short retention half-life of 20 days, followed by a long-retention half-life of 5000 days for the remainder (Tracy et al., 1992).

In body fluids, uranium tends to be converted into water-soluble hexavalent uranium (Berlin and Rudell, 1986). Approximately 60 percent of the uranium in plasma complexes with low-molecular-weight anions (e.g., bicarbonates and citrates), while the remaining 40 percent binds to the plasma protein transferrin (Stevens et al., 1980). Following oral exposure in humans, more than 90 percent of uranium is excreted in the feces and not absorbed in the gastrointestinal tract. Of the small percentage absorbed (typically less than 5 percent), approximately 60 percent is excreted in the urine within 24 hours and 98 percent is excreted within 7 days, based on animal studies (Ballou et al., 1986; Leach et al., 1984; Sullivan et al., 1986). A small portion of the absorbed uranium is retained for a longer period.

Environmental sources of uranium

Uranium is a ubiquitous element, present in the earth's crust at approximately 4 parts per million. Uranium concentrations in ground water and surface water averaged 1 pCi/L and 3 pCi/L, respectively (NCRP, 1984). It is absorbed from the soil into plant tissues to an extent depending on the plant species and the depth of its root system (Berlin and Rudell, 1986). Plant concentrations of uranium averaged 0.075 micrograms per kilogram (μg/kg) of fresh plant material in one study (Tracy et al., 1983).

The main dietary source of natural uranium for the general population is from food products such as potatoes, grains, meat, and fresh fish, which may contain uranium concentrations between 10 and 100 μg/kg (Prister, 1969). The total dietary uranium intake from consuming average foods is approximately 1 μg per day, approximately 20 to 50 percent of which can come from drinking water. Cereals and vegetables, particularly root crops, probably contribute most to the daily uranium intake (Berlin and Rudell, 1986).

Uranium toxicity

Exposure of the general public to natural uranium is unlikely to pose an immediate lethal threat to humans. No human deaths definitely attributable to uranium ingestion, have been reported; therefore, no lethal dose has been determined for humans. A uranium dose as low as 14 mg/kg-day resulted in the death of 50 percent of exposed laboratory animals following 23-day oral exposures ($LD_{50,23}$). The level of $LD_{50,23}$ depends on the solubility of the uranium compound tested (higher solubility compounds have greater toxicity), route of exposure, and animal species. High doses of uranium cause complete kidney and respiratory failure. The EPA oral RfD for uranium is 0.003 mg/kg-day, based on the endpoints of moderate nephrotoxicity and initial body weight loss.

No chronic toxic effects have been reported in humans following oral exposure to uranium. Data available from populations occupationally exposed to high concentrations of uranium compounds through inhalation and information from studies in experimental animals indicate that the critical organ for chronic uranium toxicity is the kidney, specifically, the proximal tubule (Friberg et al., 1986). In humans, chemical injury reveals itself through increased catalase excretion in urine and proteinuria. Dose-response data for the toxic effect of uranium on the human kidney are limited.

The lowest dose of uranyl nitrate to cause moderate renal damage was given to rabbits in diet at 2.8 mg/kg-day (Maynard and Hodge, 1949). Figure 5.4 summarizes the health effects of uranium as a function of dose.

5.2 CONTAMINANT INTERACTIONS

Some information is available on potential interactions among contaminants found at UMTRA sites. However, discussions of potential interactions can generally be presented only qualitatively. In addition to physiological variables among individuals that can affect toxicity, uncertainties in interactions can also result from 1) differences in the relative exposure concentrations of the different contaminants compared with the concentrations tested experimentally and 2) the presence of additional ground water constituents in sufficient quantities to modify predicted toxicities even though the constituents themselves are not considered contaminants of concern for human health. Therefore, the interactions described below should be recognized as factors that can influence predicted toxicity, although the precise nature and magnitude of that influence cannot be determined.

Iron and other metals influence the rate of manganese absorption. In states of iron deficiency, manganese is actively absorbed from the intestine. In states of excess iron, manganese absorption is by diffusion only (Saric, 1986). Because iron levels in ground water at the site are at naturally high levels, the amount of manganese absorbed by a receptor ingesting ground water at the site may be reduced. This, in turn, may reduce the potential for toxic effects to occur from manganese ingestion. Furthermore, high levels of dietary calcium and phosphorus increase the requirements for manganese in several species (Lönnerdal et al., 1987). Thus, intake of these elements may alter the potential for absorption and potential toxicity of manganese.

The primary toxicity of molybdenum is related to its interactions with copper and sulfur, leading to altered excretion patterns for these elements. Ruminants seem to be the most susceptible species to imbalances among these elements. In ruminants, copper has been shown to prevent the accumulation of molybdenum in the liver and may antagonize molybdenum absorption.

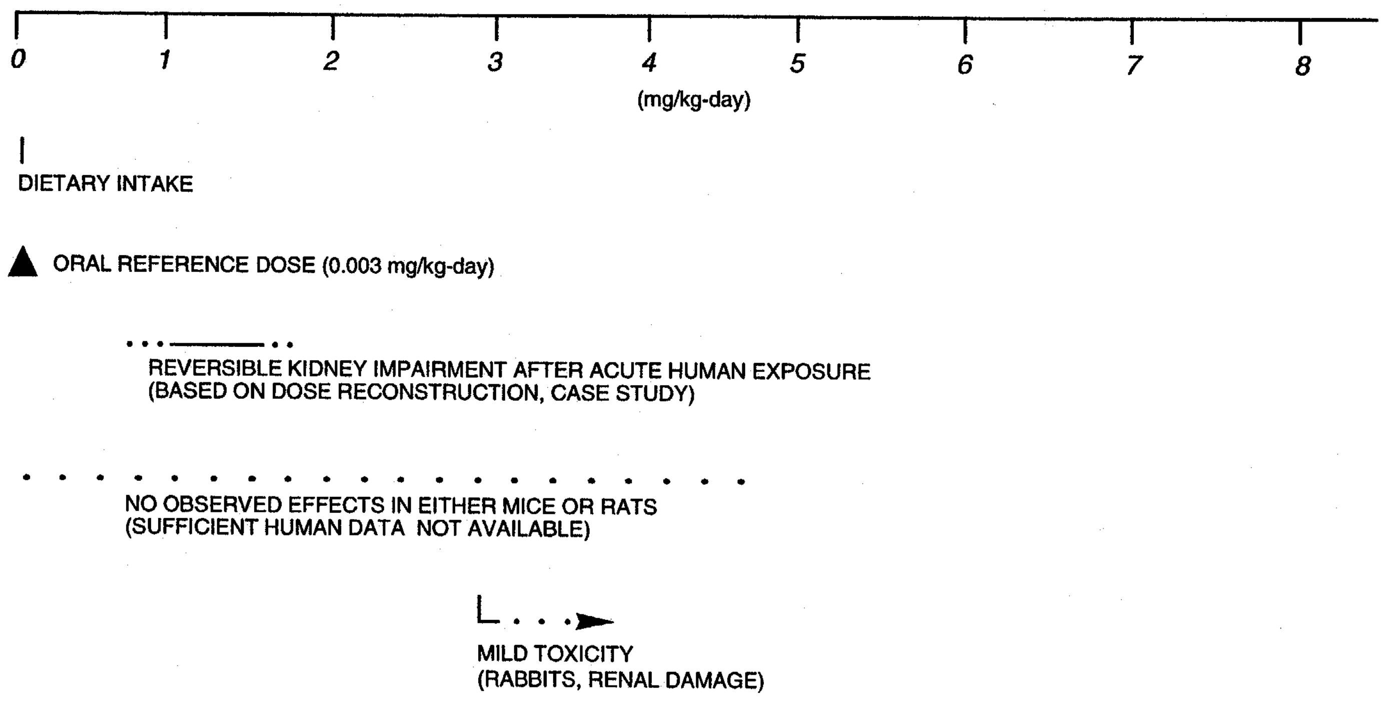


FIGURE 5.4
URANIUM TOXICITY RANGES

Molybdenum can produce a functional copper deficiency, but only in the presence of sulfate. It has been suggested that sulfur can displace molybdate in the body (Casarett and Doull, 1991). In laboratory animal studies, molybdenum toxicity is more pronounced in situations where dietary copper intake is low (EPA, 1994a). In ruminants, both copper and sulfates can protect against molybdenum toxicity, and molybdenum and sulfur can block copper toxicity.

No information was available on uranium interactions with other metals.

5.3 CONTAMINANT RISK FACTORS

The EPA Office of Research and Development has calculated acceptable intake values, or RfDs, for long-term (chronic) exposure to noncarcinogens. These values are estimates of route-specific exposure levels not expected to cause adverse effects when exposure occurs for a significant portion of the lifetime. The RfDs include safety factors to account for uncertainties associated with limitations of the toxicological data base, including extrapolating animal studies to humans and accounting for variability in response from sensitive individuals. These values, updated quarterly, are published in the Health Effects Assessment Summary Tables (HEAST). They are also provided through the EPA's IRIS data base. Table 5.1 summarizes the most recent oral RfDs for the noncarcinogenic contaminants of concern.

The EPA currently classifies all radionuclides as Group A, or known human carcinogens, based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancer in humans. Risk factors are published in HEAST and IRIS for correlating the intake of carcinogens over a lifetime with the increased excess cancer risk from that exposure. Table 5.2 provides the most recent cancer slope factors for the uranium-234/-238 radioactive decay series.

