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WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1996

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JULY 1997 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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MK-FERGUSON A MORRISON KNUDSEN COMPANY	
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Environmental Safety and Health Department Manager	7/21/97 Date
Data Administration Manager	7/22/97 Date
Quality Assurance Manager	07/22/97 Date
Project Director (or Deputy Project Director)	7/22/97 Date

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DOE/OR/21548-676

Weldon Spring Site Remedial Action Project

Weldon Spring Site Environmental Report for Calendar Year 1996

Revision 0

July 1997

Prepared by

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and
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for the

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ABSTRACT

This *Site Environmental Report for Calendar Year 1996* describes the environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). The objectives of these programs are to assess actual or potential exposure to contaminant effluents from the project area by providing public use scenarios and dose estimates, to demonstrate compliance with Federal and State permitted levels and regulations, and to summarize trends and/or changes in contaminant concentrations identified through environmental monitoring.

In 1996, the maximum total effective dose equivalent (TEDE) to a hypothetical individual who was employed full-time at the nearby Missouri Highway and Transportation Department Maintenance Facility (MHTD) was 2.7 mrem (0.027 mSv). The maximum TEDE to a hypothetical individual at the boundary of the Weldon Spring Quarry was 0.0051 mrem (5.1E-5 mSv). The maximum TEDE to a hypothetical individual who frequents the Weldon Spring Vicinity Properties was 0.0034 mrem (3.4E-5 mSv). These estimates are below the U.S. Department of Energy requirement of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways.

The combined collective population dose equivalent for the population assumed to frequent the Busch Memorial Conservation Area (160,000 individuals) and employees of the MHTD facility (nine individuals) was 0.19 person-rem (1.9E-3 person-Sv). Results from radiological air monitoring for the National Emission Standards for Hazardous Air Pollutants (NESHAPs) program indicated that all estimated total effective dose equivalents were less than the U.S. Environmental Protection Agency (EPA) standard of 10 mrem (0.1 mSv) per year.

Comprehensive monitoring indicated that emissions of radiological compounds in airborne and surface water discharges from the Weldon Spring site consisted primarily of Rn-220 gas, isotopes of thorium and radium, and natural uranium. Airborne Rn-220 emissions were estimated to be 128 Ci (4.7E12 Bq), while emissions from a combination of thorium, radium, and natural uranium isotopes to surface water was estimated to be 0.028 Ci (1.0E9 Bq), for a total of 1,630 g (1.6 kg). There was no measurable impact to any drinking water source.

Various State and Federal permit levels are monitored under National Pollutant Discharge Elimination System (NPDES) permits. Permit levels were maintained during 1996, except for five occasions when the settleable solids limit was exceeded at storm water outfalls.

Exceedances occurred at Outfall NP-0002 in June and October, at Outfall NP-0010 in April and June, and Outfall NP-0016 in June.

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1 INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) is part of the U.S. Department of Energy (DOE) Environmental Restoration Program, one of the remedial action programs under the direction of the DOE Office of Environmental Management. This *Site Environmental Report for Calendar Year 1996* summarizes the environmental monitoring results obtained in 1996 and presents the status of Federal and State compliance activities.

DOE requirements for environmental monitoring and protection of the public, the mandate for this document, are designated in DOE Order 5400.1, *General Environmental Protection Program*, DOE Order 5400.5, *Radiation Protection of the Public and Environment*, and the implementation guide for DOE Order 5400.5: *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 1).

In 1996, environmental monitoring activities were conducted to support remedial action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), the *Clean Air Act* (CAA), the *National Environmental Policy Act* (NEPA), the *Clean Water Act* (CWA), and other applicable regulatory requirements. The monitoring program at the WSSRAP has been designed to protect the public and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Site Environmental Report for Calendar Year 1996* include:

- Providing general information on the WSSRAP and the current status of remedial activities.
- Presenting summary data and interpretations for the 1996 environmental monitoring program.
- Providing information regarding ongoing remedial actions.
- Reporting compliance with Federal, State, and local requirements and DOE standards.

- Providing dose estimates for radiological compounds as appropriate for the WSSRAP.

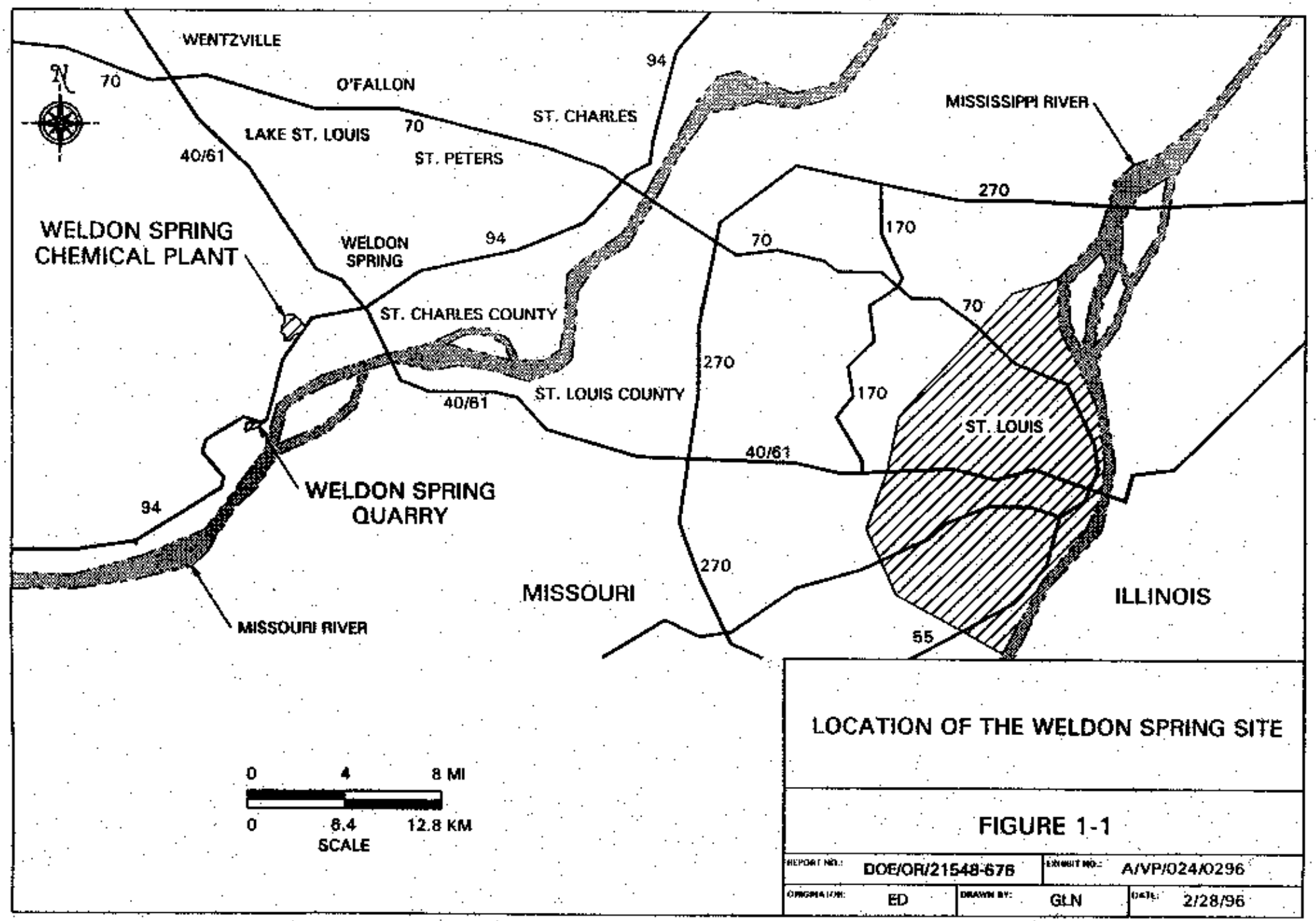
- Summarizing trends and/or changes in contaminant concentrations to support remedial actions, ensure public safety, and maintain surveillance monitoring requirements.

1.1 Site Description

The Weldon Spring site is located in southern St. Charles County, Missouri approximately 48 km (30 mi) west of St. Louis (Figure 1-1). The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94. Access to both the site and quarry is restricted by locked chain link fences with on-site security.

The Weldon Spring Chemical Plant is a 67.2 ha (166 acres) area which operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, uranium, and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants can also be found in the soil in several areas around the site. The raffinate pits are located on the chemical plant site and consist of four settling basins that cover approximately 10.5 ha (26 acres) (Figure 1-2). These pits are radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals.

The Weldon Spring Quarry is a former 3.6 ha (9 acres) limestone quarry located south-southwest of the chemical plant area (Figure 1-3). The quarry is essentially a closed basin; surface water within the rim flows to the quarry floor and into a sump. The amount of water in the sump varies in response to quarry water treatment plant operations and precipitation. The quarry bulk waste removal operation was completed in 1995. The bulk waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

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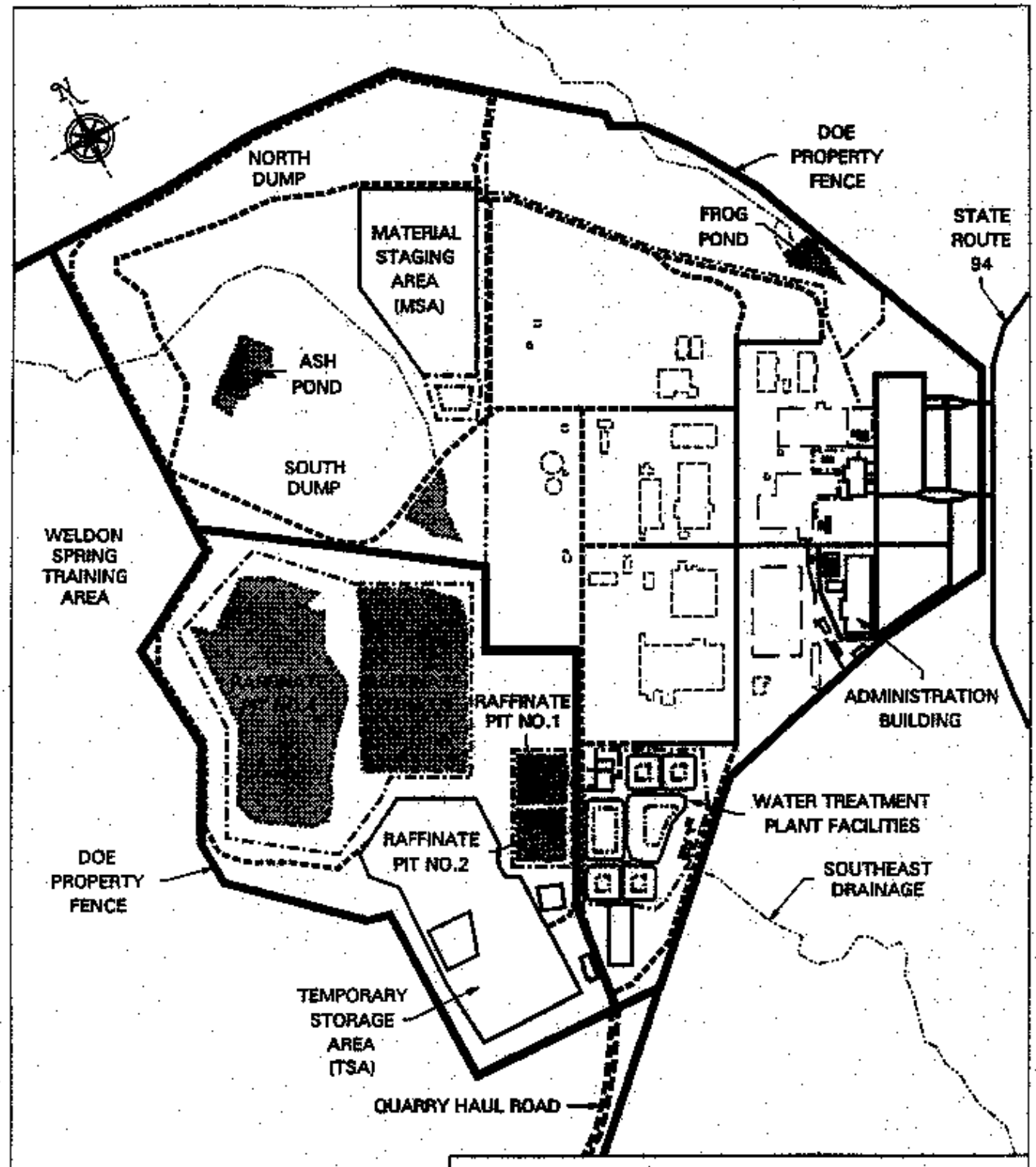

WELDON SPRING CHEMICAL PLANT AND RAFFINATE PIT AREAS

FIGURE 1-2

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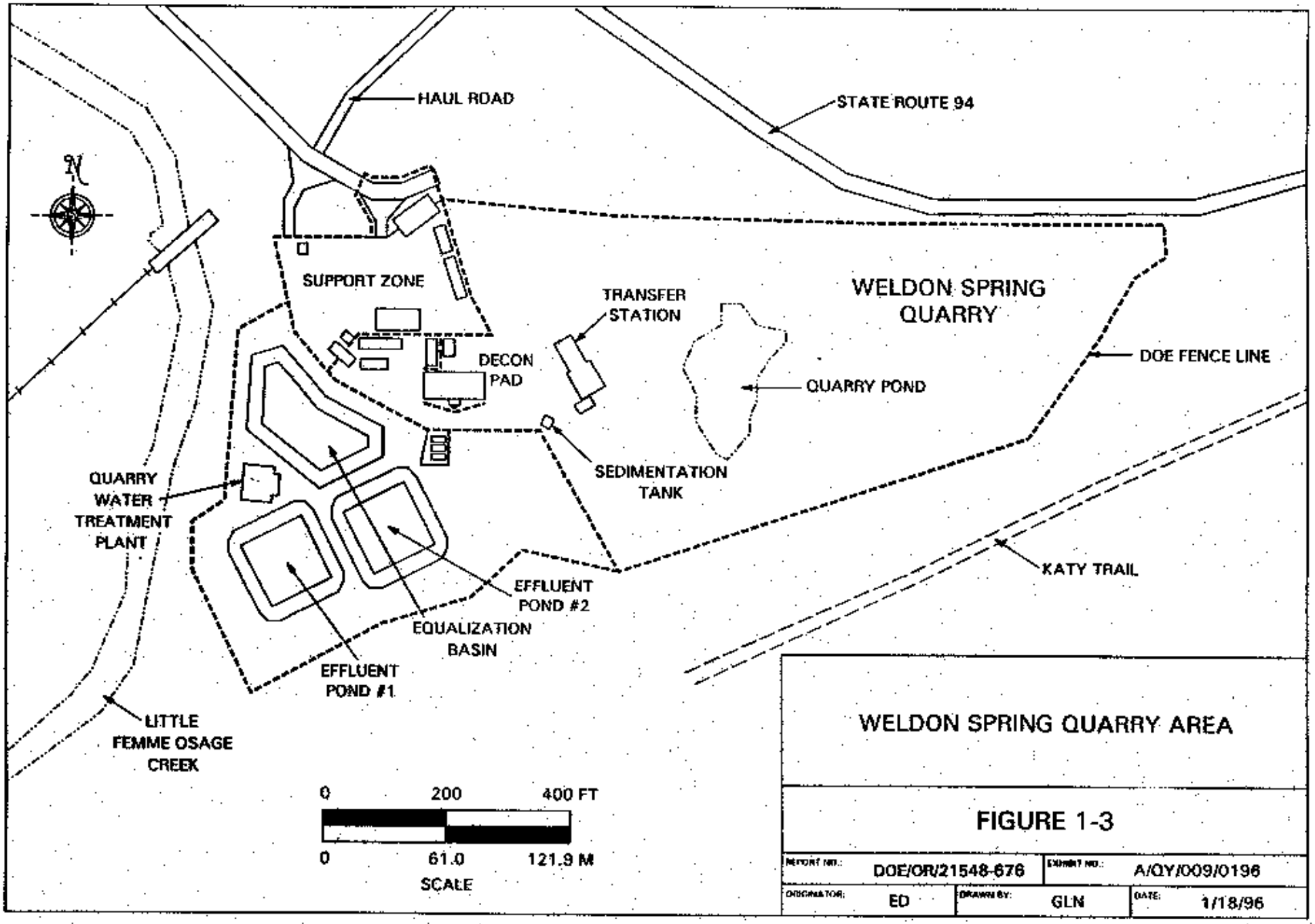
HAUL ROAD
STATE ROUTE 94
N
SUPPORT ZONE
TRANSFER STATION
WELDON SPRING QUARRY
DECON PAD
DOE FENCE LINE
QUARRY POND
SEDIMENTATION TANK
QUARRY WATER TREATMENT PLANT
KATY TRAIL
EFFLUENT POND #2
EQUALIZATION BASIN
EFFLUENT POND #1
LITTLE FEMME OSAGE CREEK
0 200 400 FT
0 61.0 121.9 M
SCALE
WELDON SPRING QUARRY AREA
FIGURE 1-3
REPORT NO.: DOE/OR/21548-676
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1.2 Site History

From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,233 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the State of Missouri (August A. Busch Memorial Conservation Area) and to the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Army training area.

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former ordnance works property was transferred in May 1955 to the AEC for construction of the WSUFMP, now referred to as the Weldon Spring Chemical Plant. Considerable explosives decontamination was performed by the Atlas Powder Company and the Army prior to WSUFMP construction. From 1958 until 1966, the WSUFMP converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium was also processed. Wastes generated during these operations were stored in the four raffinate pits.

In 1958, the AEC acquired title to the Weldon Spring Quarry from the Army. The Army had used it since 1942 for burning wastes from the manufacture of TNT and DNT and disposal of TNT-contaminated rubble during the operation of the ordnance works. Prior to 1942, the quarry was mined for limestone aggregate used in the construction of the ordnance works. The AEC used the quarry from 1963 to 1969 as a disposal area for uranium residues and a small amount of thorium residue. Material disposed of in the quarry during this time consisted of building rubble and soils from the demolition of a uranium ore processing facility in St. Louis. These materials were contaminated with uranium and radium. Other radioactive materials in the quarry include drummed wastes, uncontained wastes, and contaminated process equipment.

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. The Army started removing equipment and decontaminating several buildings in 1968. However, the defoliant project was canceled in 1969 before any process equipment was installed.

The Army retained responsibility for the land and facilities of the chemical plant, but the 20.6 ha (51 acre) tract encompassing the Weldon Spring raffinate pits was transferred back to the AEC.

The Weldon Spring site was placed in caretaker status from 1981 through 1985, when custody was transferred from the Army to the Department of Energy. In 1985, the DOE proposed designating control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major System Acquisition in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

A more detailed presentation of the production, ownership, and waste history of the Weldon Spring site is available in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 2) and the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 3).

1.3 Geology and Hydrogeology

The Weldon Spring site is situated near the boundary between the Central Lowland and the Ozark Plateau physiographic provinces. This boundary nearly coincides with the southern edge of Pleistocene glaciation that covered the northern half of Missouri over 10,000 years ago (Ref. 4).

The uppermost bedrock units underlying the Weldon Spring Chemical Plant are the Mississippian Burlington and Keokuk Limestone. Overlying the bedrock are unlithified units consisting of fill, top soil, loess, glacial till and limestone residuum of thicknesses ranging from a few feet to several tens of feet.

There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian Limestones and the middle aquifer consists of the Ordovician Kimmswick Limestone. The deep aquifer includes formations from the top of the Ordovician

St. Peter Sandstone to the base of the Cambrian Potosi Dolomite. Alluvial aquifers of Quaternary age are present near the Missouri and Mississippi Rivers.