Table 5.1 Toxicity values: potential noncarcinogenic effects

Chemical	Chronic oral RfD (mg/kg-day)	Confidence level	Critical effect/organ	RfD basis/RfD source	Uncertainty factor
Manganese	0.005	NA	Central nervous system	Water/IRIS[a]	1
Molybdenum	0.005	Medium	Increased uric acid levels in the blood	Diet/IRIS[a]	30
Uranium (soluble salts)	0.003	Medium	Decreased body weight, kidney	Diet/IRIS[a]	1000

[a] EPA, 1994a.

NA - not applicable.

Table 5.2 Toxicity values: potential carcinogenic effects

Parameter	Oral slope factor $(pCi)^{-1}$, $(mg/kg\text{-}day)^{-1}$	Weight of evidence classification	Type of cancer	Slope factor basis/slope factor source
Lead-210	5.1E-10	A	Bone	Water/HEAST[a]
Polonium-210	1.5E-10	A	Liver, kidney, spleen	Water/HEAST[a]
Radium-226	1.2E-10	A	Bone	Water/HEAST[a]
Thorium-230	1.3E-11	A	Bone	Water/HEAST[a]
Uranium-238	1.6E-11	A	Note[b]	Water/HEAST[a]
Uranium-234	1.6E-11	A	Note[b]	Water/HEAST[a]

[a] EPA, 1994b.
[b] No human or animal studies have shown a definite association between oral exposure to uranium and development of cancer.

A - human carcinogen.

6.0 HUMAN HEALTH RISK EVALUATION

To evaluate human health risks to an individual or population, the results of the exposure assessment and toxicity assessment are combined. As discussed in Section 5.0, potential adverse health effects are a function of how much of the contaminant an individual takes into his or her body. At lower levels, many of the contaminants associated with the mill tailings are essential nutrients that are beneficial to health. At higher levels, these same elements can cause adverse health effects.

In this section, expected intake ranges for potential ground water ingestion from the unconsolidated material is correlated to potential health effects.

6.1 POTENTIAL NONCARCINOGENIC HEALTH EFFECTS

6.1.1 Ground water

The potential for noncarcinogenic health effects was evaluated for the 1- to 10-year-old child. Children were evaluated for noncarcinogenic effects because they have a higher intake-to-body weight ratio than adults and, thus, would be expected to receive a larger daily dose than adults. Potential noncarcinogenic effects were assessed for the following chemical contaminants of potential concern: manganese, molybdenum, and uranium.

As shown in Figure 6.1, potential adverse health effects may result from manganese intake if ground water from the unconsolidated material in Area C is used for drinking. More than 99 percent of the exposure distribution falls above the EPA oral RfD derived from drinking water consumption studies and above the threshold of mild neurological symptoms in adults. In addition, approximately 15 percent of the intakes exceeded 0.4 mg/kg-day, which is an estimated drinking water intake associated with symptoms of intoxication, including a mask-like face, muscle rigidity and tremors, and mental disturbances. Two cases of death were reported in the literature among the individuals ingesting manganese at this level. For comparison purposes, child exposure to manganese was calculated using the maximum detected value (4.05 mg/L) in background well 410. As shown in Figure 6.1, the estimated average exposure dose is 0.12 mg/kg-day, which falls within the range of early neurological symptoms. This estimate, however, is based on a maximum detection from only one upgradient well and may not be representative of long-term background conditions.

Molybdenum levels in ground water from the unconsolidated material in Area C are not expected to result in any adverse health effects, as shown in Figure 6.2. All estimated intake levels fall within nutritional or dietary intake levels. The estimated intakes are also well below the EPA oral RfD.