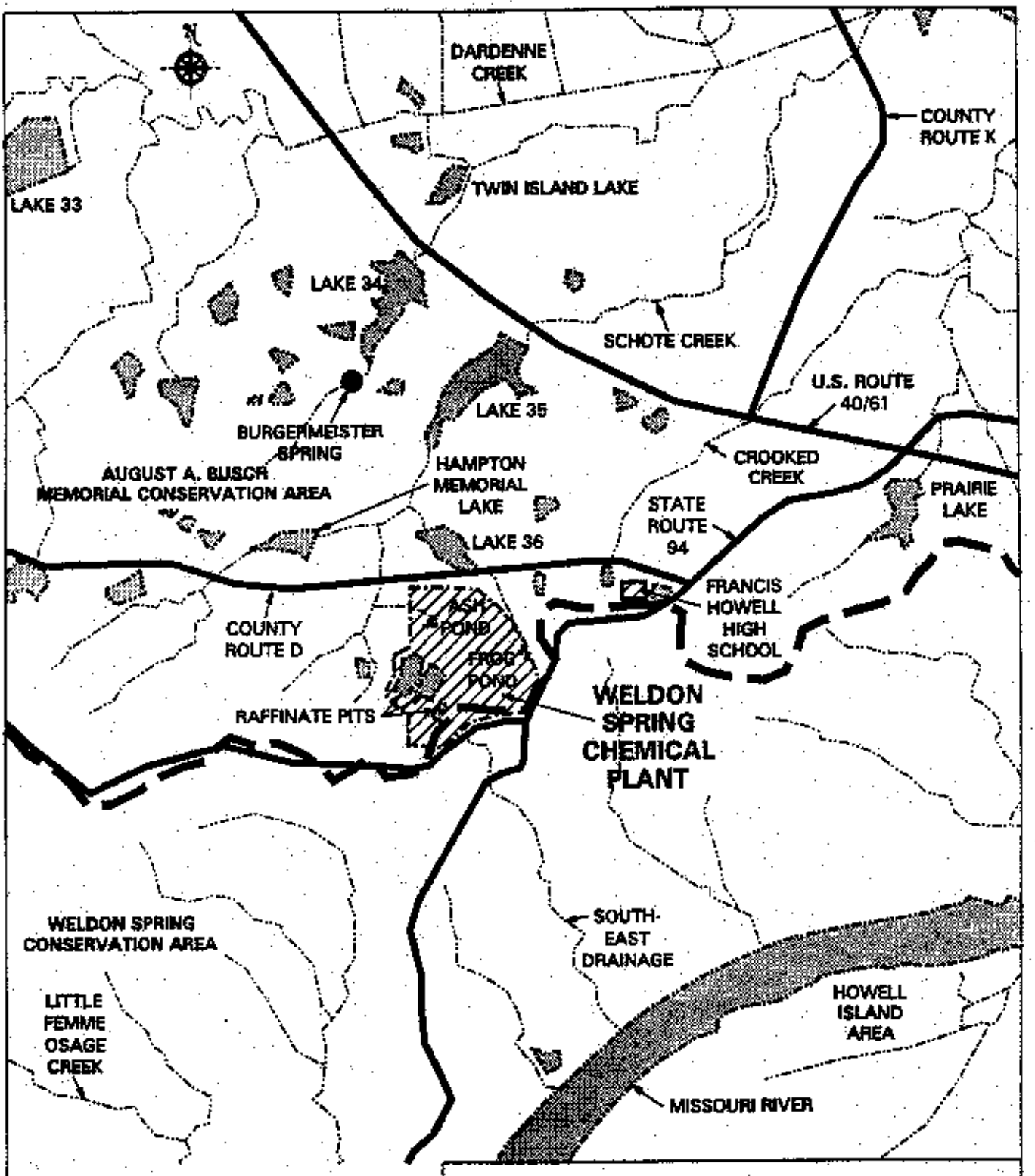
The Weldon Spring Quarry is located in low limestone hills near the northern bank of the Missouri River. The mid-Ordovician bedrock of the quarry area includes in descending order, the Kimmswick Limestone, Decorah Formation, and Plattin Limestone. These formations are predominantly limestone and dolomite. Near the quarry, the carbonate rocks dip to the northeast at a gradient of 11 m/km to 15 m/km (58 ft/mi to 79 ft/mi) (Ref. 4). Massive quaternary deposits of Missouri River alluvium cover the bedrock to the south and east of the quarry.

1.4 Surface Water System and Use

The chemical plant and raffinate pits area is located on the Missouri-Mississippi River surface drainage divide (Figure 1-4). There are eight surface water bodies at the chemical plant area: four raffinate pits, Ash Pond, Frog Pond, the chipped wood storage area pond, and the material staging area (MSA) pond. Portions of Ash Pond were capped in late 1994. As a result of the capping, Ash Pond does not accumulate water unless the valve on the discharge structure is closed. The capacity of Frog Pond was permanently reduced in 1995 when the water level was lowered to allow remediation adjacent to the pond. Elevations on the site range from approximately 185.4 m (608 ft) above mean sea level (msl) near the northern edge of the site to 205 m (673 ft) above msl near the southern edge. The topography of the site is gently undulating in the upland areas, typical of the Central Lowlands physiographic province. South of the site, the topography changes to the narrow ridges and valleys and short, steep streams common to the Ozark Plateau physiographic province (Ref. 4).

No natural drainage channels traverse the site, although remnants of a channel through the Ash Pond area are present. Drainage from the southeastern portion of the site generally flows southward to a tributary referred to as the Southeast Drainage (5300 Drainageway) that flows to the Missouri River.

In the surrounding areas, man-made lakes in the August A. Busch Memorial Conservation Area are used for public fishing and boating. No swimming is allowed in the



LEGEND

SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER

CREEK OR SURFACE DRAINAGE

POND OR LAKE

0 1 MI

0 1.6 KM

SCALE

PHYSICAL FEATURES OF WELDON SPRING AREA

FIGURE 1-4

REPORT NO.: DOE/OR/21548-676		DRAWING NO.: A/VP/076/1193	
ORIGINATOR: MGL	DRAWN BY: GLN	DATE: 4/17/97	

conservation area, although some may occur. No surface water is used for irrigation or as a public drinking water supply. The northern and western portions of the site, including the Frog Pond and Ash Pond areas, drain to tributaries for Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River.

Two sedimentation basins minimize the discharge of sediment from the site during remediation efforts. One basin is downstream of Ash Pond and collects Ash Pond runoff water as well as all waters that discharge at Outfall NP-0003 (see Section 7). The second basin collects water from the northeast section of the site and discharges to Outfall NP-0002.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 km (1 mi) northwest of the Missouri River at approximately River Mile 49. No direct surface water runoff enters or exits the quarry due to the topography of the area. A 0.07 ha (0.2 acre) pond within the quarry proper acts as a sump that accumulates both direct rainfall within the quarry and the groundwater. Past dewatering activities in the quarry suggest that the sump interacts directly with the local groundwater. Bulk waste removal, which included removal of some sediment from the sump area, was completed at the quarry during 1995. The surface area of the sump remains at 0.07 ha (0.2 acres). The quarry pond is not used for any operational or public water supply and is maintained by the DOE within an access-controlled and restricted area. Quarry restoration, including the backfilling of the sump, is expected to begin in 1998 following additional dewatering.

The Femme Osage Slough, located approximately 213 m (700 ft) south of the quarry, is a 2.4 km (1.5 mi) section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri dammed portions of the creeks between 1960 and 1963 during construction of a levee system around the University's experimental farms (Ref. 5). The slough receives contaminated groundwater migrating from the quarry, causing increased uranium concentrations in the slough. The slough is used for recreational fishing.

1.5 Ecology

The Weldon Spring site is surrounded primarily by State Conservation Areas that include the 2,828 ha (6,988 acres) Busch Conservation Area to the north, the 2,977 ha (7,356 acres) Weldon Spring Conservation Area to the east and south, and the Howell Island Conservation

Area, an island in the Missouri River which covers 1,031 ha (2,548 acres) (Figure 1-4). The wildlife areas are managed for multiple uses, including timber, fish and wildlife habitat, and recreation. Fishing comprises a relatively large portion of the recreational use. Seventeen percent of the area is open fields that are leased to sharecroppers for agricultural production. In these areas, a percentage of the crop is left for wildlife use. The main agricultural products are corn, soybeans, milo, winter wheat, and legumes (Ref. 6). The Busch and Weldon Spring Conservation Areas are open year-round, and the number of annual visits to both areas totals about 1,200,000.

Much of the chemical plant area consists of maintained grasslands and old fields (65.5 ha [162 acres]) that are periodically mowed. Grasses and forbs are found in this habitat including big bluestem, timothy, red tip grass, foxtail, fescue, thistle, and goldenrod.

The quarry is surrounded by the Weldon Spring Conservation Area, which consists primarily of forest with some old field habitat. Prior to bulk waste removal, the quarry floor consisted of old-field habitat containing a variety of grasses, herbs, and scattered wooded areas. Since bulk waste removal began this habitat has been disturbed. The rim and upper portions of the quarry still consist primarily of slope and upland forest including cottonwood, sycamore, and oak (Ref. 5).

1.6 Climate

The climate in the Weldon Spring area is continental with warm to hot summers and moderately cold winters. Alternating warm/cold, wet/dry air masses converging and passing through the area cause frequent changes in the weather. Although winters are generally cold and summers hot, prolonged periods of very cold or very warm to hot weather are unusual. Occasional mild periods with temperatures above freezing occur almost every winter and cool weather interrupts periods of heat and humidity in the summer (Ref. 7).

Long-term meteorological records (since 1870) for the St. Louis area were examined to obtain information relevant to the Weldon Spring site. The average annual temperature is 12.8° C (55.1° F). The average daily maximum and minimum temperatures are 19° C (66.2° F) and 6.5° C (43.8° F), respectively. Maximum temperatures above 32.2° C (90° F) occur 35-40 days per year. Minimum daily temperatures below 0° C (32° F) occur about

111 days of the year. Temperatures below -18° C (0° F) are infrequent, occurring only 2-3 days per year. Mean annual precipitation in the area is approximately 94.0 cm (37.0 in.).

Wind data recorded on site since 1994 indicate that prevailing winds are from the south and southwest on an annual basis. The average recorded wind speed is 2.9 m/s (6.6 mph) from the south-southwest.

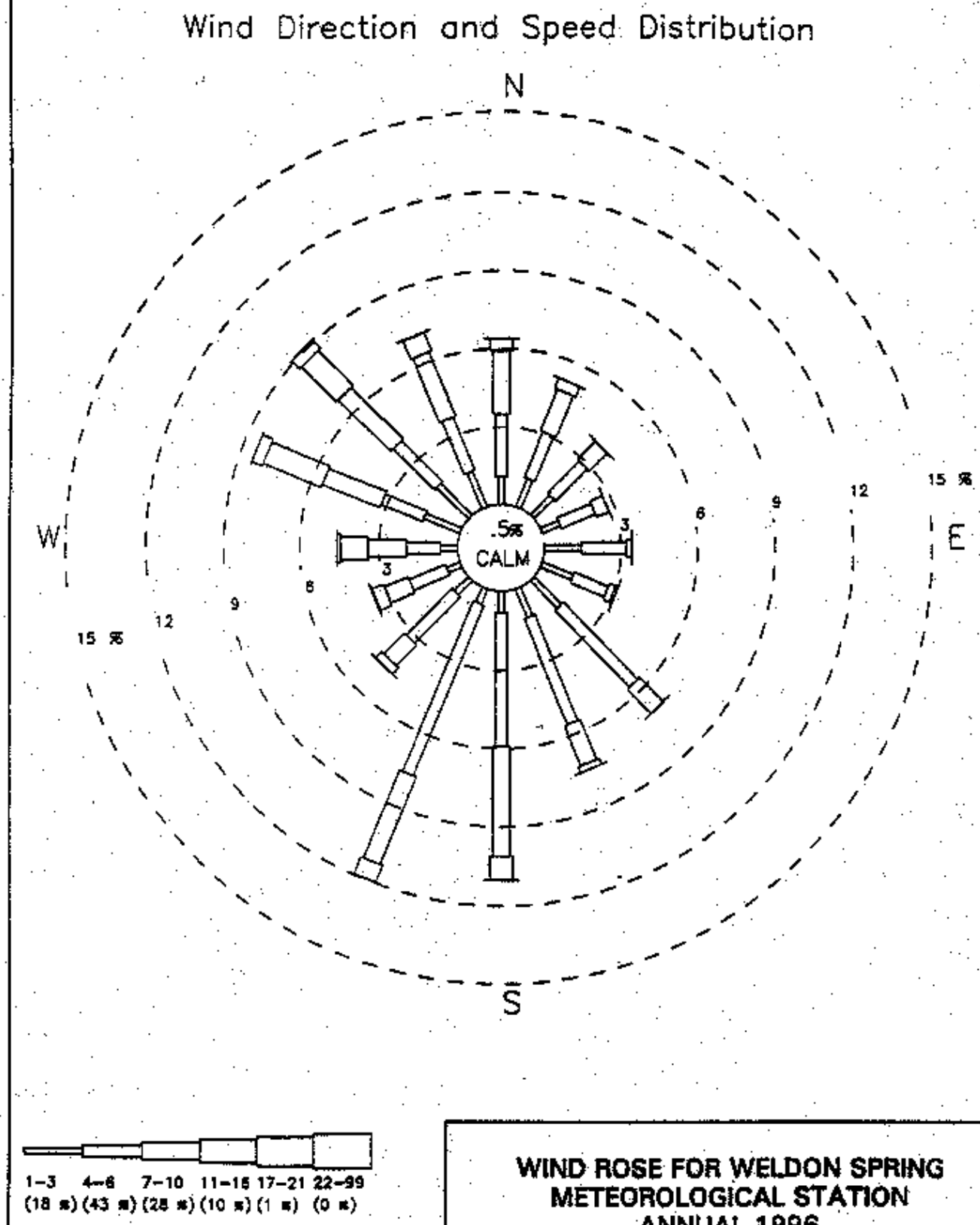
The meteorological station located at the chemical plant provides data to support site environmental monitoring programs. The station provides data on wind speed, wind direction, ambient air temperature, relative humidity, solar radiation, barometric pressure, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which help determine possible impacts of airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

On-site meteorological data recovery exceeded 99% in 1996. The quality of all data was assured by a qualified off-site meteorologist. Averages and totals are presented in Table 1-1. An annual wind rose is presented as Figure 1-5.

1.7 Land Use and Demography

The population of St. Charles County in 1996 was 255,066. The county's population increased by 20% from 1990 to 1996. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 mi) to the northeast. The combined population of these two communities in 1994 was 1,208 (Appendix A). No private residences exist between Weldon Spring Heights and the site.

Francis Howell High School and the Missouri Highway and Transportation Department are both within 1 km (0.6 mi) of the site. Francis Howell High School is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs approximately 200 faculty and staff, and about 2,820 students attend school there (Appendix A). Students and staff generally spend about 7 hours to 8 hours per day at the school. The buildings are also used for other activities, such as athletic events and school meetings. The Missouri Highway and



WIND ROSE FOR WELDON SPRING METEOROLOGICAL STATION ANNUAL 1996

FIGURE 1-5

REPORT NO.: DOE/OR/21548-576		SCHEMT NO.: A/PI/013/0497	
ORIGINATOR: ED	DRAWN BY: GLN	DATE: 4/17/97	

TABLE 1-1 Monthly Meteorological Monitoring Results for 1996

MONTH	TOTAL PRECIP (CM)	AVERAGE TEMP (DEGREES C)	AVERAGE WIND SPEED (M/SEC)	PREDOMINANT WIND DIRECTION
January	4.92	-2.1	3.98	S
February	0.53	1.9	4.02	SSW
March	8.01	4.8	4.07	N
April	21.13	11.7	3.93	SSW
May	12.55	19.2	2.90	SSW
June	12.22	22.9	2.23	SSW
July	10.14	23.6	2.23	SSW
August	2.66	24.3	1.88	SSW
September	9.59	18.5	2.19	NW
October	7.61	13.9	3.04	SSW
November	16.69	3.5	2.73	S
December	1.98	1.8	3.44	WNW
Annual Average/ Total	108.03 (43.04 in.)	12.0	3.05	SSW (12.1%)

Transportation Department, located adjacent to the northern boundary of the chemical plant, employs nine full-time employees (Appendix A). About 300 ha (741 acres) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land is being developed into a high-technology research park. The conservation areas, operated by the Missouri Department of Conservation, employ 25 full-time and part-time employees, including seasonal help during the summer months (Appendix A).

2 ENVIRONMENTAL PROTECTION/RESTORATION PROGRAM OVERVIEW

2.1 Project Purpose

The U.S. Department of Energy (DOE) is responsible for the remedial action activities at the Weldon Spring site. The program is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment posed by the waste materials on the Weldon Spring site and, to the extent possible, make surplus real property available for other uses.

Remedial actions are subject to U.S. Environmental Protection Agency (EPA) oversight under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) of 1980, as amended by the *Superfund Amendments and Reauthorization Act (SARA) of 1986.* Remedial actions at the site are subject to CERCLA requirements because the site is listed on the EPA National Priorities List (NPL). Section 3 of this document further discusses applicable Federal, State, and local compliance requirements and the current status of compliance activities at the Weldon Spring site and incorporating *National Environmental Policy Act* (NEPA) values into CERCLA documents as outlined in the secretarial policy statement on NEPA.

2.2 Project Management

In order to manage the WSSRAP under the CERCLA, the proposed strategy for remedial activities at the Weldon Spring site is organized into the following four separate operable units: Weldon Spring Quarry Bulk Waste, Weldon Spring Chemical Plant, Groundwater, and Quarry Residuals. The Weldon Spring Quarry Bulk Waste Operable Unit includes all wastes deposited in the quarry and their removal. The Weldon Spring Chemical Plant Operable Unit includes the buildings, soils, raffinate pits, quarry bulk wastes that have been relocated to the temporary storage area (TSA), and surface waters within the chemical plant boundary and vicinity properties. The Groundwater Operable Unit includes the groundwater at the chemical plant and vicinity areas. The Quarry Residuals Operable Unit includes the quarry proper (post-bulk waste removal), surrounding areas, surface waters, and groundwaters.

2.3 Environmental Monitoring Program Overview

The overall goal of the WSSRAP is different from that of most operating and production facilities for which DOE Order 5400.1, *General Environmental Protection Program*, was developed. At the WSSRAP, environmental monitoring is conducted as required by DOE Order 5400.1 to measure and monitor effluents and to provide surveillance of effects on the environment and public health. In addition to these objectives, environmental monitoring activities support remedial activities under the CERCLA. This requires a careful integration of WSSRAP activities to implement all the environmental and public health requirements of the CERCLA, DOE orders, and other relevant Federal and State regulations.

The WSSRAP also complies with DOE Order 5400.1 requirements for preparation and maintenance of an *Environmental Protection Program Implementation Plan* (EPPIP) (Ref. 8) and an *Environmental Monitoring Plan* (EMP) (Ref. 42). The EPPIP details the programs in place at the WSSRAP to provide management direction, environmental protection goals and objectives, the remedial status of the project, and the overall framework of the environmental protection program at the WSSRAP. The EMP details the schedule and analyses for performing effluent monitoring and environmental surveillance activities.

The WSSRAP environmental protection program involves radiological and chemical environmental monitoring and is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of substances in environmental media at the facility boundary, in contaminant migration pathways, and in pathways subject to compliance with applicable regulations (e.g., *National Emission Standards for Hazardous Air Pollutants* [NESHAPs]) or permit levels and requirements (e.g., *National Pollutant Discharge Elimination System* [NPDES]). Environmental surveillance consists of analyzing environmental conditions within or outside the facility boundary for the presence and concentrations of site contaminants. The purpose of this surveillance is to detect and/or track the migration of contaminants. Surveillance data are used to assess the presence and magnitude of radiological and chemical exposures and to assess the potential effects to the general public and the environment.

The WSSRAP environmental monitoring program involves sampling various media for radiological constituents; primarily U-234, U-238, Ra-226, Ra-228, Th-230, and Th-232. These

radionuclides are the primary radiological contaminants of concern at the Weldon Spring site. Radiological monitoring is conducted routinely at perimeter locations and at off-site locations near the chemical plant and quarry for air particulates, ambient gamma radiation, and radon. Radiological monitoring is also conducted on NPDES discharges, streams, lakes, ponds, groundwater and springs.