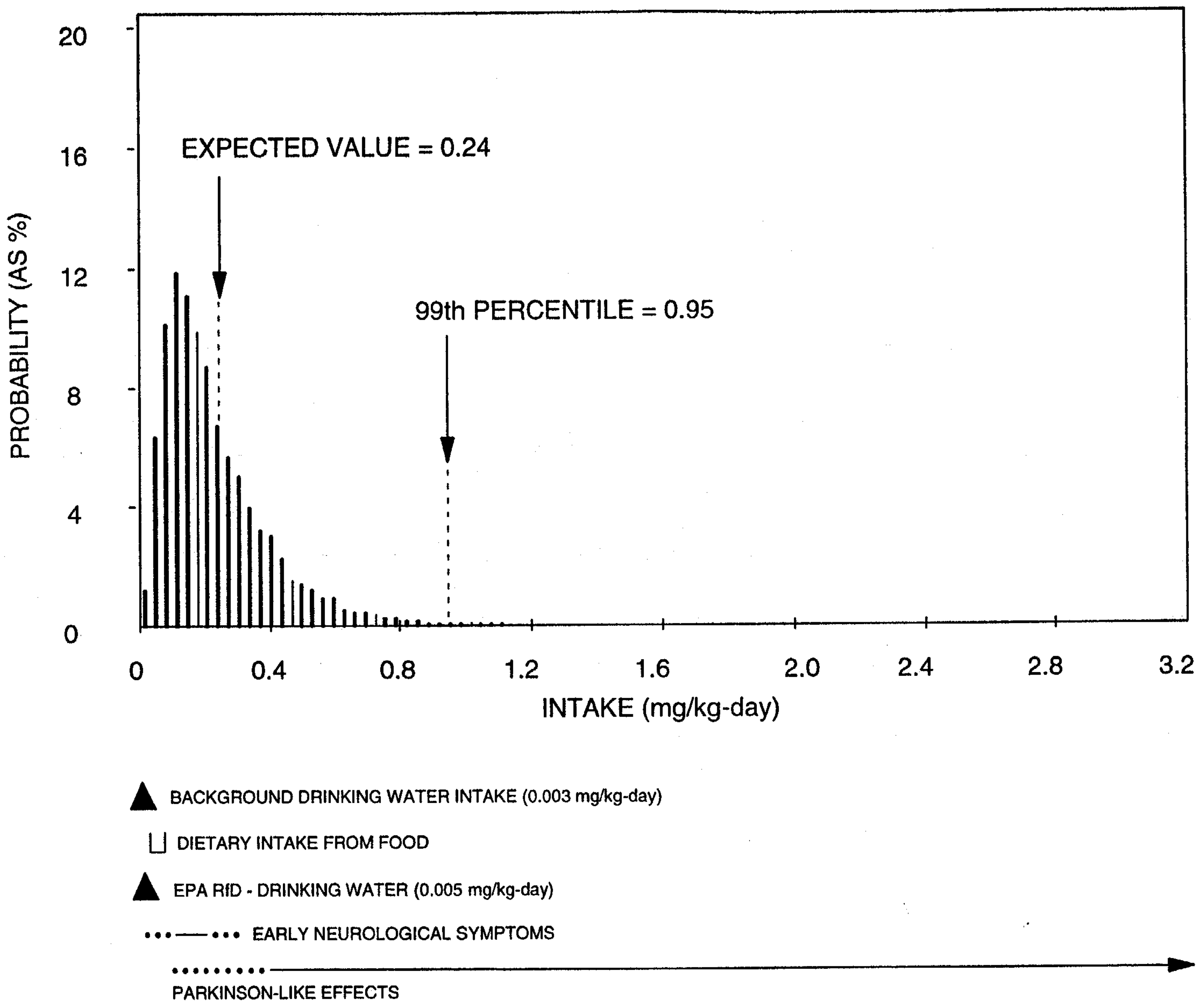


FIGURE 6.1
HEALTH EFFECTS OF POTENTIAL MANGANESE EXPOSURE RANGES TO CHILDREN CANONSBURG, PENNSYLVANIA, SITE

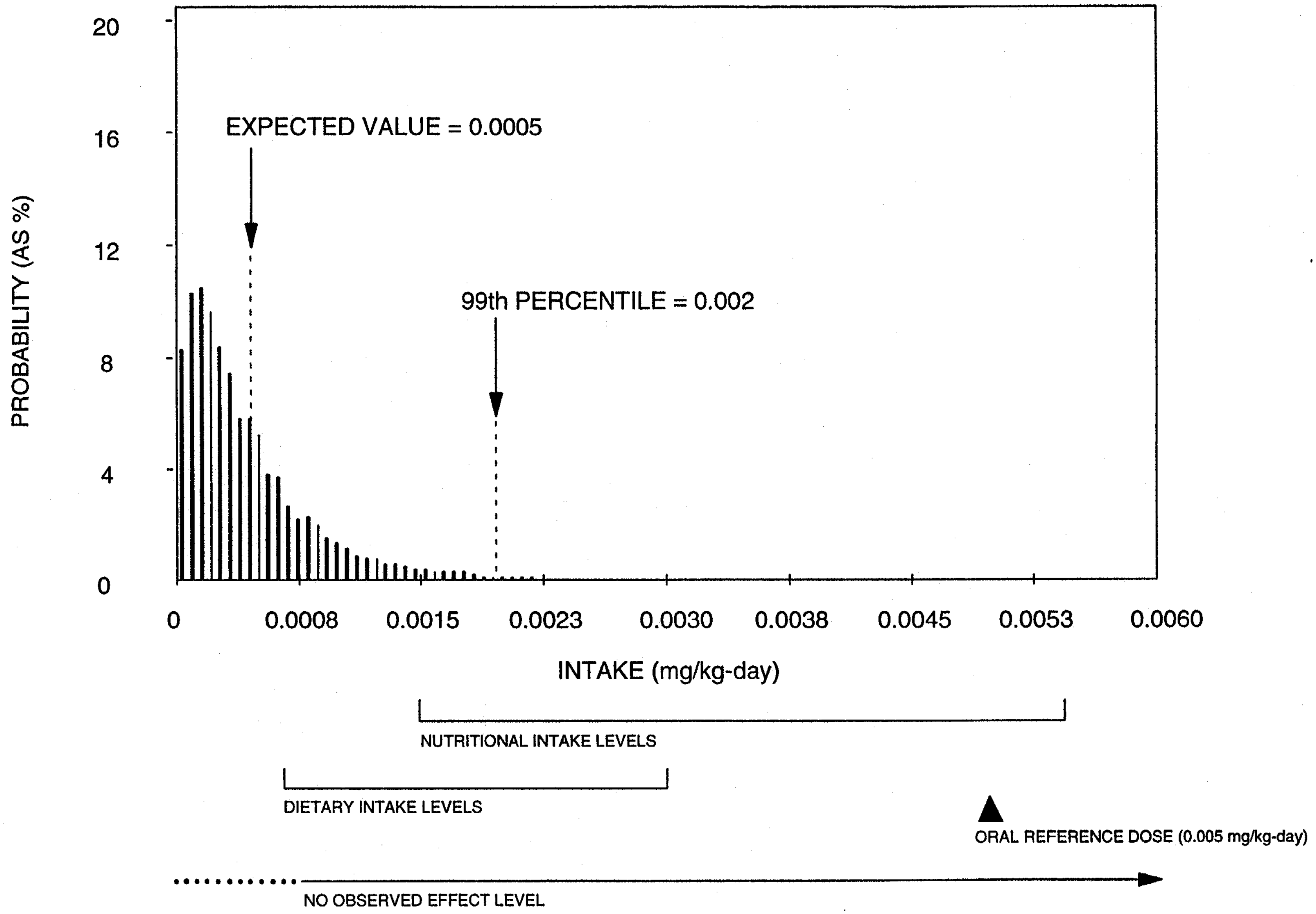


FIGURE 6.2
HEALTH EFFECTS OF POTENTIAL MOLYBDENUM EXPOSURE RANGES TO CHILDREN
CANONSBURG, PENNSYLVANIA, SITE

As shown in Figure 6.3, only 1 percent of the exposure range for uranium exceeds the EPA oral RfD. The estimated intakes for uranium fall well below any toxic effects observed in humans or in animal studies.

6.1.2 Surface water/sediment

Potential noncarcinogenic health effects were evaluated for 6- to 12-year-old children who may be exposed to contaminants while playing in Chartiers Creek. Doses were estimated in Section 4.0 for incidental surface water ingestion, dermal contact with surface water, and incidental sediment ingestion. Doses were also estimated for adults who may ingest fish caught from Chartiers Creek. These doses are presented again in Table 6.1 comparison with relevant toxicity data from Section 5.0. As seen in Table 6.1, the estimated doses for a child playing in the creek are at levels that would not be expected to result in adverse effects. All doses for the child fall below the EPA oral RfD and are below dietary and nutritional intake levels. Although the estimated manganese dose for adults from fish ingestion slightly exceeds the EPA oral RfD, it falls below the dietary intake levels and is below the levels at which adverse health effects have been observed.

6.2 POTENTIAL CARCINOGENIC HEALTH EFFECTS

6.2.1 Ground water

The contaminants considered for potential carcinogenic risk include uranium as well as all uranium isotopes. These constituents are radioactive and, as such, are considered potential carcinogens. Figure 6.4 shows the exposure distribution for uranium-234 and uranium-238 ground water exposure doses and their potential lifetime carcinogenic risks. Although natural uranium has not been demonstrated to cause cancer in humans or animals following ingestion exposures, these estimates of excess lifetime cancer risk are based on the cancer slope factor developed by the EPA. The majority of the exposure distribution for ground water ingestion of uranium falls within the range of 1 in a million (1E-06) to 1 in 100,000 (1E-05). This falls within the National Contingency Plan (NCP) guidance for acceptable risk of 1 in a million (1E-06) to 1 in 10,000 (1E-04). The expected exposure dose results in an excess lifetime cancer risk of 2.6 in a million, and the upper 99th percentile exposure is expected to result in an excess lifetime cancer risk of 9.6 in a million. The distribution presented here is considered conservative because it is based on a cumulative 30-year exposure duration. As discussed previously, this exposure duration is probably appropriate, but ground water uranium concentrations resulting from processing at this site are expected to decline after the tailings are stabilized. Therefore, this distribution may overestimate risk.

Uranium is the only radionuclide statistically above background in the unconsolidated material ground water at the Canonsburg site. However, because uranium decays to radioactive progeny, longer-lived radioactive progeny of the uranium decay series were evaluated for carcinogenic risk. Thus, the

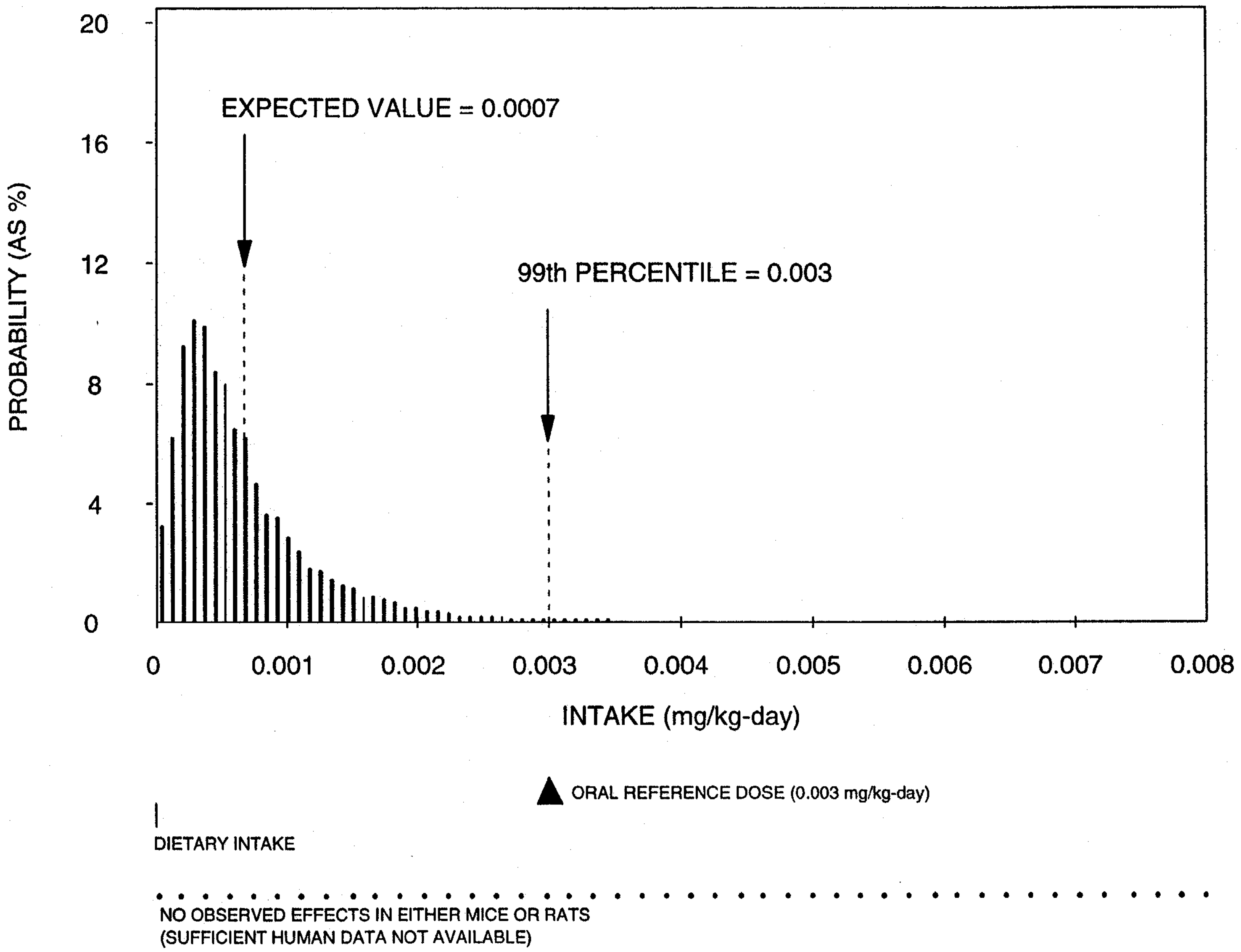


FIGURE 6.3
HEALTH EFFECTS OF POTENTIAL URANIUM EXPOSURE RANGES TO CHILDREN CANONSBURG, PENNSYLVANIA, SITE

Table 6.1 Estimated doses and toxicity values for the surface water and sediment exposure routes in Chartiers Creek, Canonsburg, Pennsylvania, site

	Exposure doses (mg/kg-day)				Toxicity values (mg/kg-day)	
Contaminant of potential concern	Surface water ingestion	Dermal contact with surface water	Sediment ingestion	Fish ingestion	EPA oral RfD	Dietary intake level
Noncarcinogenic effects						
Manganese	0.00005	0.00001	0.002	0.009	0.005	0.03-0.07
Molybdenum	0.00005	0.00001	0.00006	NC	0.005	0.0007-0.003
Uranium	NA	NA	0.000002	NA	0.003	0.000014
Carcinogenic effects (pCi per lifetime)						
Uranium	NA	NA	112	NA	NA	NA

NA - not applicable.
NC - could not be calculated.

carcinogenic risk of radium-226, lead-210, polonium-210, and thorium-230 were evaluated, based on ground water ingestion from the unconsolidated material in Area C. As shown in Table 6.2, the estimated carcinogenic risks from these radionuclides is 5E-05. This risk level falls within the 1E-06 to 1E-04 range, as presented in the NCP for Superfund sites. If the cancer risk estimated for these radionuclides is added to the range of carcinogenic risk estimated for uranium, the total carcinogenic risk ranges from 1E-05 to 2E-05, which also falls within the NCP risk range.

6.2.2 Surface water/sediment

Potential carcinogenic risk was evaluated for a 6- to 12-year-old child exposed to chemicals in Chartiers Creek. Uranium is the only carcinogenic contaminant for which data are available in surface water and sediment and was detected only in sediment. As shown in Table 6.1, the estimated lifetime dose of uranium based on the incidental ingestion of sediment is 112 pCi. Using an oral cancer slope factor of 1.6E-11 for uranium, an estimated lifetime cancer risk of 2E-09 was calculated based on this dose. This carcinogenic risk level falls well below 1E-06, which is the lower end of the acceptable risk range presented in the NCP.

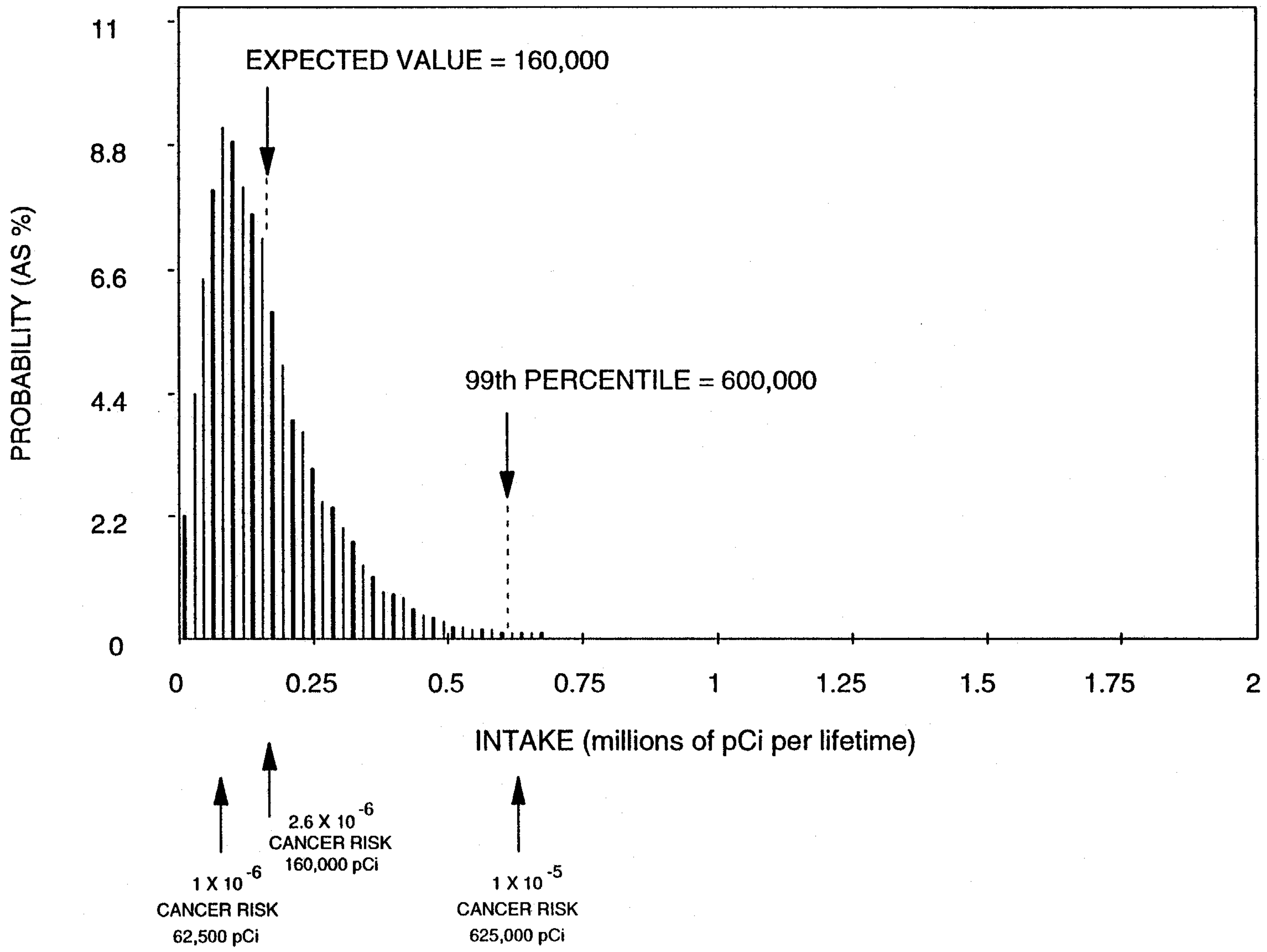


FIGURE 6.4
EXCESS LIFETIME CANCER RISK FROM POTENTIAL URANIUM -234/238 EXPOSURE RANGES
CANONSBURG, PENNSYLVANIA, SITE

Table 6.2 Carcinogenic risk for the unconsolidated layer ground water ingestion route at the Canonsburg, Pennsylvania, site

Contaminant of potential concern	Exposure point concentration (pCi/L)	Intake (pCi per lifetime)	Oral slope factor $(pCi)^{-1}$	Lifetime risk
Radionuclides				
Lead-210	5.0[a]	105,000	5.1E-10	5E-05
Polonium-210	0.2[a]	4,200	1.5E-10	6E-07
Radium-226	0.7[b]	14,700	1.2E-10	2E-06
Thorium-230	0.7[a]	14,700	1.3E-11	2E-07
			Total:	5E-05

[a] Maximum observed concentration in filtered or unfiltered water samples, 1986-1993.
[b] Maximum observed concentration in filtered or unfiltered water samples, 1988-1993.

6.3 LIMITATIONS OF THE HUMAN HEALTH RISK EVALUATION

The following potential limitations apply to the interpretation of this human health risk evaluation:

- Subpopulations with increased sensitivity are not specifically addressed on the graphs.
- Some individuals may be more sensitive to the toxic effects of certain constituents for undetermined reasons.
- Data available to interpret potential adverse health effects may not always be sufficient to allow accurate determination of all health effects due to lack of testing in humans or testing of dose ranges other than those expected at the site.
- Although ground water contaminant movement has been evaluated hydrologically and geochemically, the monitoring locations sampled may not include the most contaminated areas.
- The results of risk evaluation presented in this document are based on filtered (0.45-micron) ground water samples. Therefore, the potential loss of certain ground water constituents as a consequence of filtration represents a source of uncertainty.
- Only the drinking water exposure pathway has been considered in depth, although other pathways have been screened to determine their relative contribution. However, the incremental or independent contribution from

the ground water-irrigated produce and wild fruit ingestion pathway, which could not be estimated here, could be significant.

- This risk assessment evaluates only risks related to inorganic ground water contamination. Potential contamination from any of the organic constituents that might be used in uranium processing has not been addressed.

The evaluation presented here has considered these limitations and compensated whenever possible by presenting toxicity ranges and probabilistic exposure assessments rather than point estimates to incorporate as much variability as could be reasonably defined. Section 8.2 details the impact of these potential limitations.

7.0 ENVIRONMENTAL EVALUATION

The objective of the environmental portion of the risk assessment is to determine whether contaminants detected at the site have the potential to adversely affect the existing biological community at or surrounding the site. Currently, the EPA has no guidance for quantifying potential impacts to ecological receptors, but has developed a qualitative approach generally used for ecological evaluation (EPA, 1989c). With the qualitative approach, the EPA recommends comparing ambient environmental media concentrations with water quality, sediment quality, or other relevant criteria or guidelines to determine whether the concentrations that the ecological receptors are expected to encounter exceed these values.

Although the effects of contaminants on ecological receptors are a concern, it is difficult to predict whether effects on individual populations will cause damage to the community or ecosystem. If a prey species is affected, predators may be able to feed on other species; losses of predators may be compensated for by other predators or by immigration of another predator population. Thus, it may be difficult to recognize whether adverse effects are occurring, unless there are gross impacts such as mass killings within a population or community. Evidence of gross impacts were not observed during the field survey at the Canonsburg site.

Sublethal effects may occur if contaminants are present at concentrations that may not kill organisms directly, but diminish their ability to survive or reproduce. Types of sublethal effects include behavioral changes, reduced reproductive success, or enzyme level changes, which can affect the population or community level of organization. However, it is often difficult to identify and measure the sublethal effects and establish a causal relationship to a specific environmental stressor, such as a chemical contaminant.

Thus, it is important to note that this preliminary ecological risk assessment cannot account for all potential variables. However, it does provide a qualitative evaluation of potential ecological risks at this site.

7.1 EXPOSURE CHARACTERIZATION

This section identifies the potential exposure pathways associated with the Canonsburg site. For risk to exist, a receptor must be exposed to contaminants. Exposure can occur only with both a source of contamination and a mechanism of transport to a receptor population or individual.