Chemical monitoring is primarily conducted at the chemical plant and quarry areas, but also includes monitoring at off-site locations to confirm that no releases have occurred. The nonradiological compounds included in the routine 1996 monitoring program are metals, inorganic ions (nitrate and sulfate), and nitroaromatic compounds. Other non-radiological parameters monitored as part of the environmental monitoring program include asbestos at site perimeter air monitoring locations and geochemical parameters such as calcium, manganese, and sodium at selected groundwater locations. The geochemical data are used in characterization and contaminant flow transport studies.

2.4 Project Accomplishments in 1996

Several activities were completed in 1996 under the overall plan for remediation of the site. All four operable units are currently active, and major accomplishments for all units are detailed below.

2.4.1 Weldon Spring Chemical Plant Operable Unit

2.4.1.1 Site Water Treatment Plant. Ongoing discharges of treated water into the Missouri River have consistently been below the effluent standards set forth in the conditions of the chemical plant's NPDES permit. During 1996, 166,540,000 liters (44 million gallons) of contaminated water were treated and discharged.

2.4.1.2 RCRA/TSCA Storage. The *Resource Conservation and Recovery Act* (RCRA) and *Toxic Substances Control Act* (TSCA) storage facility, Building 434, activities included the transfer and off-site disposal of approximately 401 containers of liquid waste to the K-25 incinerator in Oak Ridge, Tennessee. One-hundred-one containers were RCRA/Department of Transportation (DOT) regulated, 16 containers were TSCA regulated, 228 containers were both RCRA/DOT and TSCA regulated, and 56 containers were either regulated

by DOT, Missouri Department of Natural Resources (MDNR), or not regulated. Other activities included sampling of approximately 40 containers for proposed shipment to the K-25 incinerator in 1997, returning numerous laboratory samples to the original containers, and compacting approximately 468 drums of radiological trash and personal protective equipment (PPE).

2.4.1.3 Disposal Cell. The disposal cell design was finalized and construction of the cell will be initiated through the direct hire organization of the Project Management Contractor. Bench scale and pilot in situ studies were conducted for developing a treatment for the nitroaromatically contaminated soils on the temporary storage area.

A revised NPDES permit was obtained in conjunction with obtaining a construction and operating permit for the disposal cell leachate recovery system construction. Currently, all leachate collected during waste placement and prior to cell closure will be treated and released through Outfall 7.

2.4.1.4 CSS Pilot Facility. This facility was used primarily for stabilizing high selenium brine waste. Cement and fly ash were added to the brine and mixed in the pugmill. After mixing, the brine was discharged into 0.9 m by 1.2 m by 0.9 m (3 ft by 4 ft by 3 ft) precast blocks. Approximately 850 cu yd of brine and miscellaneous containers of RCRA waste were treated and placed at the material staging area (MSA) in the form of blocks.

2.4.1.5 Raffinate Pit Debris Consolidation. Removal of the debris from Raffinate Pits 2 and 4 was the first step in the overall cleanup of the chemical plant pits. The debris was removed so that the underlying sludge could be accessed and dispositioned.

Debris consolidation activities were conducted from April to December 1996. During this time, approximately 2,833 m^3 (3,385 cu yd) of debris were removed from the pits, including approximately 6,130 drums. Wastes were investigated, classified, removed, handled, and placed into storage in accordance with the *Debris Consolidation Work Plan*.

Waste types included process equipment, building debris, polychlorinated biphenyl (PCB)-contaminated oils and solids, uranium/thorium process ores and intermediates, asbestos-containing materials/man-made mineral fibers (ACM/MMF), elemental magnesium and compounds, and compressed gas cylinders, among others.

2.4.1.6 Mixed Waste. The WSSRAP began treatment of mixed wastes under the Federal Facility Compliance Agreement (FFCA) site treatment plan in February 1995. The plan consists of eight treatability groups; (1) aqueous liquids; (2) inorganic sludges and particulates; (3) inorganic debris, metal, and batteries; (4) contaminated debris; (5) liquid mercury; (6) reactives and oxidizers; (7) organic liquids; and (8) organic sludges.

The status of each treatability group during 1996 was as follows:

Aqueous Liquids: Treatment of this treatability group began with batch neutralization of the acids (four drums) and bases (four drums) waste streams in February 1995. Twenty-five drums of various metals-contaminated water were treated by batch treatment in a precipitation tank followed by treatment in the site water treatment plant in December 1995. To complete treatment of the entire treatability group, three drums of metals-contaminated water were treated in February 1996.

Inorganic Sludges/Particulates: Treatment of this treatability group began March 22, 1996. Treatment of three entire waste streams and two partial waste streams has been completed.

Inorganic Debris, Metal, and Batteries: No treatment occurred during this reporting period.

Contaminated Debris: Treatment of this treatability group began July 11, 1996, with the treatment of Waste Stream No. 25.

Liquid Mercury: Bench testing and full-scale treatment of this treatability group (two drums) were completed in March 1995.

Reactives/Oxidizers: Bench testing of this entire treatability group, consisting of several types of wastes, was completed in 1995. Full-scale treatment of the sodium metal waste began April 5, 1996.

Organic Liquids: The Project Management Contractor met with representatives from the U.S. Department of Energy (DOE) Oak Ridge K-25 Incinerator in August 1995, and scheduled

these wastes for shipment to the incinerator in January and February 1996. Composite sampling of approximately 300 drums was completed in October 1995, with analysis performed by Lockheed-Martin, Oak Ridge, Tennessee. Four tanker loads were shipped in January 1996, and the remaining two tanker loads were shipped in May 1996 due to K-25 operations interruptions. The entire treatability group was treated.

Organic Sludges: Nine drums from this treatability group were shipped to K-25 for treatment; however, it was determined that 10 drums were not acceptable for treatment at K-25 at the present time due to their high solids content.

2.4.2 Weldon Spring Quarry Bulk Wastes Operable Unit

The EPA allowed the Bulk Waste ROD to remain open until June 1996 to facilitate removal of the northeast slope soils. Removal was completed in May 1996 under Work Package 486.

On April 4th, the *Final Bulk Waste Report* was submitted to the EPA.

2.4.2.1 Quarry Water Treatment Plant. Due to slow recharge to the quarry pond, the quarry water treatment plant (QWTP) must be periodically shut down. During 1996, the QWTP treated and discharged approximately 18,925,000 liters (5 million gallons) of treated water. All discharges from this plant were within the effluent standards set forth in the conditions of the NPDES permit for the Weldon Spring Quarry.

2.4.3 Weldon Spring Quarry Residuals Operable Unit

On December 7, 1996, the draft *Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri* and the *Baseline Risk Assessment for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri* were transmitted to the U.S. Environmental Protection Agency, Region 7 and the MDNR for review. Agency comments were received in February 1997. Comments were incorporated and the final draft versions of both documents were distributed in April 1997.

2.4.4 Weldon Spring Groundwater Operable Unit

The draft remedial investigation and baseline risk assessment reports for the groundwater operable unit were submitted to EPA and MDNR in 1996. The WSSRAP and the U.S. Department of the Army worked together to jointly address the groundwater issues for the Weldon Spring Chemical Plant and the Weldon Spring Ordnance Works in these joint documents. The remedial investigation was conducted in 1995 and included a joint sampling effort by the DOE and the U.S. Army Corps of Engineers of all wells in the chemical plant and ordnance works areas. The draft final *Remedial Investigation and Baseline Risk Assessment* was submitted to the EPA and the MDNR on February 20, 1997.

2.5 Incident Reporting - Environmental Occurrences in 1996

In accordance with DOE Order 5400.1, Chapter II, 2.(b), field organizations are required to prepare annual summary reports on environmental occurrence activities and to report this information in the annual site environmental report.

In 1996, seven off-normal occurrences of an environmental nature were reported under DOE Order, *Occurrence Reporting and Processing of Operations Information*. Table 2-1 lists these environmental occurrences for 1996 and the following paragraphs provide short descriptions.

TABLE 2-1 Environmental Occurrences CY1996[c]

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
1996-0003(a)	04/22/96	Noncompliance with NPDES Permit.
1996-0004(a)	04/22/96	PCB contaminated oil spill.
1996-0005(a)	05/04/96	Mislabeled drum emptied into equalization basin.
1996-0008(a)	06/03/96	Noncompliance with annual inspections of backflow prevention devices.
1996-0010(a)	06/06/96	NPDES violation at three outfall locations.
1996-0018(a)	09/26/96	Receipt of notice of violation from MDNR.

TABLE 2-1 Environmental Occurrences CY1996[c] (Continued)

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
1996-0019(a)	10/21/96	NPDES violations at outfall NP-002.

(a) Off-normal occurrence.

Occurrence 1996-0003 involved an NPDES sample from Outfall NP-0010 from the construction material staging area (CMSA). The CMSA is under development and undergoing grading near the outfall for a sedimentation basin. The settleable solids limit for the outfall is 1.0 ml/l/hr, and the actual measured settleable solids were 17.0 ml/l/hr. This was noncompliance with the daily maximum limit. The MDNR was notified.

Occurrence 1996-0004 involved an oily sheen on a puddle near a suspect PCB area. Approximately 18.9 l (5 gal) of suspect PCB contaminated oil spilled from a 208 l (55-gal) drum. Another drum was observed leaking approximately 37.8 l (10 gal) from a 132 l (35 gal) drum. These two spills together added up to approximately 56.7 l (15 gal), exceeding half the reportable quantity at 35.7 kg (75 lb). No personal contamination resulted from this occurrence.

Occurrence 1996-0005 involved a subcontract employee who was assigned to empty the contents of two drums of sodium aluminate product into the site water treatment plant (SWTP) equalization basin. The employee located a 208 l (55-gallon) drum, which he assumed to be sodium aluminate. He opened the drum, added water, and emptied the contents of the drum into the equalization basin. He then observed a green salt material, a piece of concrete, and a piece of iron in the bottom of the drum. The material was verified to be radioactive with a meter. The employee stopped his work and reported his finding to the operator in charge. The employee was donned in proper personal protective equipment for this activity and no exposure occurred.

The contents was determined to be a RCRA hazardous material for barium, based on characterization data. The drum was sent from Building 434 to the SWTP for processing. The labeling on the outside of the drum was improper and inadequate.

Occurrence 1996-0008 involved the PMC receiving two written notices from the Missouri-American Water Company (one of the suppliers of potable water to the project) concerning the requirement under State regulation 10 CSR 60-11.010 to perform an annual inspection on backflow prevention devices (BFPs). As a supplier of potable water to the site, Missouri-American is required to notify its customers and the MDNR if annual inspection reports are not received on or before 45 days following the annual due date, and the company normally alerts customers of upcoming inspection requirements each year.

The PMC conducted a thorough review of its backflow prevention device inspection program. The review resulted in the following findings:

- The BFPs (identified on inventory as Nos. 9, 14, 15, 16, 17, and 18) identified in one of the notices required inspection on February 27, 1996. Copies of the inspection reports are in PMC files and verify that the devices were inspected February 27, 1996. In a discussion with a representative of National Fire Suppression Company (the PMC's inspection subcontractor) it was learned that copies of the reports were not submitted to Missouri-American Water Company.

- A review of PMC records indicated that a total of 18 BFPs were on inventory at the Project. In accordance with 10 CSR 60-11, BFPs must be inspected within 30 days of the annual inspection due date and the subsequent inspection report must be submitted within 30 days following the inspection. Two BFPs located at the quarry (Nos. 12 and 13) were due for inspection on February 15, 1996; however, due to interim repairs the inspection was postponed to align the inspection schedule with other BFPs which are due for inspection in June.

- Two additional BFPs, which were not listed on the current inventory, were identified; one at the chemical stabilization and solidification (CSS) pilot plant and the other at the SWTP Train 2. No initial inspection documentation could be found on these BFPs following installation.

Occurrence 1996-0010 involved samples taken on June 6, 1996, showing noncompliance with daily maximum of 1.0 ml/l/hr for settleable solids at Outfalls NP-0002, NP-0010, and

NP-0116. This is a violation of the National Pollutant Discharge Elimination System permit with the State of Missouri.

Settleable solids for each outfall were:

NP-0002 - 1.2 ml/l/hr
NP-0010 - 38 ml/l/hr
NP-0116 - 15 ml/l/hr

The PMC notified the MDNR by telephone within the 24-hour requirement. A letter was sent to MDNR on June 13, 1996, as required by the permit.

Occurrence 1996-0018 involved receiving a Notice of Violation (NOV) from the Missouri Department of Natural Resources. See Section 3.1.1 MDNR.

Occurrence 1996-0019 involved a storm water sample that was collected at Outfall NP-0002 on October 21, 1996. Settleable solids were 16 ml/l/hr, which is above the daily maximum permit limit of 1 ml/l/hr. The flow at the time was recorded as 2,233 l per minute (590 gal per minute). Precipitation was approximately 3.76 cm (1.5 in.) over a short period of time, and the sample was collected while it was still raining, but after the heaviest period of rain.

This outfall is located approximately 30.5 m (100 ft) downstream of the outlet of Sedimentation Basin 1. Vegetation has been fairly well established in this area and ditches have been riprapped. Most of the flow to the outfall is from Sedimentation Basin 1.

Releases reported to other agencies (i.e., the EPA, National Response Center [NRC]) are not discussed in this section. Refer to Section 3.2.2.1, Release Reporting.

2.6 Special DOE Order Related Programs

In addition to the direct program requirements and documentation required under DOE Order 5400.1, the DOE order specifically requests that other programs be presented in the annual site environmental report, including the groundwater protection management program,

the meteorological monitoring program, and the waste minimization and pollution prevention program. This section also addresses other programs, under DOE Order 5482.1B, such as self assessments, the radiological control program, and the surface water management program at the WSSRAP.

2.6.1 Groundwater Protection Management Plan

The WSSRAP has a formal groundwater protection and management program in place. The policies and practices are documented in the *Groundwater Protection Program Management Plan* (Ref. 13). The plan outlines how monitoring programs will be developed to assess the nature and extent of contaminants in the groundwater, to evaluate potential impacts on public health, and to gather data for remedial decisions. All policies pertaining to groundwater monitoring, including well installation, decontamination, construction, sampling methods, and abandonment methods, are detailed in this plan. The plan also outlines the hydrogeological characterization program conducted as part of CERCLA activities. These include groundwater sampling, water level monitoring, slug tests, tracer tests, and geologic logging.

The plan is currently in revision and will be referred to as the WSSRAP *Groundwater Protection Management Plan*, which is expected to be completed in mid-1997. The revised program will include those practices and policies described above, as well as recently developed strategies for implementing site-wide groundwater protection practices and interdepartmental integration of these practices during all aspects of project management and development. Additionally, the practices and policies have been reviewed and revised to comply with the proposed Federal Regulation 10 CFR 834 *Radiation Protection of the Public and the Environment*, Draft, 1996.

2.6.2 Meteorological Monitoring Program

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. The meteorological station provides data on wind speed, wind direction, ambient air temperature, relative humidity, barometric pressure, solar radiation, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which determine possible impacts of

airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

Since the completion of a system upgrade in August 1994, meteorological data recovery has exceeded 99%. An off-site meteorologist provides monthly data reviews and semiannual maintenance and performance checks for the station.

2.6.3 Surface Water Management Program

The WSSRAP maintains a surface water management program to ensure effective implementation of policies detailed in DOE Order 5400.5 and documented in the *Surface Water Management Plan* (Ref. 14). This program also incorporates the as low as reasonably achievable (ALARA) concept in the execution of the program.

This plan identifies existing and potential water sources, water quality categories, and provides the requirements and methodologies for proper control, management, and disposition of site waters. Erosion and water control, and water management for the quarry and site water treatment plants are also discussed. The key elements of the plan are source identification, characterization, monitoring, engineering controls, and management methods.

2.6.4 Radiation Protection Program

The U.S. Department of Energy issued 10 CFR 835 (*Occupational Radiation Protection*), in December 1993 in the Federal Register; 10 CFR 835 sets the minimum acceptable occupational radiological control standards for DOE facilities. The regulation includes requirements for contamination control, ALARA practices, internal and external dosimetry, facility design and control, internal surveillances, instrumentation and calibration, worker training, posting and labeling, and release of materials from radiological areas.

As of December 31, 1996, the WSSRAP is in full compliance with all applicable sections of 10 CFR 835.

2.6.5 Waste Management Program

The waste management program involves characterization of hazardous chemicals and wastes found on site, proper storage, and management of the waste. This program also encompasses the transportation program, including packaging and shipping of hazardous waste samples. During 1996, 1,197 shipments (mostly environmental samples) were shipped off-site, of which 192 were regulated as hazardous materials. Hazardous and mixed wastes are stored in the on-site RCRA and TSCA storage facility (Building 434) at the asbestos storage area, and temporary storage area until a final treatment or disposal option is available.

2.6.6 Waste Minimization/Pollution Prevention Program

The Weldon Spring Site Remedial Action Project (WSSRAP) Waste Minimization Program is outlined in the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 16) in accordance with the requirements of DOE Order 5400.1. Because long-term, volume-specific goals for waste minimization are not appropriate for nonoperational facilities, the WSSRAP adopted "as low as reasonably achievable" (ALARA) goals.

The program is primarily geared toward material substitution and source or volume reduction minimization methods. This is accomplished by evaluating and reviewing all hazardous chemicals (as defined by 29 CFR 1926.59), before they are purchased or arrive on site, and recommending alternate materials or applying use restrictions. Additional methods routinely employed at the WSSRAP include removing packaging materials from products before they enter the radioactive materials management areas, limiting waste-generating activities during remediation and treatment, consolidating waste during storage, reviewing design specifications for possible methods to minimize waste generation, and segregating waste by waste types. The following is a detailed list of the waste minimization activities conducted during 1996.

- Used personal protective equipment (PPE) is being compacted on site into 208 l (55-gal) containers for on-site storage. Compaction of the PPE will reduce the amount of volume of waste placed in the disposal facility. During the period the WSSRAP generated 468 drums (41,189 kg) of compacted PPE.

- A surplus material inventory is being maintained for materials and equipment that can be reused as opposed to buying duplicates or potentially contaminating duplicate products when they are taken into the radioactive materials management areas. The inventory consists of approximately 240 materials and/or equipment that can be used again.

- One hundred sixty-eight nickel/cadmium and 25 lead batteries were sent back to the manufacturer for recycling.

- One hundred five cubic meters (126 cu yd) of cardboard and 8,000 aluminum cans were collected by a recycler.

- Reusable cotton coveralls are being laundered and reused.

- The WSSRAP gave approximately 150 computers and 150 monitors to a local high school under Executive Order 12821, which allows agencies to transfer educationally related Federal equipment to secondary schools.

- Approximately 100 vehicle and equipment tires were sent to a recycler.

- One hundred sixty-nine incandescent and 1,206 fluorescent light bulbs were shipped to a recycler.

In 1996, the WSSRAP identified numerous products that contained Class 1 and Class 2 chlorofluorinated hydrocarbons, which are being phased out by the Department of Energy. Those products identified were returned to the supplier and substitute materials were obtained. The goal for 1997 is to have no ozone depleting substances on site.

2.6.7 Training

Training is a key element of the environmental protection program. Through training, each employee is instructed in the policies and procedures related to environmental protection.

The training program can essentially be broken into three main areas: (1) required reading, (2) special courses taught on site to convey specific policies or issues, and (3) off-site courses designed to provide instruction for specific areas. Department managers establish training matrixes for each employee to ensure a comprehensive understanding of position requirements and overall policies and program requirements.