Ground water, and potentially surface water and sediment, are the only currently impacted media at the site. Thus, soil or air exposure pathways (such as incidental ingestion of soil, dermal contact with soil, and inhalation of air containing particulates) do not represent an ecological concern and will not be evaluated in this baseline risk assessment. However, surface- or ground water-related exposure pathways (such as ingestion of surface water potentially affected by contaminated ground water, bioconcentration of contaminants in surface water by aquatic organisms, and consumption of organisms that have accumulated contaminants) are possible at the site.

The main surface water body in the Canonsburg site area is Chartiers Creek (Figure 7.1). The site lies in the Chartiers Creek basin along the creek's southern bank, approximately 15 mi (24 km) upstream of its confluence with the Ohio River. In the Canonsburg area, Chartiers Creek is a meandering stream 75 to 100 ft (23 to 30 m) wide and approximately 10 ft (3 m) deep (DOE, 1983a). In the site vicinity, the stream dimensions are usually much less, ranging from approximately 25 to 40 ft (7.6 to 12 m) wide and approximately 6 ft (1.8 m) deep.

This water body is a potential exposure point for resident aquatic life and terrestrial wildlife (as well as domestic animals) that may contact surface water and/or sediments. This risk assessment evaluates these exposure pathways.

Another potential current pathway could involve plant uptake of contaminants in ground water. Due to the shallow depth to ground water (approximately 5 ft [1.5 m] or less below land surface), plant roots may reach contaminated ground water. This risk assessment evaluates plant uptake, assuming that the plant roots reach soil saturated with ground water.

Another potential pathway involves use of ground water as a water source for irrigating garden plants. For this baseline risk assessment, it was assumed that a domestic well, at some point in the future, could be installed in Area C, which is the site area being considered for public use. The water from this hypothetical well could be used for irrigating garden plants.

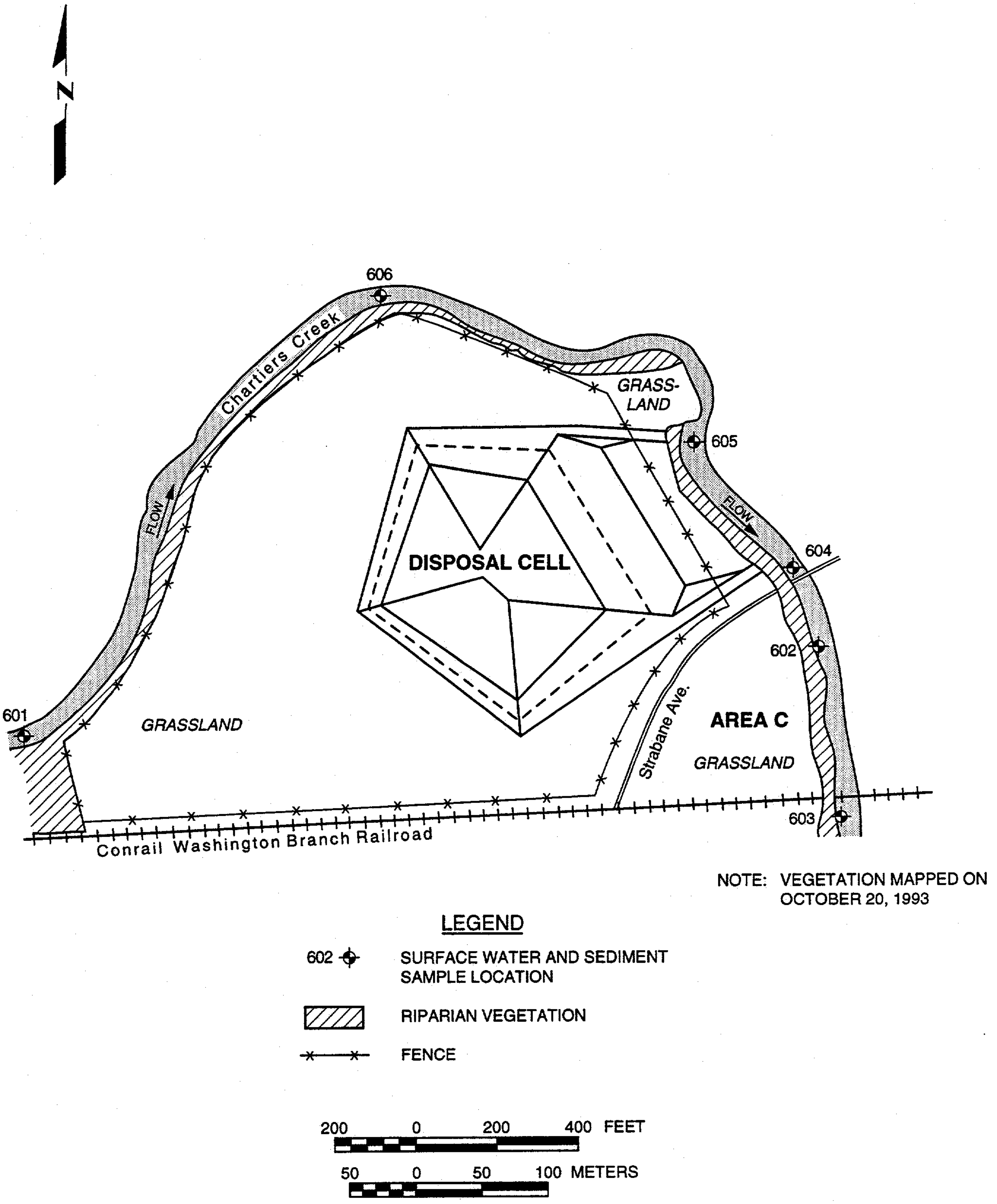
7.2 ECOLOGICAL RECEPTORS

This section identifies the ecological resources present at the site and vicinity that potentially may be exposed to site-related contaminants.

The following information on ecological receptors is based primarily on surveys performed before the tailings encapsulation process was initiated and is provided as a historical perspective. Limited observations of aquatic organisms (at the surface water and sediment sampling locations) and of terrestrial flora and fauna were conducted during an October 19 and 20, 1993, field survey.

7.2.1 Terrestrial resources

The Canonsburg disposal cell and surrounding land was planted with grass after the completion of remedial action. The disposal cell and surrounding land within the site fence line is now covered with a dense growth of grass, as well as occasional herbaceous species such as yellow hop clover, red clover, yarrow, Queen Ann's lace, curled dock, and alfalfa. This land is mowed once or twice a year, which serves to maintain the grass and herb cover; very few woody plant species occur in this mowed area (TAC, 1990; 1993).



NOTE: VEGETATION MAPPED ON OCTOBER 20, 1993

FIGURE 7.1
LOCATION OF RIPARIAN VEGETATION GROWING ALONG CHARTIERS CREEK
CANONSBURG, PENNSYLVANIA, SITE

Chartiers Creek borders the site on the north, west, and east and a wooded riparian zone occurs between the site fence line and the creek (Figure 7.1). This vegetation grows in a thin band along the eastern site boundary and forms a wider band on the north and west sides of the site. The wooded riparian plant community on the north and west sides of the site occurs on a bank 3 to 15 ft (1 to 5 m) above the creek. The majority of the site is covered by a grass dominated plant community, which typically grows up to the creek bank.

Within the riparian community along the creek, sycamore was the most frequently observed canopy tree. A few large black willows were also observed. Other large trees observed in lesser numbers were box elder, basswood, black locust, and silver maple. Box elder was clearly the most common understory species observed. Other species noted in the understory were basswood, sugar maple, black cherry, red oak, black locust, and apple. Wild grape vines were commonly observed growing in the trees. Ground cover was dominated by herbaceous species. Some grass and *Carex* sp. were observed. Black snakeroot was also very common along with poison ivy, *Aster* sp., and *Rubus* sp. (TAC, 1993).

Only limited surveys for wildlife have occurred at or near the Canonsburg site. No amphibians and only one reptile (garter snake) were observed during site visits, although a variety of frog, toad, salamander, and snake species are expected to occur at the site. Surveys for nesting birds were not conducted; species recorded in the fall include the blue jay, song sparrow, crow, downy woodpecker, black capped chickadee, white-breasted nuthatch, robin, and Carolina wren. Birds of prey recorded were the kestrel and Coopers Hawk. Waterfowl such as the mallard and wood duck have been observed in the creek, as well as the green heron. The woodchuck was observed in both the grassland and wooded riparian plant communities (DOE, 1983a; TAC, 1993).

7.2.2 Aquatic organisms

No quantitative surveys of aquatic organisms occurring in Chartiers Creek have been conducted to date as part of the technical assistance contractor (TAC) investigation (DOE, 1994). A brief qualitative survey of the aquatic organisms in Chartiers Creek was conducted in the vicinity of the six surface water and sediment sampling locations (Figure 7.1). The bottom sediments were composed of cobble and silts. Several pools and riffles occur in the reach of Chartiers Creek in the site vicinity.

A fine-mesh dip-net and soil sieve were used to collect fish and benthic macroinvertebrates at each of the surface water sampling locations. One fish, a darter (Etheostomatinae), was collected in a riffle area near location 604. Several unidentified fish were observed at various points along the creek. Four crayfish were collected and numerous burrows and chimneys were observed along the stream. Numerous isopods were observed on the undersides of rocks in the riffle areas. Chironomids and oligochaetes were found in surficial sediments throughout the creek. Limpets were observed in the riffle areas attached to rocks. No apparent differences among the locations were noted during the October 1993 survey with respect to the fauna observed.

Based on previous investigations in the site vicinity, fish reported in the reach of Chartiers Creek include creek chub, white sucker, striped shiner, and carp (DOE, 1983a). Also, the following benthic macroinvertebrates were collected from the creek during previous investigations: oligochaetes, chironomids, leeches, snails, water beetles, isopods, and crayfish (DOE, 1983a).

7.3 CONTAMINANTS OF ECOLOGICAL CONCERN

7.3.1 Ground water

The list of ground water contaminants exceeding background levels in the unconsolidated unit was used as the list of contaminants of potential concern for evaluating potential plant receptors exposed to ground water (see Section 3.3). This list was developed using data from the most contaminated monitor wells finished in the unconsolidated materials at the site (412, 413, and 414). Wells 412 and 413 are downgradient of the tailings encapsulation area, and well 414 is in Area C. The list of contaminants of potential concern from these wells include the following inorganics: ammonium, arsenic, boron, calcium, chloride, magnesium, manganese, molybdenum, potassium, sodium, strontium, sulfate, and uranium. These contaminants and their associated concentrations differ from the list used for the human health risk assessment, which only assessed data from well 414, because plant roots can access ground water beneath the site at all locations. Thus, additional contaminants of concern were added to those evaluated in the human health assessment based on the additional consideration of data from wells 412 and 413.

The list of ground water contaminants exceeding background levels in the unconsolidated unit was also used as the list of contaminants of potential concern for evaluating potential receptors of irrigation water. However, the irrigation pathway only considered data from well 414, which is in Area C. As in the human health assessment, Area C was assumed to be the only area of the site potentially accessible for the installation of a well and subsequent use for irrigation. The first column of Table 3.3 provides the list of contaminants of potential concern from well 414: ammonium, boron, calcium, manganese, molybdenum, potassium, strontium, and uranium.

The exposure point concentrations used for ground water were either the upper 95-percent confidence limit of the concentration from any one well or the maximum detected value, whichever value was lower. When applicable, the well with the highest concentration for any one contaminant was used to represent the exposure point concentration for that contaminant.

7.3.2 Surface water/sediment

The list of contaminants of potential concern in the surface water bodies was developed from the same list of contaminants evaluated for ground water because any site-related contaminants in surface water are primarily assumed to be a result of ground water discharge. This list of contaminants was then compared with the surface water data to determine which contaminants are potentially site-related (i.e., those contaminants exceeding ground water background levels in wells 412, 413, and 414). Table 7.1 presents the surface water data for these site-related contaminants.

If a contaminant was never detected in Chartiers Creek (e.g., uranium) or the concentration detected adjacent to or downstream of the site was less than or equal to the concentration upstream of the site (i.e., ammonium, sodium, sulfate, and magnesium), it was excluded as a contaminant of potential concern for ecological receptors. Additionally, calcium, chloride, and potassium were excluded as contaminants of potential concern because the differences between the upstream and adjacent concentrations were minimal (<5 percent). Although arsenic, boron, and strontium were identified as statistically elevated above background in ground water from monitor wells 412, 413, and 414, no data are available for Chartiers Creek because these constituents have never been analyzed for in surface water. Based on these comparisons, manganese and molybdenum are the contaminants of potential ecological concern selected for surface waters in Chartiers Creek.

The concentrations used in these comparisons to background were from unfiltered samples. Data from unfiltered samples were used because most of the state of Pennsylvania's water quality criteria are stated as total recoverable (unfiltered) metal concentrations.

No sediment samples were collected from Chartiers Creek prior to the October 1993 sampling. The constituents analyzed in the sediments that were identified as being site-related (i.e., above background ground water quality) were evaluated in this assessment. These include the metals manganese, molybdenum, and uranium. Table 7.2 presents the sediment data for these metals by location.

7.4 POTENTIAL IMPACTS TO WILDLIFE AND PLANTS

7.4.1 Terrestrial risk

A number of potential exposure pathways were evaluated for terrestrial vegetation and wildlife. Terrestrial vegetation can be directly exposed to contaminants in ground water through uptake by the roots. Contaminants may bioaccumulate in various plant parts and exert a wide range of influences, depending on the specific contaminant. Plant uptake rates vary greatly among species and are affected by soil characteristics (pH, moisture, redox potential, organic matter, etc.), plant sensitivity, and input-output balance. Another

Table 7.1 Occurrence of constituents detected in Chartiers Creek surface water in the Canonsburg, Pennsylvania, UMTRA Project site vicinity

	Upstream of site Location ID	Adjacent to site[a] Location ID				Downstream of site Location ID
Constituent	**601**	**606**	**605**	**604**	**602**	**603**
Ammonium[b]	0.25	NA	NA	NA	0.20	NA
Calcium[b]	83	NA	NA	NA	87	NA
Chloride[b]	50	NA	NA	NA	51	NA
Magnesium[b]	19	NA	NA	NA	19	NA
Manganese	0.13 (0.16)[b]	0.17	0.16	0.13	0.12 (0.16)[b]	0.12
Molybdenum	0.09 (0.08)[b]	0.17	0.16	0.10	0.09 (0.085)[b]	0.10
Potassium[b]	6.5	NA	NA	NA	6.8	NA
Sodium[b]	62	NA	NA	NA	58	NA
Sulfate	280 (207)[b]	250	250	280	270 (203)[b]	270
Uranium	<0.001 (<0.001)[b]	<0.001	<0.001	<0.001	<0.001 (<0.001)[b]	<0.001

[a] Refers to sampling locations adjacent to the disposal cell or Area C.

[b] Concentrations presented are median concentrations for unfiltered data collected from 1991 through 1993.

Note: All concentrations reported in milligrams per liter. Unfiltered data collected on October 19 and 20, 1993, unless otherwise specified.

NA - not analyzed.

Table 7.2 Occurrence of constituents detected in Chartiers Creek sediment in the Canonsburg, Pennsylvania, UMTRA Project site vicinity

	Upstream of site Location ID	Adjacent to site[a] Location ID				Downstream of site Location ID
Constituent	601	606	605	604	602	603
Manganese	1410	1550	2150	2820	590	1900
Molybdenum	33	13	96	25	2	16
Uranium	2.0	1.8	2.0	2.6	1.6	2.4

[a] Refers to sampling locations adjacent to the disposal cell or Area C.

Note: All concentrations reported in milligrams per kilogram dry weight. Data collected on October 19 and 20, 1993.

potential exposure route for plants is through garden irrigation by ground water. Foraging wildlife can be indirectly exposed to contaminants in ground water by ingesting plants or fruits (such as apples) that may have bioaccumulated certain contaminants. Terrestrial wildlife can also be exposed to contaminants in surface water bodies by ingesting the surface water, aquatic organisms that have accumulated contaminants, and/or sediments.

Vegetation

Based on the shallow depth to contaminated ground water at the site, some plants could have rooting zones in soils that intercept contaminated ground water. Concentrations of the contaminants of potential concern in plant tissue at harvestable maturity, based on uptake from ground water, could not be estimated but should be considered in future studies at the site.

Another potential exposure route for plants is through garden irrigation by ground water. Table 7.3 compares the ground water concentrations (represented by well 414) with the approximate concentrations in water that should be protective of plants if used as a continuous source for irrigation (EPA, 1972). The EPA developed these approximate irrigation water concentrations to protect agricultural crops from toxicity associated with buildup of a particular constituent in the soil. Two of the contaminants of potential concern, boron and manganese, have comparison values. The ground water concentration for manganese exceeds the comparison value, while boron is below the comparison value. No comparison values are available for the remainder of the contaminants of potential concern. Thus, it is not possible to evaluate the potential for these compounds to adversely affect plants when applied in irrigation water. However, based on the available information, use of the alluvial ground water near the site as a continuous source of irrigation water may result in deleterious effects to plants, due to the elevated concentration of manganese.

Table 7.3 Comparison of contaminants of potential concern in ground water with available water quality values, Canonsburg, Pennsylvania, UMTRA Project site

Contaminant	Concentration in ground water	Aquatic life water quality value[a]	Water concentration protective of livestock[b]	Concentration in irrigation water protective of plants[b]
Ammonium	1.3	NA	NA	NA
Boron	0.39	1.6	5.0	0.75
Calcium	93	NA	NA	NA
Manganese	11	1.5	NA	0.20
Molybdenum	0.03	50 (0.79)[d]	10[f]	NA
Potassium	4.3	NA	NA	NA
Strontium	0.30	NA	NA	NA
Uranium	0.04	8[e]	NA	NA

[a] Value obtained from the commonwealth of Pennsylvania, Title 25, Environmental Resources, Chapter 16.51, *Water Quality Criteria for Toxic Substances*, Pennsylvania Department of Environmental Resources (PADER, 1991), unless specified otherwise. These values are standards protective of aquatic life via chronic exposure.

[b] From EPA (1972), unless specified otherwise. Irrigation water values shown are for water used continuously on all soils.

[c] No state or federal criteria available. Value shown is the lower end of the tolerance range for freshwater organisms (EPA, 1986).

[d] No state or federal criteria available. Value presented is the current molybdenum criterion recommended by the U.S. Fish and Wildlife Service for the protection of aquatic organisms (50 mg/L), with one exception. The exception is for newly fertilized eggs of rainbow trout, which are sensitive to molybdenum concentrations above 0.79 mg/L (Eisler, 1989).