3 COMPLIANCE SUMMARY

3.1 Compliance Status for 1996

The Weldon Spring site is listed on the National Priorities List (NPL), and therefore the Weldon Spring Site Remedial Action Project (WSSRAP) is governed by the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) process. Under the CERCLA, the WSSRAP is subject to meeting or exceeding the applicable or relevant and appropriate requirements of Federal, State, and local laws and statutes, such as the *Resource Conservation and Recovery Act* (RCRA), the *Clean Water Act* (CWA), the *Clean Air Act* (CAA), the *National Historic Preservation Act* (NHPA), the *Safe Drinking Water Act* (SDWA), *Endangered Species Act*, and Missouri State regulations. Because the U.S. Department of Energy (DOE) is the lead agency for the site, the *National Environmental Policy Act* (NEPA) values must be incorporated. The requirements of DOE Orders must also be met. Section 3.1.1 is a summary of WSSRAP compliance with applicable Federal and State regulations, and Section 3.1.2 is a summary of the WSSRAP compliance with major DOE Orders.

3.1.1 Federal and State Regulatory Compliance

Comprehensive Environmental Response, Compensation and Liability Act

The WSSRAP has integrated the procedural and documentation requirements of the CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and the NEPA, as required by the policy stated in DOE Order 5400.4.

The WSSRAP used NEPA and CERCLA supporting documentation to prepare the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 24). The ROD was signed in September 1993 by the Environmental Protection Agency and the Department of Energy. This decision document presents the selected remedial action for the chemical plant area of the Weldon Spring site. The preferred remedy for the chemical plant area of the Weldon Spring site is removal, chemical stabilization/solidification of selected site wastes, and disposal on site. The ROD identifies monitoring requirements for this remedial action and for development of a *Mitigation Action Plan*.

The *Engineering Evaluation/Cost Analysis (EE/CA) for the Proposed Removal Action at the Southeast Drainage* (VP-A7 and B4) (Ref. 70) incorporated the required NEPA values as authorized in DOE Order 451.15 a (13).

Missouri Department of Natural Resources

The WSSRAP received a Notice of Violation (NOV) from the Missouri Department of Natural Resources (MDNR), dated September 26, 1996. The subject of the NOV was the inadvertent addition of a drum of hazardous waste that failed the toxicity characteristic leaching procedure (TCLP) for barium to the site water treatment plant equalization basin on May 4, 1996. Please refer to Occurrence Report Number 1996-0018. The NOV cited Section 260.380.1(7) of the Missouri Hazardous Waste Management Law for failure to utilize an authorized hazardous waste disposal facility and assessed a $10,000 fine.

During negotiations on this matter, the WSSRAP submitted responses to the NOV on October 18 and 24, 1996; a conference call was held with the MDNR on November 1, 1996; and another response was submitted by the WSSRAP on November 15, 1996. These responses disputed the allegations made by the MDNR. The MDNR issued another letter on November 27, 1996, which reiterated the original citation and added five additional alleged violations. On December 15, 1996, the WSSRAP responded with a letter that documented compliance with regard to each alleged violation cited by the MDNR. The letter also quoted the MDNR's proposed Rule 10 CSR 11.02, *Incentives for Self-Auditing*, which provides incentives for self-disclosure. The letter offered to settle the matter with the MDNR for a fine of $5,000 and no admission of violations. A formal response to this letter was received from the MDNR on May 7, 1997. The WSSRAP objected to MDNR's proposed settlement language in a letter dated May 19, 1997.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site are managed (as substantive applicable or relevant and appropriate requirements [ARARs]) as required by the RCRA. This includes characterization, consolidation, inventory, storage, treatment, and transportation of hazardous wastes that remained on site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and wastes that are generated during remedial activities.

A RCRA treatment, storage, and disposal permit is not required at the site since remediation is being performed in accordance with decisions reached under the CERCLA. Section 121(e) of the CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

The RCRA was amended by the *Federal Facility Compliance Act* (FFCA), which was enacted on October 6, 1992. The site treatment plan for mixed waste which was required by the FFCA was finalized with a consent agreement with MDNR in October 1995. The *1996 Annual Update to the Site Treatment Plan for the Weldon Spring Site* (Ref. 72) was submitted to the MDNR by October 15, 1996. The Update included *Volume I: Compliance Plan Volume* and *Volume II: Background Volume*. It is submitted in accordance with Section 2.3 of the *Compliance Plan* of the *Site Treatment Plan*. The highlights from the update included (1) the completion of three treatability groups: Aqueous Liquids, Liquid Mercury, and Organic Liquids; (2) the shipment of organic wastes to the K-25 Oak Ridge Incinerator; (3) the proposal of a new target date for the treatability group Organic Sludges; and (4) information regarding the new waste stream: nitroaromatic soils.

RCRA groundwater monitoring for regulated units is discussed in detail in Chapter 8.

Clean Air Act

CAA compliance requirements pertaining to the site are found in Title I -Nonattainments, Title III - Hazardous Air Pollutants (including National Emission Standards for Hazardous Air Pollutants [NESHAPs]) and Title VI - Stratospheric Ozone Protection. NESHAPs dose calculations for 1996 indicate the highest receptor activity was below the NESHAPs standard of 10 mrem (0.1 mSv).

St. Charles County is classified in the *Federal Register* of November 6, 1991, 56 FR 215 as a moderate nonattainment area for ozone. As a moderate ozone nonattainment area, the requirements would affect sources emitting nitrogen oxides (NO_x) and volatile organic compounds (VOCs). At present, these sources do not exist at the WSSRAP.

Under Title III, asbestos and radionuclides are hazardous air pollutants. The standards establish criteria for the control of radionuclide and asbestos emissions. WSSRAP monitoring

programs for radionuclides and asbestos are described in detail in Sections 4 and 6, along with the 1996 status of the monitoring.

Currently, the potential major source categories existing at the WSSRAP do not exceed the threshold limits of 9.07 metric tons per year (mtpy) (10 tpy) of any single hazardous air pollutant or 22.7 mtpy (25 tpy) of a combination of hazardous air pollutants; nor does the project currently store over 3,780 liters (1,000 gal) of gasoline per container on site. Therefore, the project is not subject to the requirement for vapor recovery systems for gasoline distribution. However, the Project Management Contractor (PMC) will continue to monitor the various sources for applicability. The categories of radionuclide emitters are not yet listed because the criteria for defining major and area sources of these pollutants have not been selected. Upon promulgation of the Maximum Available Control Technology standards, the WSSRAP will develop appropriate plans to comply with the standard for each of these source categories.

Sections 608 and 609 of Title VI are applicable to the WSSRAP. Section 608 establishes requirements for national recycling and emission reduction of Class I and II substances (chlorofluorocarbons and hydrochlorofluorocarbons, respectively). The section makes it unlawful to release, vent, or dispose of any Class I or II substances. Requirements in Section 608 apply to servicing, repairing, maintaining, and disposing of any refrigeration system (old or new) or air conditioning system (old or new). Section 609 specifies requirements that pertain to servicing motor vehicle air conditioners and applies to all WSSRAP vehicles. The WSSRAP is complying with Sections 608 and 609 of Title VI of the 1990 CAA amendments by (1) implementing a phase-out policy of ozone-depleting substances by instituting controls in the purchasing and use of these substances; and (2) obtaining copies of the personnel training certifications and equipment approval records for personnel and subcontractors that service any WSSRAP equipment containing Class I or Class II substances (e.g., refrigerators, heating, ventilating, and air conditioning [HVAC] units, abandoned refrigeration units) or any WSSRAP vehicle cooling system.

Clean Water Act

Effluents discharged to waters of the United States are regulated under the *Clean Water Act* (CWA) through regulations promulgated and implemented by the State of Missouri. The

Federal government has granted regulatory authority for implementation of CWA provisions to those states with a regulatory program that is at least as stringent as the Federal program.

Compliance with the CWA at the WSSRAP included meeting parameter limits set in four National Pollutant Discharge Elimination System (NPDES) permits. Under these permits, both effluent and erosion-control monitoring are performed. Section 7 includes additional details on the NPDES permits.

During 1996, 18,925,000 liters (5 million gallons) of water was treated through the quarry water treatment plant (QWTP) and discharged through the QWTP NPDES outfall. In the same period, 166,540,000 liters (44 million gallons) of water was treated through the site water treatment plant (SWTP) and discharged through the SWTP NPDES outfall.

Floodplain Management

The floodplain management Executive Order 11988; 10 CFR Part 1022 is applicable at the Southeast Drainage area, which lies in the Missouri River floodplain. Mitigative measures will be taken to minimize any adverse impacts, and the areas will be restored to original conditions after completion of the removal action. A floodplains notice of involvement was published in the Federal Register on April 16, 1997. After a 15 day public comment period, a floodplain statement of findings was published.

Rivers and Harbors Act

No work activity was conducted during this reporting period that would fall under the Act.

Federal Insecticide, Fungicide, and Rodenticide Act

The WSSRAP maintains compliance with *Federal Insecticide, Fungicide, and Rodenticide Act* requirements through inspection of controlled pesticide/herbicide storage areas. No application of restricted-use pesticides occurred during 1996.

Department of Transportation

Pursuant to U.S. Department of Transportation (DOT) training requirements, the WSSRAP continues to conduct on-site training on hazardous material transportation. The training targets personnel with responsibilities for hazardous materials transportation. The training covers classification of hazardous materials by shipping names, performance based packaging requirements, requirements for marking, labeling and placarding, and proper segregation and modes of transportation. Retraining is required every 3 years.

Safe Drinking Water Act

Currently, the *Safe Drinking Water Act* (SDWA) is not an applicable and/or relevant and appropriate requirement at the WSSRAP. The SDWA is currently being evaluated for its applicability to the groundwater and Quarry Residuals Operable Units.

Emergency Planning and Community Right-to-Know Act

The *1995 Emergency Planning and Community Right-to-Know Act (EPCRA) Tier II* report was completed and provided on January 30, 1996, to the local emergency planning committee (LEPC) and to the Missouri State Emergency Response Commission (MERC).

The *Toxic Release Inventory* (TRI) report was submitted on June 14, 1996, to the EPA for the only chemical (hydrochloric acid) exceeding usage thresholds.

The July 25, 1996, revision to the TRI list made hydrochloric acid reportable only in the aerosol form. This report was resubmitted on September 16, 1996.

National Historic Preservation Act

No activity was conducted during this reporting period that would fall under this Act.

Cultural Resources

A review of existing file and literature information regarding archaeological and historic resources of the Southeast Drainage area and an archeological field survey and evaluation were conducted for the DOE in 1990 (Ref. 70). The field survey entailed a surface examination of the stream bed and exposed cutbacks. One prehistoric lithic artifact (projectile object) was recovered from the stream bed; the artifact exhibited evidence of extensive water transport and probably had been redeposited. No archeological remains were observed in the exposed stream cutbanks. One historic period site (farmstead location) is located at the creek mouth near the confluence with the Missouri River; structures associated with this farmstead were demolished when the U.S. Army acquired the property. No evidence was found of significant cultural remains in the area directly affected by the stream. Neither the isolated prehistoric artifact nor the historic farmstead location appears likely to meet eligibility criteria for listing in the National Register of Historic Places. As engineering design for remediation of the Southeast Drainage progressed, other areas outside of the defined stream channel were identified as locations that would be disturbed during the work. On April 21-24, 1997, a Phase I archeological survey of these locations was performed. No archeological sites were found to be located within the planned construction zone. A survey report will be provided to the State Historic Preservation Officer.

Endangered Species Act

In support of the *EE/CA for the Southeast Drainage* (Ref. 70) the list of endangered and threatened species was reviewed. Federal-listed threatened, endangered, and candidate species have been identified by the U.S. Fish and Wildlife Service as occurring in the Weldon Spring Area (Ref. 70); none of these species are expected to use habitats in the Southeast Drainage. Several State-listed species also occur in the area, and some may use the drainage. The State rare wood frog, a forest-floor-dwelling species, has been found in the Southeast Drainage, and the State rare Cooper's hawk could use terrestrial habitats along the drainage. The western sand darter is a State watch-listed species that has been reported from St. Charles County and may be present in the lowermost reaches of the Southeast Drainage. However, surveys in the drainage have not found this species. No critical habitat has been identified in the Southeast Drainage area, and no adverse impacts to threatened or endangered species are expected to result

from the removal action. Informal consultations have occurred with the U.S. Fish and Wildlife Service; if such species might be affected, the requirement would be applicable.

Engineering Evaluation/Cost Analysis (EE/CA) for Southeast Drainage

The *EE/CA for the Southeast Drainage* (Ref. 70) was completed in August 1996. Under the proposed action selected in the EE/CA, specific contaminated sediment in accessible areas of the drainage would be removed with track-mounted equipment and transported by off-road haul trucks. Implementing the proposed action would require use of three minimal-access routes capable of supporting off-road haul trucks at slow speed. It is anticipated that all of these routes could be constructed without additional clearing and with minimal upgrade. Access would be from the south end of Katy Trail and from temporary previously disturbed off-road routes to the north and south of the upper Southeast Drainage. Excavated materials would be stored temporarily at an on-site storage area, with final disposal in the planned engineered disposal cell for the Weldon Spring site. On the basis of stability testing previously performed for related wastes, the waste material from the excavations would not be treated before disposal (Ref. 70). Characterization data are being used to define the excavation volumes and depths, which typically are 0.6 m to 0.9 m (2 ft to 3 ft) below the surface. The sediment would be excavated with track-mounted loaders, the buckets would be covered with tarpaulins at the excavation site, and the excavated material would be hauled out of the drainage to haul trucks at the staging areas. Multiple trips would be made by the track loaders to avoid building a road in the drainage. The materials would be hauled to the site from the staging areas in off-road trucks.

Locations selected for soil removal were determined using risk-based concentrations calculated by combining the appropriate intake and risk equations for the exposure pathways identified for both current and future land use scenarios (Ref. 70). The most likely scenario is that a hunter that would hunt in the drainage 20 times a year, for 4 hours each event, over a duration of 10 years. Another hypothetical use scenario involves a child playing in the drainage 90 times a year, for 4 hours each time, over a 10 year period. At a 1×10^{-5} risk level, concentrations are as follows: Ra-226, 13 pCi/g; Ra-228, 13 pCi/g, Th-230, 350 pCi/g; and U-238, 290 pCi/g. The concentration limit for U-238 includes the contribution from U-234, and the level for Ra-228 includes the contribution from Th-228. For comparison, the equivalent risk-based cleanup criteria for each radionuclide for the hunter scenario are 60 pCi/g for both Ra-228 and Ra-226, 1,600 pCi/g for Th-230, and 1,300 pCi/g for U-238.

3.1.2 DOE Order Compliance

3.1.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment. DOE Order 5400.5 establishes primary standards and requirements for DOE operations to protect members of the public and the environment against undue risk from radiation. The DOE operates its facilities and conducts its activities so that radiation exposures to members of the public are maintained within established limits.

The annual dose to the maximally exposed member of the public as a result of activities at the Weldon Spring site was below the 100 mrem (1 mSv) guideline for all potential exposure modes. The 10 mrem (0.1 mSv) annual dose limit for public exposure to airborne emissions, excluding radon and its respective decay products as specified in 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*, was not exceeded in 1996. The appropriate dose evaluation techniques were used to assess 1996 environmental monitoring and surveillance data in compliance with this requirement.

The annual average uranium concentrations at all NPDES outfalls were below the derived concentration guideline (DCG) of an annual average of 600 pCi/l (22.2 Bq/l).

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 1996 are being maintained in accordance with the requirement of this order. All reports and records generated at the WSSRAP in 1996, pursuant to DOE order requirements, presented data in the units specified by the applicable regulation or order.

3.1.2.2 DOE Order 5820.2A, Radioactive Waste Management. DOE Order 5820.2A establishes policies, guidelines, and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities. The Weldon Spring site was in compliance with the applicable portions of Chapter IV management of waste containing Area 11e(2) by-product material and naturally occurring and accelerator produced radioactive material, Chapter V (decommissioning of radioactively contaminated facilities), and Chapter VI (administrative activities related to the *Waste Management Plan* [Ref. 20]). The types of wastes addressed in Chapters I, II, and III of the Order were not present at the site. While the term "low level waste" is used in the FFCA site treatment plan abatement order, we expect to be able

to clarify the definition of these wastes to reflect that they are by-product materials as defined in DOE Order 5820.2A.

3.1.2.3 DOE Order 5400.1, General Environmental Protection Program. The WSSRAP conducted both radiological and nonradiological environmental monitoring programs at the site and vicinity properties. Environmental monitoring required by DOE Order 5400.1 was conducted to measure and monitor effluents and to provide surveillance of their effects on the environment and public health.

The WSSRAP was in compliance with Order 5400.1 requirements for preparation of an *Environmental Protection Program Implementation Plan* (EPPIP) (Ref. 8). The EPPIP details programs in place at the WSSRAP to provide management direction, environmental protection goals and objectives, and the overall framework for the environmental protection program at the WSSRAP. The project has prepared an *Environmental Monitoring Plan* (Ref. 42) that is reviewed annually and revised as necessary.

In addition to the plans developed for overall environmental monitoring and protection, the WSSRAP annually reviews and revises, as necessary, the *Groundwater Protection Program Management Plan* (Ref.13) and the *Waste Minimization and Pollution Prevention Awareness Plan* (Ref. 16). Refer to Section 2.6 for additional details.

3.2 Current Issues and Actions

3.2.1 Current Issues

3.2.1.1 National Emission Standards for Hazardous Air Pollutants Compliance. The WSSRAP has developed a critical receptor monitoring program for compliance with the requirements of 40 CFR 61 Subpart H. Point source and environmental monitoring has been mandated per 40 CFR 61.93 (b)(5), whereby air concentrations are monitored at six designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by the U.S. Environmental Protection Agency (EPA). The EPA has also approved the WSSRAP plan to report annual

monitoring results and effective dose equivalents at critical receptor locations via the annual site environmental report.

3.2.2 Current Actions

3.2.2.1 Release Reporting. No reportable releases occurred during this reporting period.

3.2.2.2 Functional Appraisal - Environment, Safety and Health, and Quality Assurance. As a result of a request from the DOE, an internal assessment of environmental safety and health functional areas at the WSSRAP was performed in December 1996. The assessment specifically evaluated the following areas of concern:

- Timeliness of reporting.
- Incident investigation (incident critique).
- PMC oversight of environmental safety and health functional areas.
- Adherence to procedures.

The final report for Assessment No. 96-PMC-ESH-027 was issued on February 19, 1997, and included four Items of Concern (see Project Quality Department Assessment File 96-PMC-ESH-027 for details). Based upon the acceptance of the PMC's response to each item of concern, the assessment was closed on March 31, 1997.

3.3 Summary of Permits for 1996

Various permits were maintained by the WSSRAP for remedial activities including NPDES, excavation, and floodplain permits. Table 3-1 provides a summary of all NPDES permits. Three active NPDES permits covered discharges from the site water treatment plant (MO-01077701), quarry water treatment plant (MO-0108987), and storm water discharges from the Borrow Area and Borrow Area haul road (MO-R100B69). An NPDES permit construction permit for the leachate collection removal system of the cell was issued in January 1997.

3.4 Site Remedial Mitigation Action Plan

The progress of the mitigative actions for the remediation of the Weldon Spring site is reported annually in the annual site environmental report in accordance with DOE Order 5440.1E. Information on the implementation of the *Mitigation Action Plan for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 18) and the effectiveness of the mitigation action are reported annually.

Construction activities at the Weldon Spring site are managed by using good engineering practices for control of surface water runoff at, and from, the site. During 1996, four sedimentation basins and two retention ponds were in place at the chemical plant area in preparation for soil excavation activities planned for 1996. Surface water protection during 1996 included erosion prevention and sediment control and monitoring. Monitoring was conducted at four outfall locations at the chemical plant, and the requirements of three NPDES permits and the *Missouri Clean Water Act* were observed during 1996.

The wetlands mitigation agreement was signed in 1994 and construction of the replacement wetlands for the chemical plant area, Borrow Area, and haul road is scheduled to be completed in August 1997. Construction activities eliminated some wetlands in these areas during 1996. Development of the replacement wetland on the Busch Memorial Conservation Area was initiated in 1996; the development will be monitored to ensure establishment of viable wetland features.

Topsoils and subsoils from the Borrow Area that are being stored for restoration have been stockpiled at the Borrow Area. Stockpile heights and slopes have been limited to 15 ft and 3:1 and stockpiles have been seeded and mulched to control erosion. Erosion control measures have also been implemented at the Borrow Area and the haul road. Stockpiles are routinely inspected for erosion. Two sedimentation ponds have been constructed at the Borrow Area, and surface water has been monitored to measure the effective removal of settleable materials.

TABLE 3-1 Summary of WSSRAP NPDES and Construction Permits

PERMIT NO.	(a)	DATE ISSUED	DATE EXPIRED	(b)	DATE RENEWAL OR EXTENSION REQUEST DUE	SCOPE AND COMMENTS
MO-0107701	O	03/03/94	03/04/99	Y	09/04/98	Covers storm water, sanitary, and SWTP discharges.*
MO-0108987	O	06/09/94	06/10/99	Y	01/10/99	Covers QWTP discharge.
MO-R100B69	O	09/01/94	06/11/97	N	12/11/96	Storm water discharges from the borrow area and haul road operations.

(a) Permit type, O = Operating, C = Construction
(b) Permit extended/renewed? N = No, Y = Yes
QWTP Quarry water treatment plant
SWTP Site water treatment plant
* See Section 3.5

During the development of the Borrow Area in 1996, vehicle and equipment noise levels were monitored to ensure that nuisance noise levels remained at acceptable levels. Roadways were sprayed with water on an as-needed basis for dust control during the active construction periods at the Borrow Area.

Air, surface water, and groundwater have been monitored as part of the routine environmental monitoring activities at the chemical plant area. Results of that monitoring are detailed extensively in this report.

Eligibility surveys for archeological or historic sites were conducted on the 30.5 m (100 ft) site perimeter around the chemical plant site, and no sites were found that would require avoidance or data recovery. Confirmation letters in regard to this decision have been received by the State Historic Preservation Officer.

4 RADIATION AND ASBESTOS MONITORING PROGRAMS

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental monitoring and surveillance program in accordance with U.S. Department of Energy (DOE) Orders and with the *Environmental Monitoring Plan* (Ref. 42). This section describes monitoring results for radon, external gamma radiation, airborne radioactive particulates, contamination control surveys, and asbestos at various site perimeter and off-site locations. A program overview, summary of applicable standards, actual monitoring results, and an assessment of any associated environmental impacts are provided below for each parameter mentioned in the plan.

4.1 Highlights of Radiation and Asbestos Monitoring

- Statistical analysis at the 95% confidence level indicated that one integrated radon track-etch monitoring station at the chemical plant/raffinate pits area exceeded annual average background levels in 1996. This monitoring station was located within the site boundary. No integrated radon track-etch stations along the site perimeter or at critical receptor locations were statistically greater than background levels.

- Statistical analysis at the 95% confidence level indicated that four modified Rn-220 track etch monitoring locations in the chemical plant/raffinate pits area exceeded 1996 average background levels. The highest above background Rn-220 concentration was 57% of the DCG for Rn-220.

- Gross TLD results for 1996 for the chemical plant perimeter, quarry perimeter, and off-site locations ranged from 53 mrem/yr (0.53 mSv/yr) to 95 mrem/yr (0.95 mSv/yr). Statistical analysis of the results indicate at the 95% confidence level that one quarry station and four chemical plant/raffinate pit stations exceeded background levels.

- Asbestos analyses performed during 1996 showed fiber concentrations at all monitoring locations to be in compliance with the U.S. Environmental Protection Agency (EPA) acceptable clearance levels for schools.

- Statistical analysis at the 95% confidence level indicated all 17 low volume airborne particulate monitoring stations had annual average concentrations that were indistinguishable from background levels.

4.2 Radon Gas Monitoring Program

4.2.1 Program Overview

Both U-238 and Th-232 are naturally occurring radionuclides in soil and rock. Radon gases (i.e., Rn-222 and Rn-220) are naturally occurring radioactive gases found in the uranium and thorium decay series. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 and Th-232 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon is produced at the Weldon Spring site from these natural sources as well as from the contaminated waste materials present at the site.

Airborne radon concentration is governed by source strength and dilution factors, both of which are strongly affected by meteorological conditions. The soil surface constitutes the largest source of radon, although secondary contributors include oceans, natural gas, geothermal fluids, volcanic gases, ventilation from caves and mines, and coal combustion. Radon levels in the atmosphere have been observed to vary with height above the ground, season, time of day, and location. The chief meteorological parameter governing airborne radon concentration is atmospheric stability; however, the largest variations in atmospheric radon occur spatially (Ref. 73).

Two types of track etch detectors are used at the WSSRAP to measure ambient levels of radon gas: standard "F-type" detectors, which measure a combination of Rn-222 and Rn-220 gas (results are termed "integrated"), and modified "M-type" detectors, which indirectly indicate ambient levels of Rn-220 only. "F-Type" and "M-type" track etch detectors are used in conjunction to distinguish Rn-222 and Rn-220 concentrations by analyzing the relative response of paired sets of these detectors at each monitoring location where they are deployed.

In 1996, a pair of standard "F-type" radon track etch detectors was deployed at each of 35 permanent monitoring locations: five at the Weldon Spring Chemical Plant (WSCP)

perimeter, seven at the Weldon Spring Quarry (WSQ) perimeter, 14 at the raffinate pits area, two at the chemical stabilization and solidification (CSS) pilot facility, and seven at off-site locations. One pair of detectors was temporarily deployed in 1996 near Train 2 at the site water treatment plant. Most radon track etch monitoring locations are identified with an "RD" prefix and are shown in Figures 4-1, 4-2, 4-3, and 4-4; however, monitoring locations adjacent to the CSS pilot facility are identified by ET-3015 and ET-3016 and are shown in Figure 4-5. Monitoring locations are distributed around the chemical plant, raffinate pits, and quarry perimeters to ensure adequate detection of radon under varying meteorological conditions. Locations RD-4005 and RD-4009 monitor background radon concentrations. "F-type" track etch detectors are sensitive to all isotopes of radon and are deployed quarterly.

Modified "M-type" alpha-track detectors were deployed in 1996 at 22 monitoring locations: five at the WSCP perimeter, two at the WSQ perimeter, seven at the raffinate pits area, one at the CSS pilot facility, one near Train 2 of the site water treatment plant, and six at off-site locations (including two background locations, RD-4005 and RD-4009). Specific locations are identified in Section 4.1.3. These detectors were placed in conjunction with "F-Type" track etch detectors to distinguish radon from thoron concentrations. Using Pearson's method (Ref. 49), separate concentrations of radon and thoron were calculated for these stations.

The WSSRAP radon monitoring program also uses electret detectors. Like track etch detectors, electret detectors provide a passive means of measuring radon gas concentrations in air. Twenty-eight pairs of electret detectors that measure Rn-222 only were placed at the following monitoring locations: 22 in the chemical plant and raffinate pits area (including three along the chemical plant perimeter), four at the quarry perimeter, and two off site. Ten pairs of electrets that indicate Rn-220 were deployed at the following locations: six in the vicinity of the raffinate pits and temporary storage area (TSA), two at the quarry perimeter, and two off site (including one background location, ET-4009). Electrets are exchanged and read biweekly. These locations, designated by an "ET" prefix, are shown in Figures 4-1 through 4-5.

Continuous radon gas monitors and radon progeny monitors (also called working level monitors) complete the environmental radon monitoring network. Continuous radon gas monitors are sensitive to both Rn-222 and Rn-220. A continuous radon gas monitor was placed at the Francis Howell High School during spring and fall of 1996. Four additional monitors were placed in on-site work zones throughout the year to evaluate local airborne levels of

Rn-222 and Rn-220 present as a result of remediation activities. On-site locations included the raffinate pits and Train 2 of the site water treatment plant.

Working level monitors are sensitive to the short-lived decay products of Rn-220 and Rn-222. Results are recorded in milli-working levels (mWL). Working level monitors are used in work zones in conjunction with continuous radon gas monitors to determine the degree of equilibrium of radon (or thoron) gas with its decay products. The working level monitors operated during 1996 at the Francis Howell High School, quarry trailers, raffinate pits, CSS pilot facility area, TSA, and AP-2005.

4.2.2 Applicable Standards

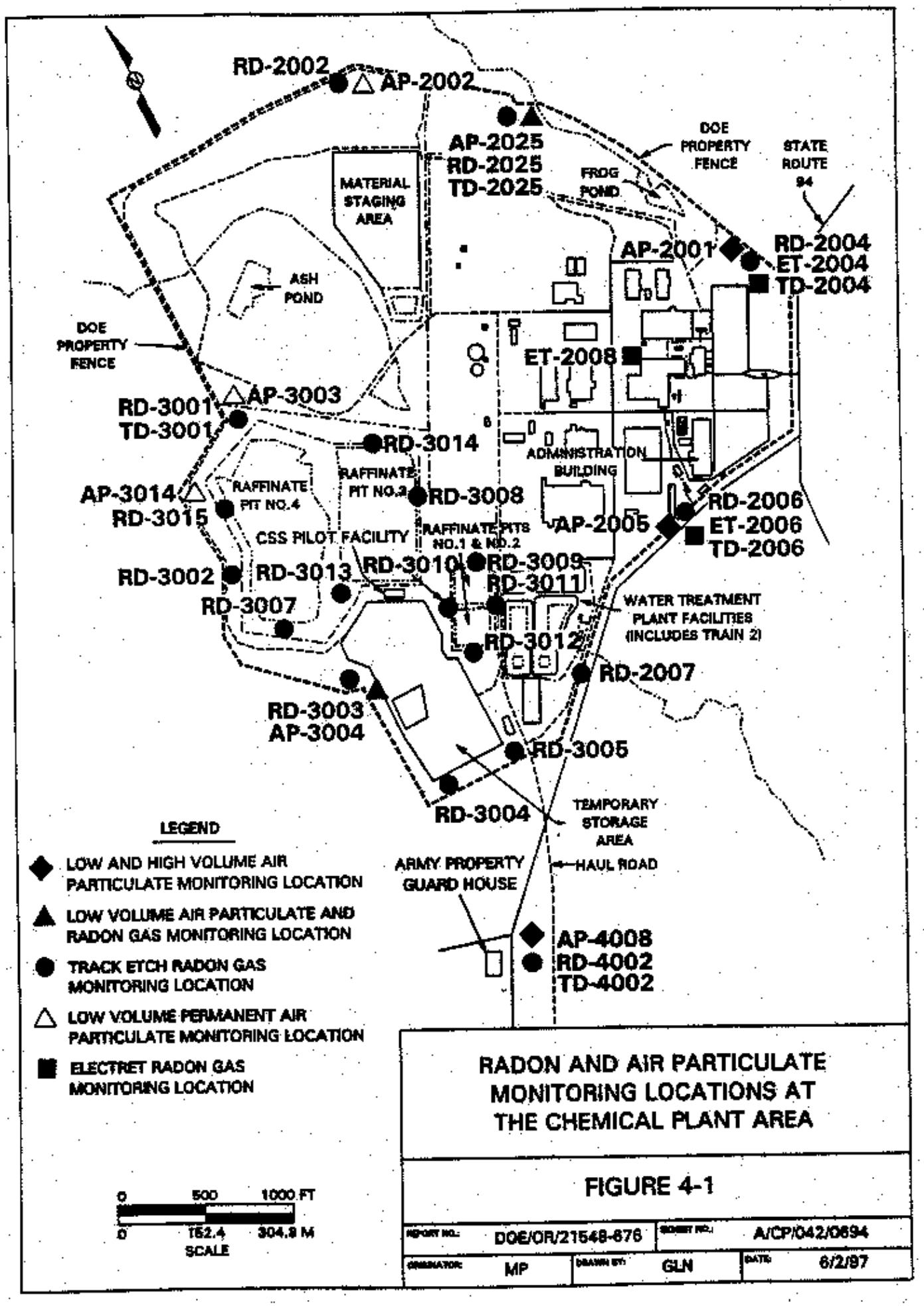
As established by DOE Order 5400.5, the DOE annual public dose equivalent limit is 100 mrem (1 mSv). Dose limits for the inhalation of radon and thoron progeny and gas, however, are based on working levels, and concentrations in air and are addressed independently in the Order.

The derived concentration guide (DCG), which is a limiting airborne concentration of a specified radionuclide, is specified by DOE 5400.5 to be 3 pCi/l (100 Bq/m^3) above background for both radon and thoron in unrestricted (off-site) areas.

4.2.3 Monitoring Results

Table 4-1 summarizes quarterly and annual average integrated radon concentrations as measured by F-type track etch detectors. Since radon is naturally occurring, concentrations measured at each monitoring location were compared to measured background concentrations to determine whether any significant differences existed at the 95% confidence level. Only locations with integrated radon concentrations statistically greater than background were compared to the DCG for radon by subtracting the average annual background concentration from the gross annual average concentration measured at a given location.

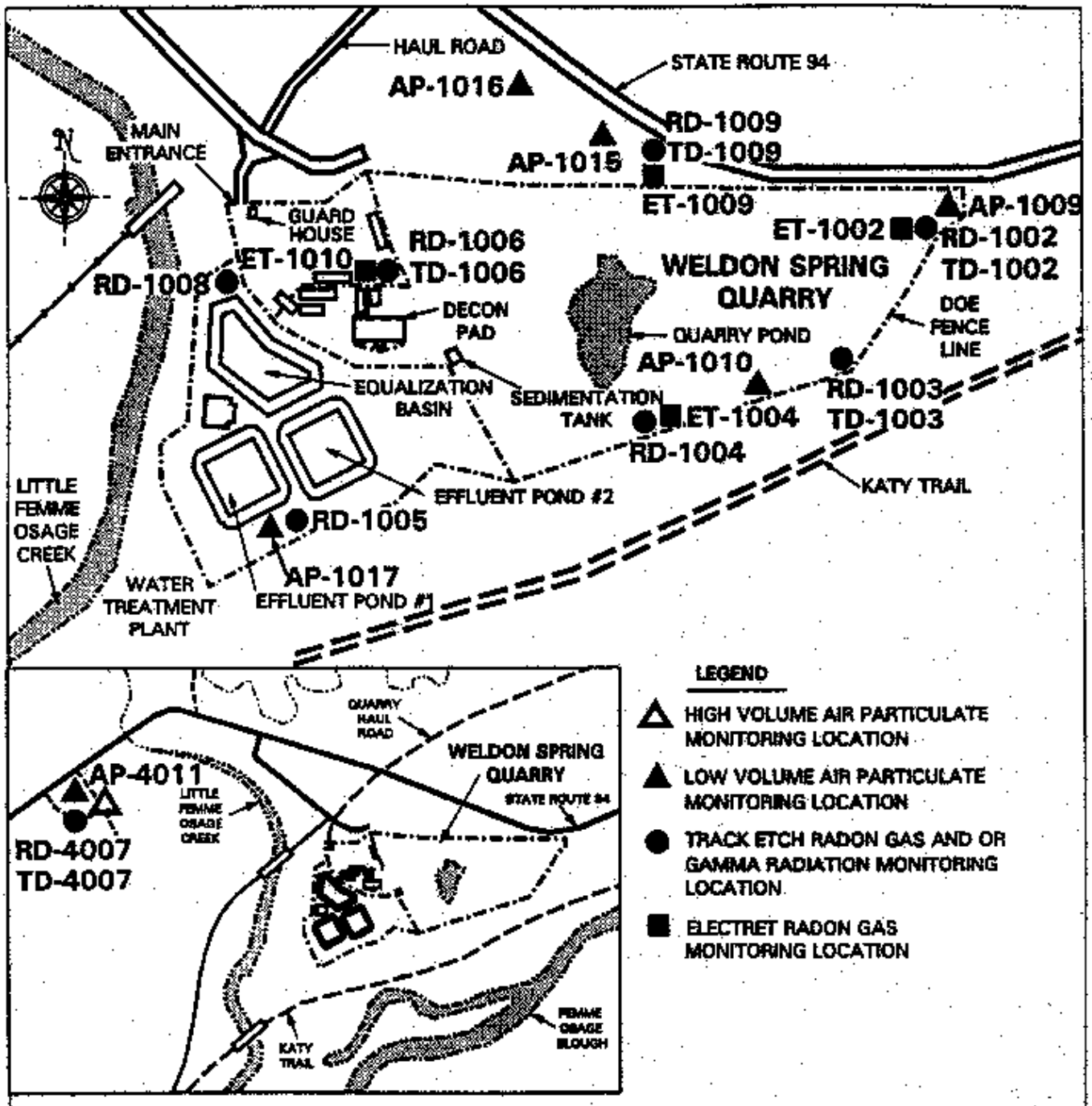
The results obtained from the pair of F-type track etch detectors at each location were averaged to determine the quarterly average integrated radon concentration. These averages were then used to calculate the annual average integrated radon gas concentration. The annual



RADON AND AIR PARTICULATE MONITORING LOCATIONS AT THE CHEMICAL PLANT AREA

FIGURE 4-1

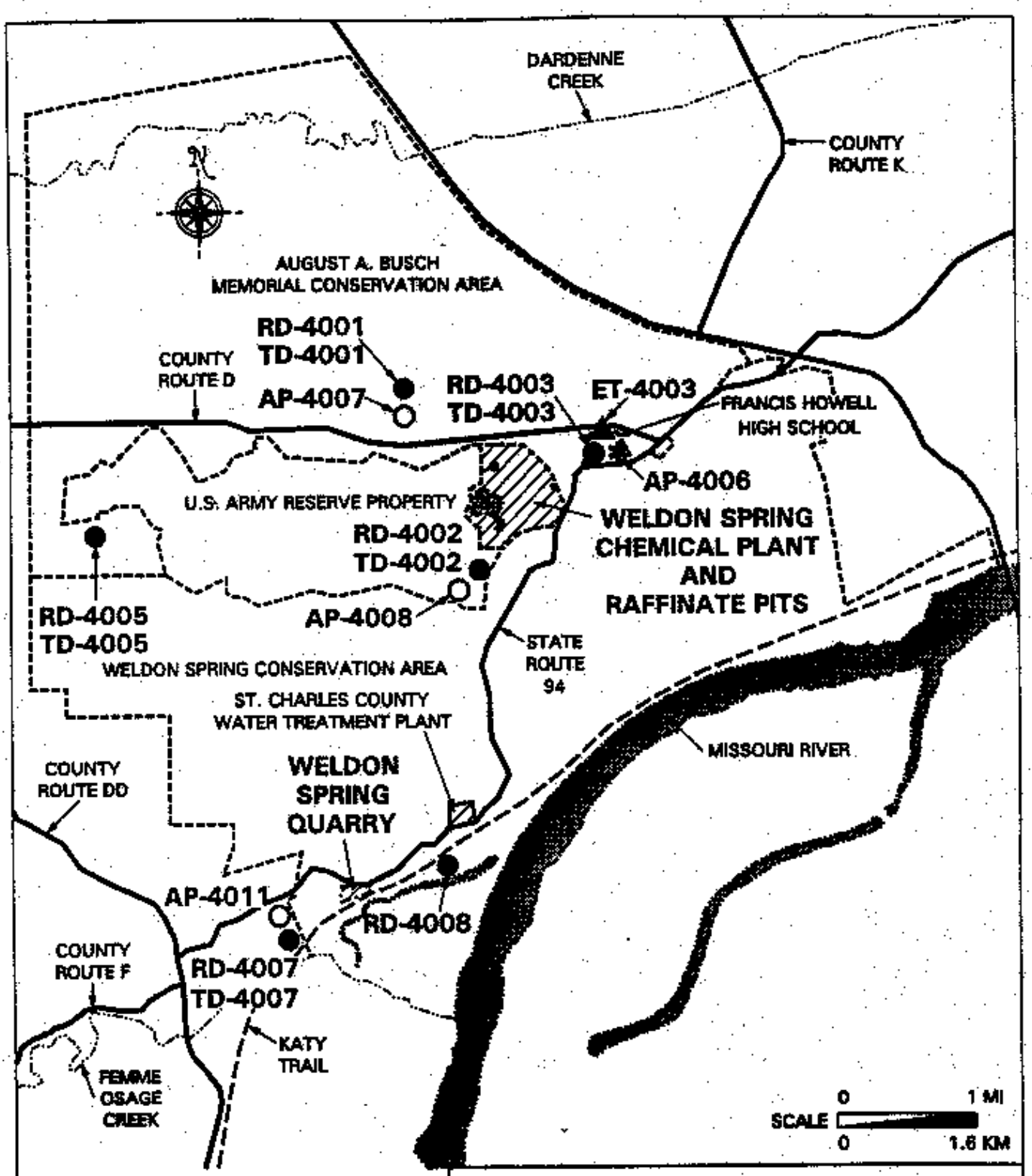
REPORT NO.: DOE/OR/21548-676		SHEET NO.: A/CP/042/0694	
ORIGINATOR: MP	DRAWN BY: GLN	DATE: 6/2/97	