[e] No Pennsylvania or federal criteria available. Value presented is the state of Colorado's hardness dependent water quality standard for the protection of aquatic life via chronic exposure (CDPHE, 1991).

[f] Value presented is the current safe level for molybdenum in cattle drinking water recommended by the U.S. Fish and Wildlife Service (Eisler, 1989).

Concentrations reported in milligrams per liter unless otherwise noted. Concentration in ground water is the upper confidence limit or maximum detected concentration, whichever is less.

L/kg - liters per kilogram.
mg/kg DW - milligrams per kilogram dry weight.
NA - not available.

Wildlife

The exposure of terrestrial organisms from the ingestion of plants or animals that have accumulated contaminants (e.g., birds eating fish) is a potential exposure pathway at the site. Birds and other vertebrates consuming these plants and animals can bioaccumulate some of the contaminants of potential concern if the amount ingested exceeds the amount eliminated. This is often a function of the areal extent of contamination versus the areal extent of the animals feeding range. In the case of small contaminated areas, the contribution of impacted food to the total diet is usually very minute, and bioaccumulation is not a concern. Therefore, although exposure via the diet may be possible, the potential for bioaccumulation is not always a concern.

Biomagnification is potentially of greater concern and involves increased concentration of a constituent at each successive trophic level in the food chain. Of particular concern for biomagnification effects are the top predators, especially the carnivorous birds and mammals. Only a limited number of constituents have the potential for magnifying in the food chain. Most constituents are metabolized in organisms and eliminated at each level of the food chain and, thus, would not increase in concentration at each successive trophic level. Based on available information on the contaminants of concern at this site, the potential for these contaminants to represent a hazard via food chain transfer is probably low.

Other potential pathways of exposure to wildlife include ingesting water or sediments in Chartiers Creek. Animals may drink from the creek and, thus, be potentially exposed to contaminants in surface water and/or sediments. However, no available federal or state criteria or guidelines have been established to protect terrestrial wildlife from water or sediment exposure. Therefore, the potential hazards to terrestrial receptors from surface water and sediment ingestion were not evaluated.

7.4.2 Aquatic risk

Surface water

A potential exposure point for aquatic life is Chartiers Creek in the site vicinity. The ground water from the unconsolidated material is believed to discharge into the creek. Comparing the surface water data collected from the creek at the upstream location with those of the adjacent and downstream locations indicates that most of the constituents did not exceed upstream concentrations.

Manganese and molybdenum were identified as contaminants of potential concern in the creek water. The maximum concentrations for manganese (0.17 mg/L) and molybdenum (0.17 mg/L) were detected at sampling location 606 (Figure 7.1). No state or federal water quality criteria have been developed for these two constituents (PADER, 1991; EPA, 1992b). However, the EPA reported a value of 1.5 mg/L of manganese as the lower end of a tolerance range for freshwater organisms (EPA, 1986). The maximum detected manganese concentration in Chartiers Creek falls approximately 1 order of magnitude below this value. For molybdenum, the U.S. Fish and Wildlife Service currently recommends a value of 50 mg/L to protect most aquatic organisms and 0.79 mg/L to protect newly fertilized rainbow trout eggs (Eisler, 1989). Because Chartiers Creek is a warm water habitat, protecting trout eggs is not of concern. The maximum detected molybdenum concentration in Chartiers Creek falls well below the 50 mg/L value protective of aquatic organisms. The concentrations for manganese and molybdenum at sampling locations 606 and 605 were only slightly higher than those at the upstream location (Table 7.1). This suggests that ground water discharge to the creek has not affected the water quality, although the limited sampling is not conclusive.

Sediment

Surficial sediment (approximately 0 to 4 inches below sediment surface) was collected from six locations (Figure 7.1) during the October 19 and 20, 1993, sampling event. No sediment samples had been collected prior to this sampling event. The sediment data for manganese and molybdenum varied among sampling locations (Table 7.2). The highest concentration for each contaminant of potential concern was detected at a location adjacent to the site: location 604 for manganese and uranium and location 605 for molybdenum. The lowest concentration for each constituent was detected at location 602.

No established state or federal sediment quality criteria or guidelines exist to protect aquatic life from the contaminants of potential concern at this site (EPA, 1988; NOAA, 1990). The EPA is evaluating a methodology based on the three-phase sorption model for free metal ion activity and is assessing its applicability for determining the bioavailable fraction within sediments (EPA, 1989d). Currently, a number of other predictive models and methods are being investigated for metals, but no single approach has been accepted to adequately develop sediment-based metals criteria (Shea, 1988; Chapman, 1989; EPA, 1989d; NOAA, 1990; Di Toro et al., 1991; Burton, 1991).

Because no sediment quality values currently exist for manganese, molybdenum, and uranium, the potential for detected sediment concentrations to adversely affect biota could not be addressed. It is difficult to draw any conclusions concerning sediment quality conditions in Chartiers Creek due to the limited data set (i.e., one sampling event) and the variability of the data.

7.5 LIMITATIONS OF THE ECOLOGICAL RISK ASSESSMENT

The qualitative evaluation of potential ecological risks presented here is a screening level assessment of the risks associated with potential exposure of plants and animals to contaminated ground water, surface water, and sediment at the Canonsburg site. Sources of uncertainty in any ecological assessment arise from the monitoring data, exposure assessments, toxicological information, and the inherent complexities of the ecosystem. In addition, methods of predicting nonchemical stresses (e.g., drought), biotic interactions, behavior patterns, biological variability (i.e., differences in physical conditions, nutrient availability), and resiliency and recovery capacities are often unavailable. In general, limitations for the Canonsburg ecological risk assessment include the following:

- Only a small amount of ecological data were collected during this screening.
- Little is known about site-specific intake rates for wildlife or amounts of contaminants taken up by plants. General literature values were used in many cases.
- Only limited ecotoxicological reference data are available.
- Considerable uncertainty is associated with the toxicity of mixtures of contaminants.

7.6 SUMMARY

Surface water data from Chartiers Creek in the site vicinity indicate the presence of slightly higher concentrations for two constituents (manganese and molybdenum) at some downgradient locations. However, it is not known whether site-related constituents have adversely affected the water quality of the Chartiers Creek.

A limited data set (one sampling round) currently exists of the sediment quality in Chartiers Creek in the site vicinity. Although a statistical analysis cannot be conducted with the limited data, no trends are apparent in the data. Sediment concentrations for the contaminants of potential concern were highest at two locations adjacent to the site. However, insufficient data are available to determine if this is related to releases from the site or due to natural variability. Sediment quality values to protect aquatic life are not available for the contaminants of potential concern; thus, it is not possible to evaluate the potential for these concentrations to represent an ecological concern.

Based on available data and criteria, no ecological threat exists to plants at harvestable maturity that may have roots in contact with soil saturated with the most contaminated ground water in the alluvial aquifer. Due to manganese levels, this ground water would not be suitable for continuous long-term irrigation for plants.

The potential for the contaminants of potential concern detected in media at the site to represent a food chain hazard (via bioaccumulation and biomagnification) is considered low, based on available surface water and sediment data. However, no tissue analysis from potential ecological receptors (e.g., wildlife and plants) has been conducted.

Insufficient water quality and sediment quality values were available to allow a comprehensive evaluation of the impact of surface water, sediments, and contaminated ground water on ecological receptors. However, based on available data, it does not appear that former site activities have impacted surface water and sediments in the site vicinity.

8.0 INTERPRETATION AND RECOMMENDATIONS

8.1 RISK SUMMARY

The UMTRCA requires the UMTRA Project to protect public health and the environment from radiological and nonradiological hazards associated with the uranium mill sites. This baseline risk assessment was conducted on the Canonsburg site to evaluate the presence of these hazards. Because contaminated ground water is currently not used by area residents, human health is not at risk. However, health risks are associated with potential future use of contaminated ground water from the unconsolidated unit.

The primary human health risk associated with ground water contamination in the unconsolidated unit at the Canonsburg site is from manganese ingestion. Using ground water from the unconsolidated unit in Area C for drinking purposes would result in ingesting manganese at levels that would most likely produce adverse effects to the nervous system. A large percentage of the estimated doses fall above the threshold for mild neurological symptoms in adults. Doses based on the maximum background levels detected in one well in the unconsolidated materials would also result in mild neurological symptoms. Manganese in ground water was also at levels that may be potentially harmful to ecological receptors. Ground water would not be suitable for continuous long-term irrigation for plants.

8.2 LIMITATIONS OF THIS RISK ASSESSMENT

Limitations to this evaluation of health risks follow:

- Most of the results presented here are based on 0.45-micrometer filtered ground water samples. The effects of filtration differ for different elements. Filtered samples generally have lower concentrations of a given constituent than unfiltered samples because suspended particles are removed during filtration. However, constituents bound to these suspended particles can still produce toxic effects if ingested and broken down in the acid environment of the stomach.

- Potential exposure to and subsequent toxicity of a contaminant will vary from individual to individual. By using the probability distributions for potential exposure and presenting ranges of exposures that can produce toxic effects, this assessment attempts to emphasize that variability. However, it is not possible to account for all sources of variability and still present useful and meaningful analyses. Using ranges for expected toxic effects and distributions for expected exposures should provide the reader with a better understanding of the likelihood of toxic effects.

- To assess toxicity, standardized reference values developed by various agencies, as well as toxicity data in the literature, were used. These data have limitations, including the following:

  - Not all constituents elevated above background levels at a given site have comprehensive toxicity data available.