AIR MONITORING LOCATIONS AT THE WSQ AREA

FIGURE 4-2

REPORT NO.: DOE/OR/21548-678		DWGS NO.: A/QY/059/1194	
OPERATOR: EKA	DRAWN BY: GLN	DATE: 5/2/97	



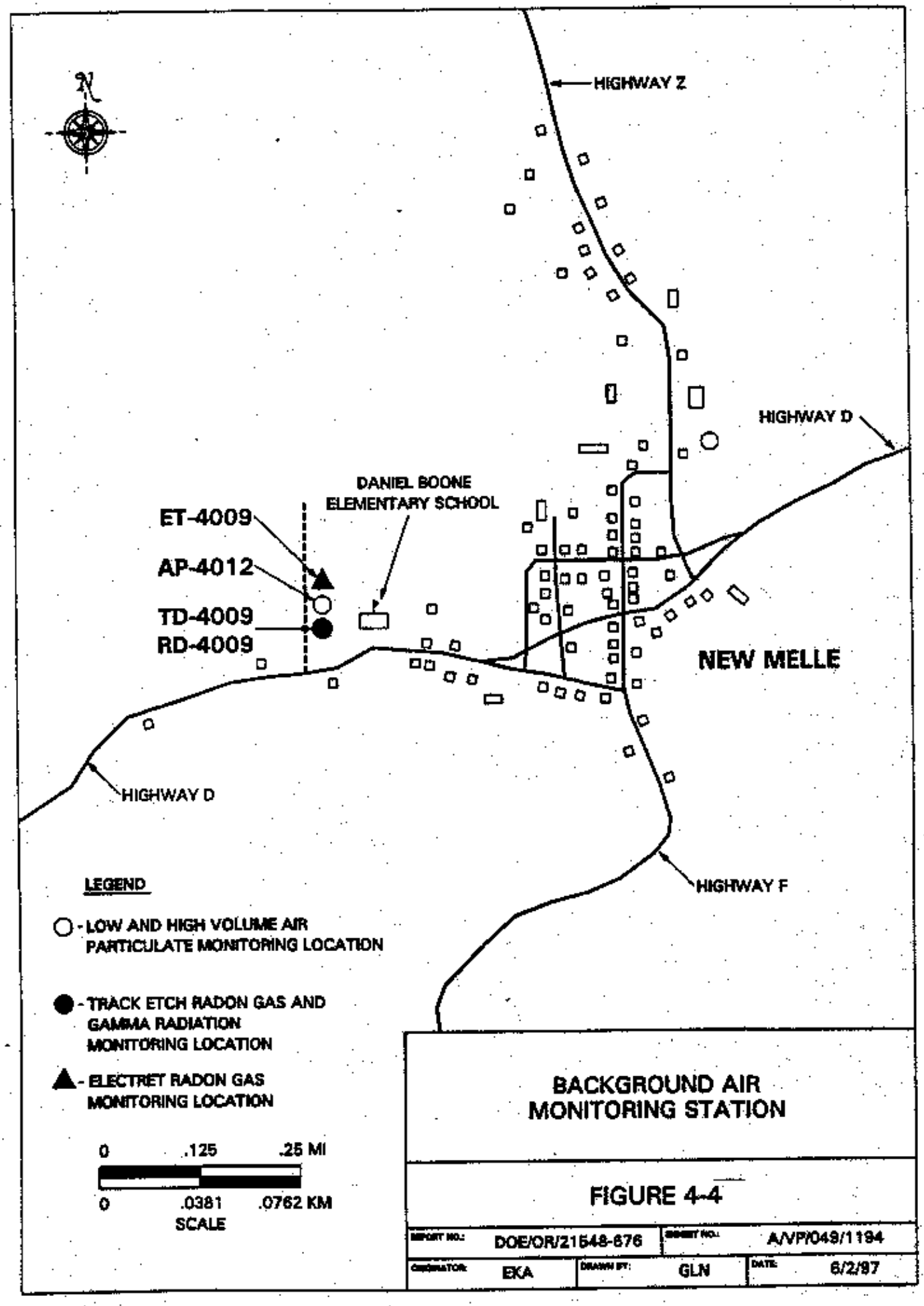
LEGEND

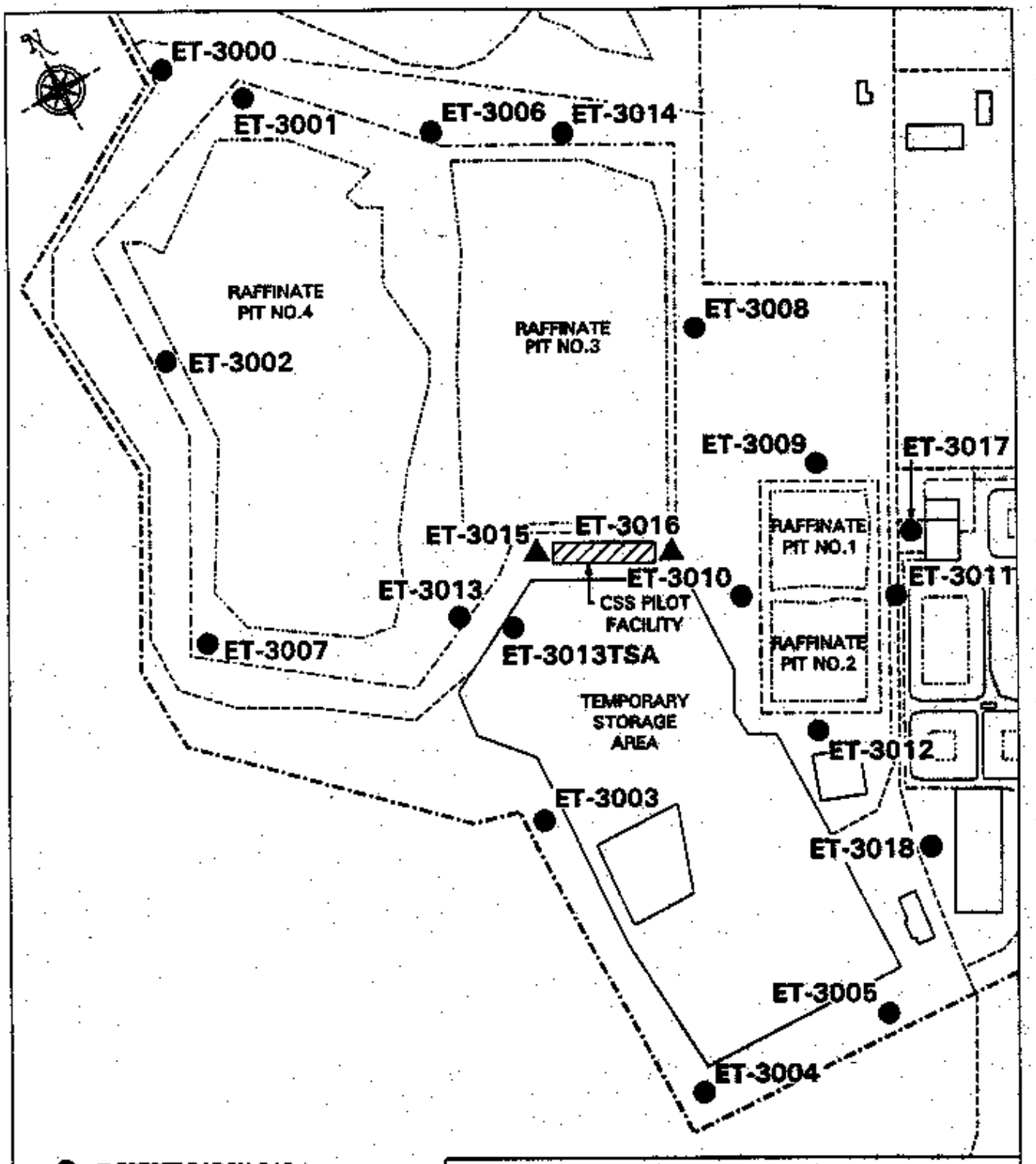
- ● - TRACK ETCH RADON GAS AND GAMMA RADIATION MONITORING LOCATION
- ✱ - LOW AND HIGH VOLUME AIR PARTICULATE AND CONTINUOUS GAS MONITORING LOCATION
- ○ - LOW AND HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- ▲ - ELECTRET RADON GAS MONITORING LOCATION

OFF-SITE AIR MONITORING LOCATIONS

FIGURE 4-3

REPORT NO.: DOE/OR/21548-676		SHEET NO.: A/VP/048/1194	
ORIGINATOR: EKA	DRAWN BY: GLN	DATE: 6/2/97	


N
HIGHWAY Z
HIGHWAY D
DANIEL BOONE
ELEMENTARY SCHOOL
ET-4009
AP-4012
TD-4009
RD-4009
NEW MELLE
HIGHWAY D
HIGHWAY F
LEGEND
- LOW AND HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- TRACK ETCH RADON GAS AND GAMMA RADIATION MONITORING LOCATION
- ELECTRET RADON GAS MONITORING LOCATION
0 .125 .25 MI
0 .0381 .0762 KM
SCALE
BACKGROUND AIR MONITORING STATION
FIGURE 4-4
REPORT NO.: DOE/OR/21548-676
SHEET NO.: A/VP/049/1194
ORIGINATOR: EKA
DRAWN BY: GLN
DATE: 6/2/97



● ELECTRET RADON GAS MONITORING LOCATION

▲ ELECTRET, TRACK ETCH RADON GAS DETECTOR, AND/OR GAMMA MONITORING LOCATION

NOT TO SCALE

ELECTRET MONITORING LOCATIONS AT THE WELDON SPRING RAFFINATE PITS AREA

FIGURE 4-5

REPORT NO.: DOE/OR/21548-676		DOCUMENT NO.: A/RP/010/0694	
ORIGINATOR: MP	DRAWN BY: GLN	DATE: 6/2/97	

TABLE 4-1 1996 Track Etch Integrated Radon Results[a]

LOCATION I.D.	1ST QUARTER pCi/l[b]	2ND QUARTER pCi/l[b]	3RD QUARTER pCi/l[b]	4TH QUARTER pCi/l[b]	ANNUAL AVERAGE pCi/l[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT [c]	PERCENT OF GUIDELINE[d]
WELDON SPRING QUARRY								
RD-1002	0.2	0.4	0.7	0.6	0.5	0.2		N/A
RD-1003	0.1	0.1	0.2	0.6	0.3	0.2		N/A
RD-1004	0.1	0.2	0.4	0.6	0.3	0.2		N/A
RD-1005	0.1	0.2	0.4	0.6	0.3	0.2		N/A
RD-1006	0.1	0.2	0.4	0.6	0.3	0.2		N/A
RD-1008	0.1	0.3	0.2	0.5	0.3	0.2		N/A
RD-1009	0.1	0.2	0.3	0.6	0.3	0.2		N/A
WELDON SPRING CHEMICAL PLANT								
RD-2002	0.1	[e]	[e]	0.6	0.4	0.4		N/A
RD-2004	0.1	0.3	0.5	0.6	0.4	0.2		N/A
RD-2005	0.1	0.4	0.3	0.6	0.4			
RD-2006	0.1	0.1	0.3	0.5	0.3	0.2		N/A
RD-2007	0.2	0.1	0.3	0.5	0.3	0.2		N/A
RD-2025	0.1	0.4	0.3	0.6	0.4	0.2		N/A
Train 2	0.1	0.2	--	0.5	0.3	0.2		N/A

TABLE 4-1 1996 Track Etch Integrated Radon Results[a] (Continued)

LOCATION I.D.	1ST QUARTER pCi/l[b]	2ND QUARTER pCi/l[b]	3RD QUARTER pCi/l[b]	4TH QUARTER pCi/l[b]	ANNUAL AVERAGE pCi/l[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT [c]	PERCENT OF GUIDELINE[d]
WELDON SPRING RAFFINATE PITS								
RD-3001	0.5	0.6	0.9	2.8	1.2	1.1		N/A
RD-3002	0.1	0.3	0.7	1.0	0.5	0.4		N/A
RD-3003	0.2	0.4	0.7	0.6	0.5	0.2		N/A
RD-3004	0.1	0.1	0.5	0.6	0.3	0.3		N/A
RD-3005	0.2	0.2	0.4	0.5	0.3	0.2		N/A
RD-3007	0.2	0.4	0.7	0.8	0.5	0.3		N/A
RD-3008	0.2	0.4	0.5	0.8	0.5	0.3		N/A
RD-3009	0.2	0.3	0.4	0.7	0.4	0.2		N/A
RD-3010	0.2	0.5	0.6	1.0	0.6	0.3		N/A
RD-3011	0.1	0.2	0.5	0.6	0.4	0.2		N/A
RD-3012	0.2	0.4	0.7	0.9	0.6	0.3		N/A
RD-3013	0.7	0.7	1.5	2.7	1.4	0.9	X	N/A[f]
RD-3014	1.7	1.0	0.4	5.0	2.0	2.1		N/A
RD-3015	0.2	0.7	2.1	3.1	1.5	1.3		N/A
CSS PILOT FACILITY								
ET-3015	0.1	0.3	0.3	--	0.2	0.1		N/A
ET-3016	0.3	0.2	0.6	--	0.4	0.2		N/A

TABLE 4-1 1996 Track Etch Integrated Radon Results[a] (Continued)

LOCATION I.D.	1ST QUARTER pCi/l[b]	2ND QUARTER pCi/l[b]	3RD QUARTER pCi/l[b]	4TH QUARTER pCi/l[b]	ANNUAL AVERAGE pCi/l[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT [c]	PERCENT OF GUIDELINE[d]
OFF SITE								
RD-4001	0.1	0.2	0.5	0.4	0.3	0.2		N/A
RD-4002	0.1	0.1	0.2	0.4	0.2	0.1		N/A
RD-4003	0.1	0.1	0.4	0.5	0.3	0.2		N/A
*RD-4005	0.1	0.2	0.4	0.5	0.3	0.2		N/A
RD-4007	0.1	0.1	0.5	0.4	0.3	0.2		N/A
RD-4008	0.1	--	--	--	0.1	--		N/A
*RD-4009	0.1	0.1	0.4	0.5	0.3	0.2		N/A

(a) Results include natural background levels except where otherwise noted.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed Student's t-test at the 95% confidence level.
(d) Percent of guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE concentration guideline for Rn-222 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
(e) Missing detectors.
(f) No percentage calculation performed for above-background monitoring locations within the site boundary.
* Background station.
N/A No percentage calculation performed for background locations or locations not statistically greater than background.
-- No measurement taken.

standard deviation reported reflects the error propagated by taking the sample standard deviation of the mean of the quarterly results.

The annual F-type track etch background concentration was calculated using the arithmetic average of the two background locations. The data yielded an annual background average integrated radon concentration in 1996 of 0.3 pCi/l (11 Bq/m^3). This result is consistent with previous years' monitoring results.

Based on measurements from modified track etch detectors at locations where a combined release of Rn-222 and Rn-220 was suspected, Rn-220 concentrations were estimated using Pearson's method (Ref. 49). Locations with Rn-220 concentrations statistically greater than background at the 95% confidence level were compared with the DCG for thoron. Results are presented in Table 4-2.

Although results in Tables 4-1 and 4-2 may appear inconsistent for a given monitoring station, this is to be expected since "F-type" detectors have a higher response function for Rn-222 than for Rn-220. The supplemental thoron measuring technique using the "M-type" detectors provides a better estimate of the thoron contribution to the total radon concentration. Therefore, for monitoring stations where virtually all of the integrated radon concentration is contributed by thoron (see results for RD-3001 and RD-3002, Tables 4-1 and 4-2), the thoron results using Pearson's method is larger than the integrated result.

Radon concentrations measured by the electret monitors are summarized in Tables 4-3 and 4-4. Because electret results are obtained biweekly rather than quarterly (as with the track etch detectors), they are used primarily as advance indicators of trends in radon/thoron levels at a given monitoring location. Track etch results, rather than electret results, are used in performing off-site dose calculations.

Historical average background concentrations of Rn-222 and Rn-220 gas near the site are both typically 0.2 pCi/l (7 Bq/m^3). Continuous radon and working level measurements at the Francis Howell High School taken in 1996 indicate background levels of both Rn-222 and Rn-220 gas and progeny. On-site work zone measurements, however, indicate elevated concentrations of both Rn-222 and Rn-220, particularly in localized areas where remedial actions involve the disturbance of raffinate sludge. The maximum hourly Rn-222 and Rn-220

TABLE 4-2 1996 Thoron Concentrations as Determined Using Paired F-type and M-type Track Etch Detectors[a]

STATION ID	FIRST QUARTER (pCi/l)[b]	SECOND QUARTER (pCi/l)[b]	THIRD QUARTER (pCi/l)[b]	FOURTH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (x)[c]	PERCENT OF GUIDELINE[d]
Weldon Spring Quarry								
RD-1002	0	0.4	0.7	0.5	0.4	0.29		N/A
RD-1006	0	0.1	0.2	0.1	0.1	0.08		N/A
Weldon Spring Chemical Plant								
RD-2002	-	-	0.3	0.4	0.4	0.07		N/A
RD-2004	-	-	0.5	0.4	0.5	0.07	X	10
RD-2006	-	-	0.0	0.0	0.0	0.0		N/A
RD-2007	-	-	0.0	0.0	0.0	0.0		N/A
RD-2025	-	-	0.0	0.1	0.1	0.07		N/A
Train 2	-	-	-	0.0	0.0	0.00		N/A
Weldon Spring Raffinate Pits								
RD-3001	-	-	0.7	3.1	1.9	1.70	X	57
RD-3002	-	-	1.5	0.7	1.1	0.57	X	30
RD-3003	0	0.5	0.5	0.6	0.4	0.27		N/A
RD-3004	-	-	0.3	0.5	0.4	0.14		N/A
RD-3005	-	-	0.2	0.4	0.3	0.14		N/A
RD-3010	0	0.4	0.2	0.0	0.2	0.19		N/A
RD-3014	1.8	0.9	3.6	0.5	1.7	1.38	X	N/A[e]

TABLE 4-2 1996 Thoron Concentrations as Determined Using Modified Track-Etch Detectors (Continued)

STATION ID	FIRST QUARTER (pCi/l)[b]	SECOND QUARTER (pCi/l)[b]	THIRD QUARTER (pCi/l)[b]	FOURTH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (x)[c]	PERCENT OF GUIDELINE[d]
RD-3015	0	0.4	0.2	-	0.2	0.20		N/A
Off-Site								
RD-4001	-	-	0.2	0.1	0.2	0.07		N/A
RD-4002	-	-	-	0.1	0.1	0.00		N/A
RD-4003	-	-	0.0	0.2	0.1	0.14		N/A
RD-4005*	-	-	-	0.3	0.3	0.00		N/A
RD-4007	-	-	-	0.1	0.1	0.00		N/A
RD-4009*	0	0	0.3	0.2	0.1	0.15		N/A

* Background station
(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed Student's t-test at the 95% confidence level.
(d) Percent of guideline is calculated by taking the annual station average minus the annual average of the background station, divided by the DCG for Rn-220 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
(e) No percentage calculation performed for above-background monitoring locations within site boundary.
N/A No percent of guideline calculated for stations not statistically greater than background.