  - In some cases, data obtained from laboratory animal testing at exposure doses different from those expected at the site were used to determine toxicity. The relationship between dose and response is not always linear, and humans do not always exhibit toxic effects similar to those seen in animals.

  - Data used to determine toxicity are generally based on exposure to only one chemical. In reality, exposure to multiple chemicals occurs simultaneously. The interactive effects of multiple constituents and the impact of these interactions on expected toxicity generally cannot be accurately assessed from existing data.

- This document evaluates risks associated with exposures only to organic contaminants of ground water at the UMTRA Project site at Canonsburg. Potential organic contaminants related to uranium processing have not been considered.

- To assess potential intake via the vegetable and fish ingestion exposure routes, assumptions were made regarding uptake of contaminants into these media. Uncertainties are associated with the uptake and BCFs used to make these estimates because these factors are taken from the literature and do not consider site-specific conditions. In addition, data on the bioconcentration of molybdenum in fish were not available. Therefore, the fish ingestion pathway could not be quantitatively assessed for molybdenum.

- Although considerable effort has been directed at determining contaminant movement and placing monitor wells in locations that capture maximum contamination, variability in physical systems and models used to determine contaminant migration could still result in well placements that do not measure the highest contaminant concentrations or determine the fullest extent of contamination.

- The drinking water pathway has been used as the major determinant of exposure. Although other pathways have been screened and determined not to contribute significantly to the total exposure, the additivity of exposure from these pathways should be kept in mind. Section 6.0 considers cases where a measurable contribution from other pathways could increase expected exposure significantly enough to alter the predicted toxicity. However, the incremental contribution from ground water-irrigated produce and wild fruit ingestion pathway, which could not be estimated here, could be significant.

- The limitations for the Canonsburg ecological risk assessment include a limited amount of ecological data collected during this screening; little knowledge about site-specific intake rates for wildlife or amounts of contaminants taken up by plants; limited availability of ecotoxicological reference data; and considerable uncertainty associated with the toxicity of mixtures of contaminants.

By presenting ranges of toxic effects, probable exposure distributions, summaries of available data on health effects and interactions, and outlines of potential limitations, this document should provide a realistic interpretation of potential health risks associated with ground water contamination at this site. This assessment is designed to present as accurate a picture of contamination and risk as is possible based on the available data and to convey areas where uncertainties exist.

8.3 GROUND WATER CRITERIA

In 1983, the EPA established health and environmental protection standards for the UMTRA Project, and in 1987 the EPA proposed revised ground water standards in UMTRCA. The UMTRA Project is required to adhere to the 1987 proposed ground water standards until final standards are published. The UMTRCA ground water standards consist of ground water protection standards to evaluate disposal cell performance and ground water cleanup standards for existing contamination at processing sites. Table 8.1 summarizes these standards for contaminants with a proposed maximum concentration limit (MCL). Because an MCL is not established for every contaminant, the proposed standard requires meeting background levels or alternate concentration limits (ACL) for those contaminants without an MCL.

While these standards apply only to the UMTRA Project, the EPA has also published drinking water health advisory levels for both long- and short-term exposures. Table 8.1 presents these advisories.

Data from well 414, which was used to assess potential risk in this assessment, do not exceed any of the EPA proposed MCLs in UMTRCA, based on data since 1988. However, the uranium health advisory for children was exceeded once in the last sampling round in October 1993. The uranium MCL has been consistently exceeded from 1986 to 1993 in wells 413 (unconsolidated unit) and 506 (bedrock). The uranium MCL was also exceeded in well 412 (unconsolidated unit) from 1991 to 1993. The molybdenum MCL was exceeded several times, and the MCL was also exceeded in background wells. The lead MCL was exceeded a few times in both the unconsolidated and bedrock wells in 1987 and 1988. However, data from subsequent years did not exceed MCLs. The chromium MCL was also exceeded in unconsolidated and bedrock wells; however, this only occurred in 1988, and the MCL was also exceeded in a background well.

Table 8.1 Concentration limits of constituents

Constituent	UMTRA MCL 40 CFR 192.02 (mg/L)	Health advisories 10-kg child, 10-day (mg/L)	Health advisories 70-kg adult lifetime (mg/L)
Chemicals (inorganic)			
Antimony	-	0.015	0.003
Arsenic	0.05	-	-
Barium	1.0	-	2
Boron	-	0.9	0.6
Cadmium	0.01	0.04	0.005
Chromium	0.05	1.0	0.1
Copper	-	-	-
Fluoride	-	-	-
Lead	0.05	-	0.015[a]
Manganese	-	-	-
Mercury	0.002	-	0.002
Molybdenum	0.1	0.08	0.04
Nickel	-	1.0	0.1
Nitrate	44[b]	44[b]	-
Selenium	0.01	-	-
Silver	0.05	0.2	0.1
Strontium	-	25.0	17
Sulfate	-	-	-
Thallium	-	0.007	0.0004
Vanadium	-	0.08	0.02
Zinc	-	6.0	2
Radionuclides			
Radium-226/-228	5 pCi/L	-	-
Uranium (U-234/-238)	30 pCi/L (0.044 mg/L)	0.03 mg/L[c]	0.1 mg/L[c]

[a] Action level.
[b] Equals 10 mg/L nitrate as nitrogen.
[c] Proposed values, under review; expected revision 1995.

8.4 RISK MITIGATION MEASURES

A potential for adverse health effects to occur exists following long-term use of contaminated ground water from the unconsolidated material below the former Canonsburg uranium processing site. The cities of Canonsburg and Houston, North Strabane Township, and Chartiers Township are close to the processing site in Washington County, Pennsylvania. Although ground water from a deep bedrock aquifer is used in the area for domestic purposes including drinking, no affected ground water is known to be used for any purposes. Ground water discharges into Chartiers Creek, which borders the western, northern, and eastern boundaries of the site. However, no site-related releases are known to affect the creek.

This section presents possible ways to restrict access to contaminated ground water so as to mitigate risks.

Institutional controls are defined in the preamble to the proposed ground water standards for the UMTRA Project as mechanisms that can be effectively used to protect human health and the environment by controlling access to contaminated ground water (52 FR 36000). Although the preamble refers to institutional controls for long periods of time (e.g., up to 100 years during natural flushing), this concept can also be applied to short-term access restrictions to ground water. Because not all 24 UMTRA Project sites can be evaluated simultaneously, institutional controls may be needed pending remedial action decisions or during implementation of remedial action for individual sites.

The Department of Environmental Resources Ground Water Quality Protection Strategy of the commonwealth of Pennsylvania describes the principles that the department intends to follow in implementing its ground water quality protection program through regulations, policies, and technical guidance. It states that the owner/operator of a property of concern is responsible for detecting and reporting contamination in the ground water. Once ground water monitoring and assessment have documented the existence of a problem, ground water remediation and other applicable measures will be required. Applicable measures will include, but may not be limited to, treatment/containment of contaminated ground water as necessary to restore the ground water or to protect human health and the environment. The ultimate goal of ground water remediation is to reduce contamination levels to background quality. An owner/operator who restores contaminated ground water to its background quality will be released from further liability for remediation of those contaminants. If achieving background quality is not possible, the owner/operator will not be released from liability.

The Waste Management Division, Department of Environmental Resources, has jurisdiction over waste sites in the commonwealth of Pennsylvania. The UMTRA Project disposal cells are not under the jurisdiction of the department. However, at waste sites within their jurisdiction, the department implements institutional controls and engineering controls, when necessary, to protect human health and the environment. When waste sites do not fall under the strict definition of waste sites under department jurisdiction, provisions exist for a policy to be developed to require implementation of site-specific institutional controls. Examples could be deed notices to inform about the site or restrict certain activities at the site, or requirements for public notice dictated by a consent decree between the property owner and the state (Arnold, 1994).

8.5 RECOMMENDATIONS

In general, the proposed UMTRCA ground water standards consisting of MCLs or background concentrations are sufficient to protect human health and the environment. However, in some cases, a risk assessment may identify site-specific factors that suggest that these standards are too restrictive or not restrictive enough. When standards are too restrictive, as in the case where there is no exposure potential, a less restrictive ACL may be sought. In other cases, the standards may not be sufficiently protective (e.g., if many contaminants are near the MCL with additive or synergistic adverse health effects).

Ground water use is restricted on the majority of the Canonsburg site, with the potential exception of Area C, which is being considered for public use. Based on the risk assessment results, the manganese levels in Area C will result in potential adverse health effects. Thus, it is recommended that restrictions also be placed on potential ground water use in Area C.

Additional data should be collected to better characterize interactions between surface water and ground water and the vertical and horizontal ground water flow in the unconsolidated materials and bedrock. In addition, water quality monitoring should be continued in well 510, which lies directly downgradient from well 506 in the shallow bedrock, to confirm that the localized contamination detected in well 506 is not migrating further downgradient. Also, those bedrock wells that lie north of Chartiers Creek (wells 502 and 505) should continue to be monitored to confirm that contamination from the site is not migrating beneath the creek.

It is also recommended that additional characterization be conducted to further evaluate conditions in Chartiers Creek (e.g., water and sediment sampling), as well as evaluate potential ecological receptors in the site vicinity.

Plant uptake studies are being conducted for the UMTRA Ground Water Project. Results of these studies will be used to evaluate the irrigated-produce and wild-fruit-ingestion exposure route meaningfully. The results will be included in the NEPA document and ground water strategy planning for this site.

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