TABLE 4-3 1996 Electret Radon-222 Results[a]

LOCATION I.D.	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
ET-1002	0.4	0.5	0.5	0.5	0.5	0.05
ET-1004	0.5	--	--	--	0.5	-
ET-1009	0.5	0.4	0.5	0.5	0.5	0.04
ET-1010	0.6	0.5	0.7	0.6	0.6	0.05
ET-2004	0.5	0.4	0.6	0.5	0.5	0.08
ET-2006	0.5	0.4	0.4	0.5	0.5	0.02
ET-2008	0.5	0.5	0.5	0.5	0.5	0.03
ET-3001	0.3	0.4	0.9	0.4	0.5	0.23
ET-3002	0.5	1.00	0.7	0.6	0.7	0.19
ET-3003	0.2	0.4	0.7	0.5	0.4	0.17
ET-3004	0.2	0.3	0.5	0.4	0.4	0.10
ET-3005	0.5	0.4	0.7	0.4	0.5	0.14
ET-3006	0.0	0.3	0.6	0.4	0.3	0.22
ET-3007	0.7	0.9	0.8	0.4	0.7	0.17
ET-3008	0.5	0.6	1.0	0.5	0.7	0.22
ET-3009	0.3	0.5	1.0	0.7	0.6	0.25
ET-3010	0.4	0.3	0.7	0.6	0.5	0.15
ET-3011	0.4	0.3	0.8	0.6	0.5	0.19
ET-3012	0.3	0.3	0.8	0.5	0.5	0.20
ET-3013	0.8	0.7	1.1	0.5	0.8	0.22
ET-3013TSA	0.5	0.7	0.8	0.6	0.6	0.10
ET-3014	0.7	0.7	0.8	0.3	0.7	0.17
ET-3015	0.4	2.3	0.6	0.5	0.9	0.78
ET-3016	0.3	0.3	0.6	0.6	0.5	0.14
ET-3017	0.2	0.2	0.3	0.5	0.3	0.13

TABLE 4-3 1996 Electret Radon-222 Results (Continued)

LOCATION I.D.	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
ET-3018	0.4	0.4	0.7	0.5	0.5	0.14
ET-4003	0.5	0.3	0.5	0.4	0.4	0.08
ET-4009*	0.4	0.5	0.5	0.5	0.5	0.04

(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
* Background station.
-- Measurement not collected.

TABLE 4-4 1996 Electret Radon-220 Results[a]

LOCATION I.D.	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
ET-1002	0.8	1.8	1.5	1.3	1.3	0.35
ET-1010	0.4	0.4	0.3	0.7	0.4	0.14
ET-3006	2.4	1.3	2.7	2.8	2.3	0.58
ET-3010	0.6	1.0	1.1	0.7	0.9	0.24
ET-3013	1.0	1.1	1.8	1.4	1.3	0.31
ET-3013TSA	1.0	1.9	0.8	1.0	1.2	0.44
ET-3015	1.9	0.9	1.2	0.9	1.2	0.42
ET-3016	0.4	0.6	1.1	0.5	0.6	0.27
ET-4003	0.5	0.2	0.7	0.4	0.5	0.18
ET-4009*	0.1	0.4	0.7	0.5	0.5	0.22

(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
* Background station.

concentrations recorded on site in 1996 were approximately 42 pCi/l (1.6E3 Bq/m^3) and 440 pCi/l (1.6E4 Bq/m^3), respectively, and were measured in August in the northeast portion of Raffinate Pit 4. Monthly average continuous radon and thoron concentrations at Raffinate Pit 4 tend to be on the order of 10 times lower than the maximum values reported here. These values are higher than comparable measurements taken using track etch and electret detectors because the continuous monitors are placed in the immediate vicinity of work zones within the raffinate pits, while track etch and electret detectors are placed along the raffinate pit berms and site perimeter fence.

4.2.4 Data Analysis

Statistical analysis of the track etch radon integrated results indicated that, at the 95% confidence level, integrated radon levels at one of the 14 raffinate pit locations were greater than the background station results. The analysis further indicates that, although a number of stations had annual average results numerically greater than background, the results for other stations were not statistically distinguishable from background levels.

Statistical analysis of the modified track etch Rn-220 results indicated that, at the 95% confidence level, measured concentrations at one of the five chemical plant perimeter stations were greater than the background station results. Furthermore, the analysis indicated that three of the seven raffinate pit locations exceeded background levels. The analysis indicates that the results for all other stations were statistically indistinguishable from background levels.

4.2.4.1 Chemical Plant, CSS Pilot Facility, Site Water Treatment Plant, and Raffinate Pits. Statistical analysis of four Rn-220 monitoring locations indicated results greater than background levels. One of the four stations, RD-2004, is located along the northeastern chemical plant perimeter. The remaining three stations (RD-3001, RD-3002, and RD-3014) are located near Raffinate Pit 4. The annual average concentrations for these stations exceeded background levels by 0.3 pCi/l (11 Bq/m^3) to 1.7 pCi/l (63 Bq/m^3). These results were anticipated, given the decreased water levels in Raffinate Pit 4. The quarterly measured Rn-220 concentrations for all stations ranged from 0 pCi/l (0 Bq/m^3) to 3.6 pCi/l (133 Bq/m^3).

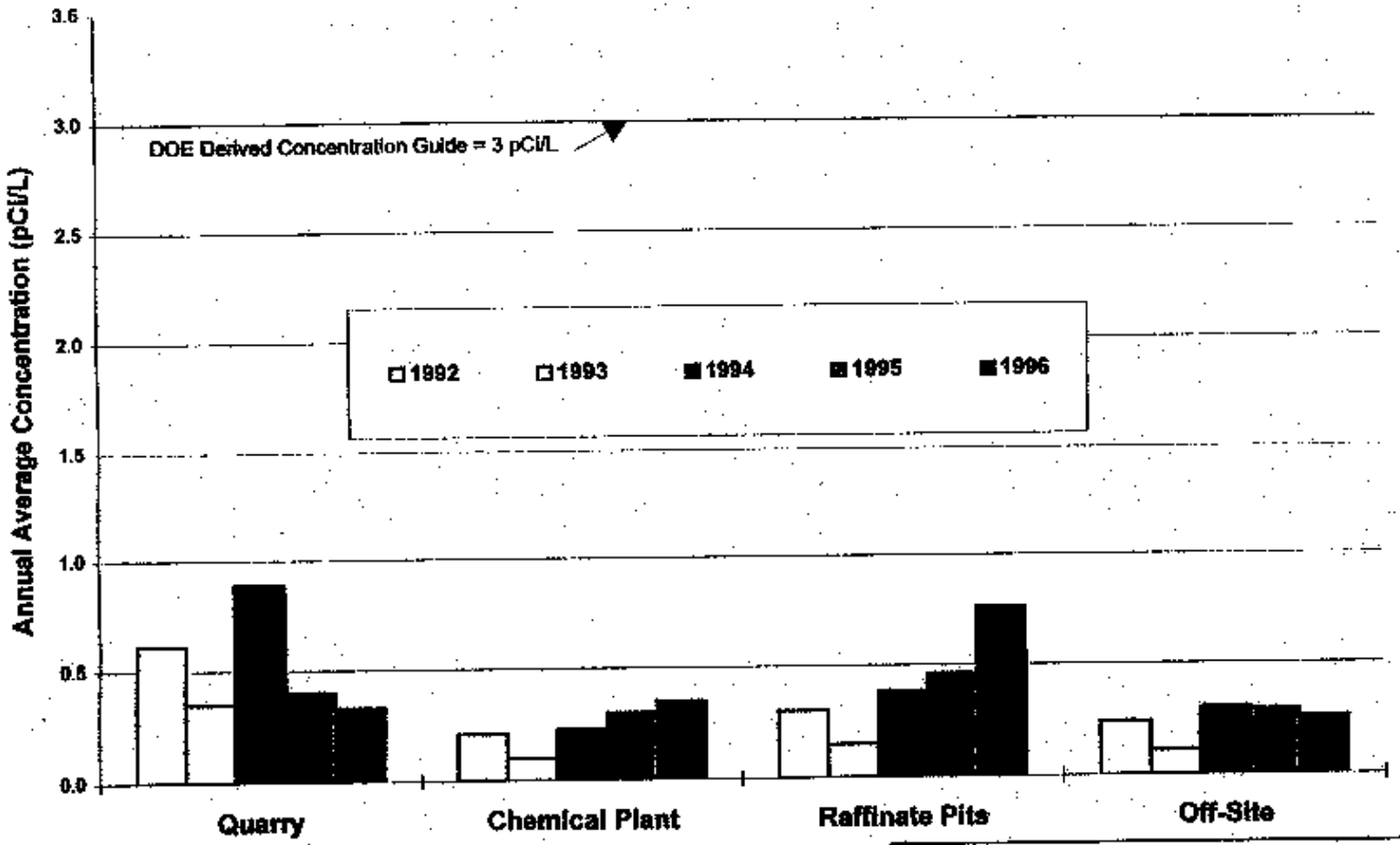
Statistical analysis of one radon monitoring location indicated measured integrated radon gas results greater than background levels. This station RD-3013, is located between Raffinate

Pits 3 and 4. The annual average concentration for this station exceeded the annual average background by 1.1 pCi/l (41 Bq/m^3). The quarterly radon measurements for all stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 5.0 pCi/l (185 Bq/m^3).

4.2.4.2 Quarry. Statistical analysis of both track etch integrated radon and Rn-220 monitoring results from all quarry stations indicated that there was no reason to suspect at the 95% confidence level that these results exceeded background levels. The quarterly measured results for integrated radon from all quarry stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.7 pCi/l (26 Bq/m^3). Quarterly results for Rn-220 at the quarry stations ranged from 0 pCi/l (0 Bq/m^3) to 0.7 pCi/l (26 Bq/m^3).

4.2.4.3 Off Site. Statistical analysis of both track etch integrated radon and Rn-220 monitoring results from off-site locations (shown in Figure 4-3) indicated that there was no reason to suspect at the 95% confidence level that measured concentrations at any of the stations were greater than background levels. The quarterly integrated radon concentration measurements at off-site locations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.6 pCi/l (19 Bq/m^3). Quarterly results for Rn-220 at the off-site stations ranged from 0 pCi/l (0 Bq/m^3) to 0.3 pCi/l (11 Bq/m^3). These results are similar to results obtained during previous years.

4.2.4.4 Five Year Trend Analysis of Integrated Radon Gas. Figure 4-6 shows 5 years of annual average track etch integrated radon concentrations for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. These monitoring results include natural background radon concentrations. Radon gas levels at the quarry have shown a downward trend since the peak of bulk waste removal in 1994. Conversely, measurements at the chemical plant and raffinate pits have trended upward since 1993; however, no DCGs were exceeded in 1996, and estimates of emissions through the end of the project indicate no reason to believe that DCGs will be exceeded in the future (Ref. 75). These upward trends are attributable to ongoing remediation projects in the raffinate pits.



RADON TRACK ETCH DETECTOR
5-YEAR TRENDS

FIGURE 4-6

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ORIGINATOR: ED	DRAWN BY: CRM	DATE: 8/13/95	

4.3 Gamma Radiation Monitoring

4.3.1 Program Overview

Gamma radiation is emitted from natural, cosmic, and manmade sources. The earth naturally contains gamma radiation-emitting substances, such as uranium, thorium, and potassium (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise the majority of natural gamma background radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (Ref. 33) estimates the typical gamma radiation dose is 35 mrem/year (0.35 mSv/year) from the earth and 30 mrem/year (0.30 mSv/year) from cosmic sources. The total estimated background radiation dose equivalent due to gamma exposure is thus 65 mrem/year (0.65 mSv/year).

Gamma radiation is monitored at the site using environmental thermoluminescent dosimeters (TLDs) at 18 monitoring stations: three at the site perimeter, four along the site perimeter near the raffinate pits, one near the CSS pilot facility (at ET-3014, shown in Figure 4-5), four along the quarry perimeter, and six off site. The locations are denoted by a "TD" prefix on Figures 4-1, 4-2, 4-3, and 4-4. Stations TD-4005 and TD-4009 measure natural background at locations unaffected by the site. The TLDs are exchanged and read every quarter of the calendar year.

4.3.2 Applicable Standards

No specific standard for gamma radiation is stated in the DOE orders. However, DOE Order 5400.5 specifies that members of the public shall receive less than 100 mrem/year (1.0 mSv/year) from DOE operations for all exposure pathways, excluding exposure to natural background radiation.

4.3.3 Monitoring Results

Table 4-5 summarizes quarterly and annual total gamma radiation monitoring results. The table includes quarterly and annual totals, the annual sample standard deviation for each station, and whether a station's annual monitoring results are statistically distinguishable from

TABLE 4-5 1996 Environmental TLD Results[a]

LOCATION	1ST QUARTER (mrem)[c]	2ND QUARTER (mrem)[c]	3RD QUARTER (mrem)[c]	4TH QUARTER (mrem)[c]	ANNUAL TOTAL (mrem/yr)[c]	STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X)[d]
WELDON SPRING QUARRY							
TD-1002	14.2	14.0	17.2	14.8	60	1	
TD-1003	17.2	17.0	19.7	18.0	72	1	X
TD-1006	15.0	12.4	15.6	15.6	59	2	
TD-1009	14.6	13.1	15.9	14.7	58	1	
WELDON SPRING CHEMICAL PLANT							
TD-2025	16.2	14.1	17.4	16.9	65	1	
TD-2004	17.0	16.8	18.6	18.7	71	1	X
TD-2006	16.2	15.5	17.3	16.5	66	1	
WELDON SPRING RAFFINATE PITS							
TD-3001[b]	20.0	20.7	**	30.3	95	5	X
TD-3003	17.7	15.9	21.7	21.1	76	3	X
TD-3004	15.3	14.3	17.8	16.5	64	2	
TD-3005	19.6	18.3	23.2	20.5	82	2	X
ET-3015[b]	14.0	**	33.4	--	95	13	X
OFF SITE							
TD-4001	16.1	15.4	17.3	17.7	66	1	
TD-4002	13.1	12.3	14.3	14.4	54	1	
TD-4003	12.9	12.2	14.2	14.0	53	1	
*TD-4005	15.2	16.0	15.8	15.8	63	1	
TD-4007	14.9	14.5	15.8	15.4	61	1	
*TD-4009	15.3	14.8	16.6	15.8	63	1	

* Denotes background location.

(a) Results include natural background gamma radiation.

(b) To calculate the annual total, missing data were replaced with the average of the recorded quarterly results for a given station.

(c) To convert from mrem to mSv, divide by 100.

(d) Statistical significance is determined by comparing the total annual concentration for a monitoring location with the total annual background concentration, using a one-tailed Student's t-test at the 95% confidence level.

-- No measurement taken.

** Denotes lost or damaged TLD.

background levels as determined by a one-tailed Student's t-test at the 95% confidence level. As shown in the table, two detectors were damaged or missing during the year, resulting in missing quarterly data for those stations.

Gamma background levels for 1996 were determined by averaging the annual total measurement from the two background stations. The annual average result from these stations was 63 mrem/year (0.63 mSv/year) with a standard deviation of 1 mrem/year (0.01 mSv/year). This average background is comparable to the UNSCEAR 1982 estimate of 65 mrem/year (0.65 mSv/year) (Ref. 33).

4.3.4 Data Analysis

Statistical analysis of TLD results revealed that, at the 95% confidence level, six stations had annual results greater than background levels. These stations included TD-1003, located at the quarry; TD-2004, located along the northeastern perimeter of the chemical plant; and TD-3001, TD-3003, TD-3005, and BT-3015, located around the raffinate pits and TSA. The analysis further revealed that results for all other stations were indistinguishable from background levels.

4.3.4.1 Chemical Plant/Raffinate Pits. Annual total TLD gamma radiation measurements at the chemical plant and raffinate pits ranged from 64 mrem (0.64 mSv) to 95 mrem (0.95 mSv). These results are generally higher than previous years for these areas due to quarry bulk waste storage at the TSA and remediations at the raffinate pits, including the dewatering of Raffinate Pit 4.

4.3.4.2 Quarry. The annual total gamma radiation measurements from TLDs at the quarry ranged from 58 mrem (0.58 mSv) to 72 mrem (0.72 mSv). These results are comparable to previous years for this area.

4.3.4.3 Off-Site. The annual total gamma radiation measurements from TLDs at off-site locations ranged from 53 mrem (0.53 mSv) to 66 mrem (0.66 mSv). These results are comparable to previous years for these areas.

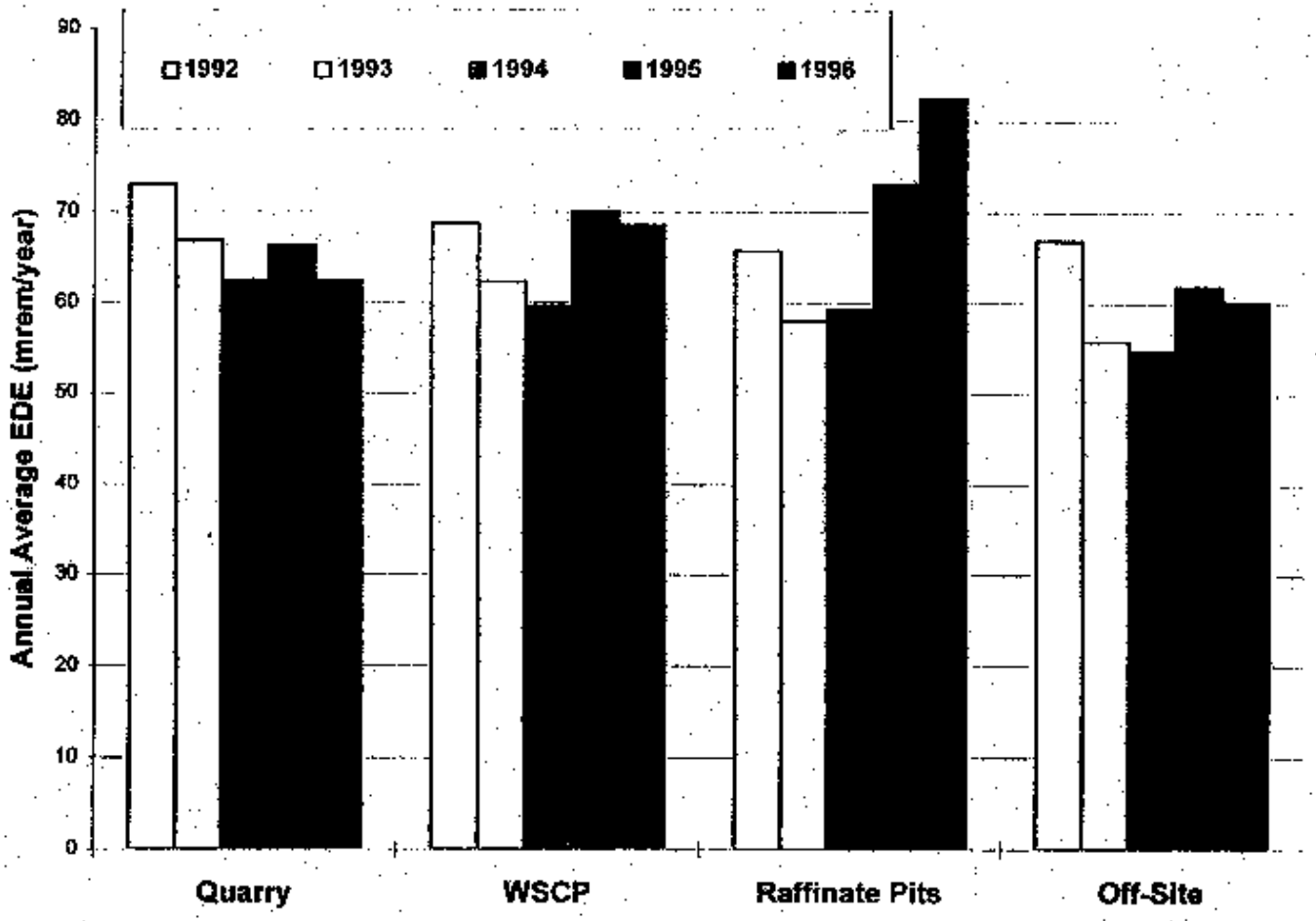
4.3.4.4 Five Year Trend Analysis of TLDs. Gamma radiation exposure monitoring results for the last five years are shown graphically in Figure 4-7. The graph shows yearly monitoring result totals for the chemical plant, raffinate pits, quarry, and off-site locations. The results include the natural background dose rate. Results indicate a marked increase around the raffinate pits area due to the startup of remedial activities in the raffinate pits. However, no regulatory exposure limits were approached as a result of this increase.

4.4 Radioactive Air Particulate Monitoring

4.4.1 Program Overview

Radioactive air particulates are airborne dust particles that contain radioactive contaminants. Background concentrations of radioactive air particulates are affected by the soil concentrations of naturally occurring radionuclides, soil moisture content, meteorological conditions, and geological conditions. Many areas on site contain above background concentrations of soil contamination, which can result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emissions from the site can result from wind erosion of contaminated soils piles or remedial work activities, such as moving equipment and vehicles in contaminated areas.

The WSSRAP monitors radioactive air particulates weekly using 17 continuous permanent low volume air samplers: seven at the site perimeter, five at the quarry, and at five off-site locations. These locations are denoted by an "AP" prefix on Figures 4-1, 4-2, 4-3, and 4-4. In addition, six temporary low-volume air monitoring stations are deployed around the chemical plant perimeter. These portable air particulate samplers are deployed at temporary stations when current activities warrant their use. The low volume samplers collect airborne particulates by drawing ambient air at a flow rate of approximately 40 l/minute through mixed cellulose ester filters with a 0.80 micron pore size. The filters are then analyzed on a gas flow proportional counter to determine the amount of long-lived gross alpha activity in the particulates present on the filter surface.



ENVIRONMENTAL TLD
5 - YEAR TRENDS

FIGURE 4-7

REPORT NO.:	DOE/OR/21548-676	DOCUMENT NO.:	A/PI/015/0497		
ORIGINATOR:	ED	DRAWN BY:	GLN	DATE:	4/17/97

4.4.2 Applicable Standards

The DCGs for inhalation of various radioactive air particulates are specified in Chapter III of DOE Order 5400.5.

4.4.3 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 17 permanent low volume stations are summarized in Table 4-6. Annual averages were calculated using uncensored weekly air particulate analysis results. Uncensored data refers to all results, including those near or below the minimum detectable concentration (MDC). The DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 1) requires the use of uncensored data to minimize any bias in arithmetic averages and standard deviation calculations.

TABLE 4-6 1996 Radioactive Air Particulate Gross Alpha Results

MONITORING STATION IDENTIFICATION NUMBER	ANNUAL AVERAGE LONG-LIVED GROSS ALPHA CONCENTRATION (x1E-15 μCi/ml)[b]	STANDARD DEVIATION (x 1E-15 μCi/ml)	NUMBER OF SAMPLE VALUES ABOVE MDC[c]/TOTAL NUMBER OF SAMPLES	STATISTICALLY SIGNIFICANT (X)[d]
AP-2001	1.55	0.540	51/51	
AP-2002	1.52	0.534	53/53	
AP-3003	1.52	0.503	53/53	
AP-3004	1.56	0.577	53/53	
AP-2005	1.49	0.699	53/53	
AP-4006	1.41	0.519	52/53	
AP-4007	1.41	0.525	53/53	
AP-4008	1.48	0.548	53/53	
AP-1009	1.48	0.561	51/53	
AP-1010	1.61	0.555	14/14	

TABLE 4-6 1995 Radioactive Air Particulate Gross Alpha Results (Continued)

MONITORING STATION IDENTIFICATION NUMBER	ANNUAL AVERAGE LONG-LIVED GROSS ALPHA CONCENTRATION (x1E-15 μCi/ml)[b]	STANDARD DEVIATION (× 1E-15 μCi/ml)	NUMBER OF SAMPLE VALUES ABOVE MDC[c]/TOTAL NUMBER OF SAMPLES	STATISTICALLY SIGNIFICANT (X)[d]
AP-4011	1.40	0.488	51/52	
AP-4012[a]	1.40	0.552	52/53	
AP-3014	1.49	0.470	53/53	
AP-1015	1.39	0.472	53/53	
AP-1016	1.41	0.418	52/53	
AP-1017	1.47	0.459	52/52	
AP-2025	1.37	0.434	53/53	

(a) Indicates background monitoring station. Background concentration is a 2-year average.
(b) The annual average gross alpha concentrations include background and were calculated using uncensored data, which includes results less than reported minimum detectable concentrations.
(c) MDC - minimum detectable concentration.
Multiply by 37,000 to convert μCi/ml to Bq/ml.
(d) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 2-year (104-week) background average concentration, using a one-tailed Student's t-test at the 95% confidence level.

The typical MDC for low volume air particulate sampling at the WSSRAP is 3.3E-16 μCi/ml (1.2E-11 Bq/ml). This MDC is low enough to allow detection of Th-232, which has the lowest DCG at the site of 7.0E-15 μCi/ml (2.6E-10 Bq/ml) (DOE 5400.5). If an individual inhales airborne contaminants at the DCG for one year, the resulting committed effective dose equivalent is 100 mrem (1 mSv).

4.4.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated no reason to suspect that results at any of the stations were greater than

background levels. Background Station AP-4012 had a 104-week average of 1.40E-15 μCi/ml.

4.4.4.1 Chemical Plant/Raffinate Pits. The average concentrations at the chemical plant/raffinate pits perimeter ranged from 1.37E-15 μCi/ml (5.07E-11 Bq/ml) to 1.56E-15 μCi/ml (5.77E-11 Bq/ml). These results are comparable to those measured in 1995.

4.4.4.2 Quarry. The average concentrations at the quarry perimeter ranged from 1.39E-15 μCi/ml (5.14E-11 Bq/ml) to 1.61E-15 μCi/ml (5.96E-11 Bq/ml). These results are lower than those measured during 1995 and previous years.

4.4.4.3 Off-Site. The average concentrations at off-site locations ranged from 1.40E-15 μCi/ml (5.18E-11 Bq/ml) to 1.48E-15 μCi/ml (5.48E-11 Bq/ml). These results are similar to those measured during previous years.

4.5 Radioactive Contamination Control Monitoring

4.5.1 Program Overview

The unrestricted area radioactive contamination control monitoring program ensures that areas used by the general public are not contaminated by radioactive materials migrating from the site as a result of remedial activities. Monitoring consists of in situ measurements (fixed contamination) and swipe sample (removable contamination) collection.

The unrestricted area radioactive contamination control monitoring program includes radiological surveys in both the controlled and uncontrolled areas at the site. Site roadways are monitored to ensure that contamination is kept from these accessible areas.

During 1996, 20 roadway areas outside the site controlled areas were routinely surveyed. These surveys continue to confirm that radioactive contamination has not been carried into unrestricted areas.

Direct survey in situ measurements are made with a beta-gamma detector or alpha scintillation detector. One-minute measurements are collected to provide the total (removable plus fixed) radioactivity within the tested area. If the total radioactivity measurement is greater

than the most conservative DOE radiological limit for removable activity (20 dpm/100 cm^2) for the radioactive constituents present on-site, then a swipe is taken at that location. The swipe is wiped over an approximate area of 100 cm^2 (15.5 $in.^2$), using a dry cloth or paper swipe. The swipe is analyzed using an alpha scintillation detector. The count rates are corrected for detector efficiency and background, and the removable radioactivity is reported in dpm/100 cm^2.

4.5.2 Monitoring Results

The site roadway surveys indicated an annual removable average alpha radioactivity level for all monitoring locations of < 3 dpm/100 cm^2. The highest level was 12 dpm/100 cm^2. The average minimum detectable activity (MDA) for alpha radioactivity was 3 dpm/100 cm^2. The roadway surveys indicated an annual average total alpha radioactivity level for all monitoring locations of < 17 dpm/100 cm^2; the highest level was 50 dpm/100 cm^2. The average MDA for fixed alpha radioactivity was 17 dpm/100 cm^2.

The 1996 site roadway surveys further indicated a range of fixed beta-gamma radioactivity of <490 dpm/100 cm^2 to 1,394 dpm/100 cm^2, with an average of 606 dpm/100 cm^2. The average MDA for beta-gamma radioactivity was 490 dpm/100 cm^2. The annual averages are based upon actual results, whether negative, positive, or zero.

4.5.3 Data Analysis

The site monitoring results show fixed contamination present in a few locations, but at levels well below the DOE uranium surface contamination guidelines for unrestricted use (5,000 dpm/100 cm^2). The contamination was probably caused by airborne uranium deposits that occurred during the operational period of the Weldon Spring Uranium Feed Material Plant. Little removable contamination was found. No increase in removable contamination levels has been measured since the monitoring program was initiated in 1987.

4.6 Airborne Asbestos Monitoring

During 1996, environmental monitoring for asbestos was conducted at the Francis Howell High School (AP-4006) and at the Weldon Spring site perimeter (AP-2002, AP-2005, and

AP-3004). These locations are identified in Figures 4-1 and 4-3. Filters were collected weekly and shipped off-site for analysis.

Two methods are used to analyze asbestos samples. Phased contrast microscopy (PCM) indicates fibers that have the same general size and shape as asbestos; however, this method does not distinguish between asbestos and nonasbestos fibers. Transmission electron microscopy (TEM) measures actual asbestos fiber concentrations. If a PCM measurement indicates a concentration above the site environmental action level (0.01 fibers per milliliter of air), the sample is then resubmitted to the off-site laboratory for TEM analysis.

The results of environmental samples collected at Francis Howell High School and the site and quarry perimeters are provided in Table 4-7. A total of 197 PCM samples were collected with 146 samples indicating results above the detection limits. The range of samples above the detection limit (as measured by the PMC) was 0.001 fibers per milliliter of air (f/ml) to 0.006 f/ml. No samples were resubmitted for TEM analysis. All results of the environmental air samples collected from the site and quarry perimeters and Francis Howell High School were below the fiber concentration limits of 0.01 fibers/ml established in the EPA's acceptable clearance levels for schools. These results indicate that asbestos fibers were effectively contained during the year.

TABLE 4-7 Summary of Asbestos Air Monitoring Results

LOCATION	NUMBER OF SAMPLES/SAMPLES ABOVE DETECTION LIMIT	RANGE (f/ml)	AVERAGE (f/ml)
AP-2002	48/38	0-0.006	0.001
AP-2005	49/36	0-0.006	0.001
AP-3004	49/36	0-0.005	0.001
AP-4006	51/36	0-0.004	0.001

5 RADIATION DOSE ANALYSIS

This section evaluates the effects of atmospheric releases and surface and groundwater discharges of radiological contaminants from the Weldon Spring Site Remedial Action Project (WSSRAP). Potential annual dose equivalents to the general public have been calculated and are presented here. These calculations are compared against U.S. Department of Energy (DOE) guidelines contained in DOE Order 5400.5.

Dose calculations are presented in this section for a maximally exposed individual and a collective population. The exposure conditions used in the dose calculations are further discussed in respective environmental monitoring sections of this report.

Dose calculations related to airborne emissions as required by 40 CFR 61, Subpart H *(National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities)* are presented in Section 6, National Emission Standards for Hazardous Air Pollutants (NESHAPS) Program.

5.1 Highlights

- The largest TEDE to a maximally exposed individual from all pathways combined was 2.7 mrem (0.027 mSv), estimated for an individual who works full-time at the Missouri Highway and Transportation Department Maintenance (MHTD) facility. This value represents 2.7% of the DOE guideline of 100 mrem (1 mSv) above background levels.

- The collective population dose equivalent was estimated to be 0.19 person-rem (1.9E-3 person-Sv) for users of the Busch Memorial Conservation Area and employees of the MHTD.

5.2 Pathway Analysis

In developing specific elements of the WSSRAP environmental monitoring program, potential exposure pathways and health effects of the radioactive and chemical materials present on site are reviewed annually to determine which pathways are complete. This pathway analysis

is detailed in the site *Environmental Monitoring Plan* (Ref. 42). As required by DOE Order 5400.1, evaluation of each exposure pathway is based on the sources, release mechanisms, types, and probable environmental fates of contaminants, and the locations and activities of potential receptors. Pathways are then reviewed to determine whether a link exists between one or more contaminant sources, or between one or more environmental transport processes, to an exposure point where human or ecological receptors are present. If it is determined that a link exists, the pathway is termed complete. Complete pathways are used in assessing radiological and nonradiological exposures. Each complete pathway is reviewed to determine whether a potential for exposure was present during the time frame of concern. If this is the case, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 5-1 lists the six complete pathways for exposure from radiological contaminants evaluated by the WSSRAP environmental monitoring program. These pathways are used to evaluate monitoring requirements and to determine radiological exposures from the site. Of the six complete pathways, five were applicable in 1996 and were thus incorporated into radiological dose estimates. These are Liquid (B), Liquid (C), Airborne (A), Airborne (B), and External. Assessments of potential exposure routes in the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 69) have shown that the dose potential for pathways not listed in Table 5-1 is negligibly small.

TABLE 5-1 Complete Radiological Exposure Pathways for the Weldon Spring Site

EXPOSURE PATHWAY	PATHWAY DESCRIPTION	APPLICABLE TO 1996 DOSE ESTIMATE
Liquid(A)	Ingestion of groundwater from local wells downgradient from the site.	N
Liquid(B)	Ingestion of game and fish inhabiting wildlife area.	Y
Liquid(C)	Ingestion of surface water and sediments.	Y
Airborne(A)	Inhalation of particulates dispersed through wind erosion and remedial action.	Y

TABLE 5-1 Complete Radiological Exposure Pathways for the Weldon Spring Site (Continued)

EXPOSURE PATHWAY	PATHWAY DESCRIPTION	APPLICABLE TO 1996 DOSE ESTIMATE
Airborne(B)	Inhalation of radon emitted from contaminated soils/wastes.	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y

As shown in Table 5-1, the Liquid (A) pathway is not applicable to the 1996 dose estimate for the WSSRAP. Concentrations of radioactive contaminants in the production wells near the Weldon Spring Quarry are currently comparable to background concentrations (see Section 8.4). In addition, no drinking water wells are located in the vicinity of the chemical plant and raffinate pits area.

The applicable radiological public dose guidelines for the WSSRAP are as follows:

- NESHAPs standard of 10 mrem (0.10 mSv) effective dose equivalent annually due to airborne emissions other than radon at off-site receptor locations.
- DOE guideline of 100 mrem (1 mSv) total effective dose equivalent for all exposure pathways on an annual basis (excluding background).

5.3 Radiological Release Estimates

5.3.1 Airborne Radiological Releases

Because annual average airborne Rn-220 concentrations at three chemical plant perimeter air monitoring stations exceeded background levels in 1996, an estimate was made to determine the total activity of Rn-220 gas released off site for the year. Off-site airborne releases of other radionuclides in 1996 were not calculated because perimeter concentrations of Rn-222 gas and

radioactive air particulates were not distinguishable from background for the year. Furthermore, Rn-220 levels at the quarry were at background levels, thus no release estimate was made for the quarry. Table 5-2 shows the estimated airborne activity release of radionuclide to the environment, the corresponding mass released, and the half-life for each radionuclide.

As shown in Table 5-2, the estimated off-site Rn-220 release to the atmosphere was approximately 128 Ci (4.7E12 Bq). Raffinate Pit 4 is the primary source of Rn-220 emissions at the Weldon Spring site. Calculations and assumptions are provided in Appendix B.

TABLE 5-2 Radionuclide Emissions to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDES RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDES RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDES RELEASED (grams)	HALF-LIFE (Yrs)
U-238	--	1.28E-2	3.8E-4	4.47E09
U-235	--	6.00E-4	280	7.04E08
U-234	--	1.28E-2	2	2.46E05
Th-232	--	1.49E-4	1,350	1.40E10
Th-230	--	3.00E-4	1.43E-2	7.54E04
Th-228	--	2.43E-4	2.96E-7	1.91
Ra-228	--	1.28E-4	4.71E-7	5.76
Ra-226	--	8.39E-4	8.39E-4	1,600
Rn-222	--	N/A	N/A	3.82 days
Rn-220	128	N/A	N/A	55.6 seconds
Total Activity	128	2.79E-2	1,630	N/A

N/A Not analyzed for this radionuclide.
-- Not distinguishable from background at perimeter monitoring locations.
Multiply by 3.7E10 to convert Ci to Bq.

5.3.2 Waterborne Radiological Releases

During 1996, intermittent surface water runoff transported isotopes of uranium, thorium, and radium from the site through six major discharge routes. These include two water treatment plant outfalls and four storm water outfalls (see Section 7). These outfalls were monitored monthly as required under the site National Pollutant Discharge Elimination System (NPDES). Natural uranium concentrations measured in runoff water were multiplied by the natural uranium activity ratios for U-234, U-235, and U-238 (49.1%, 2.3%, and 48.6%, respectively). All results are listed in Table 5-2.

5.4 Exposure Scenarios

Dose calculations were performed for the maximally exposed individual, collective population, and NESHAPs critical receptors for applicable exposure pathways (see Table 5-1) to assess dose from the Weldon Spring site. First, conditions were set to determine the total effective dose equivalent to a maximally exposed individual at each of the main site areas: the chemical plant and raffinate pits area, the quarry, and vicinity properties. A second dose equivalent for a collective population was calculated. A third set of dose equivalent calculations was performed to meet NESHAPs requirements (see Section 6).

Statistical testing indicated background levels of radioactive air particulates at both high volume NESHAPs critical receptor monitoring locations and low volume perimeter monitoring locations during 1996. Calculations using perimeter and off-site monitoring data determined the collective population dose equivalent to be less than 1 person-rem per year (0.01 person-Sv) from all pathways combined. Since all off-site low volume air particulate samplers and radon gas detectors (other than the background station) are within a 13 km (8.1 mi) radius of the site, and all results measured within this radius are well below NESHAPs and DOE limits, incorporating a dose calculation for a population within 80 km (49.6 mi) of the site is unnecessary. Rather, the collective population dose equivalent was calculated for specific target populations where complete exposure pathways were found to exist.

The scenarios and models used to evaluate these radiological exposures are conservative but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual using the methods prescribed

here. Estimates of health risks are based on epidemiological data collected from large groups of people exposed to radiation under various circumstances; therefore, statistical models are not applicable to single individuals. Dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable but conservative scenario. This method is acceptable when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case for the WSSRAP. The scenarios and resulting estimated doses used in the calculations are outlined in Table 5-3. In addition, the percentage of the DOE guideline of 100 mrem (1.0 mSv) total effective dose equivalent (TEDE) is provided.

The collective population dose equivalent estimate, provided in units of person-rem (person-Sv), is the product of the effective dose equivalent estimate at an exposure point and the number of persons exposed. Exposure points are locations where members of the public are potentially exposed to airborne radioactive particulates, radon gas, external gamma radiation, or above-background radionuclide concentrations in water or food. The committed effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, and food at a given exposure point and applying standard breathing rates and dose equivalent conversion factors. These concentrations and reasonable exposure scenarios are used to estimate the amount of radioactivity ingested or inhaled by the potentially exposed population. The contribution from exposure to gamma radiation is then factored into the collective population dose equivalent.

All ingestion calculations were performed using the methodology described in *International Commission on Radiation Protection* (ICRP) Reports 26 and 30 (Ref. 26 and 27) for a 50-year committed effective dose equivalent. Fifty-year committed effective dose equivalent (CEDE) conversion factors were obtained from the EPA *Federal Guidance Report No. 11* (Ref. 28).

5.5 Dose Equivalent Estimates

Dose equivalent estimates for the exposure scenarios were calculated using 1996 monitoring data. Calculations for dose scenarios are provided in Appendix B. Dose equivalent estimates are well below the standards set by the DOE for annual public exposure and U.S. Environmental Protection Agency (EPA) NESHAPs limits.

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INTAKE RATE	CONCENTRATION	ESTIMATED EFFECTIVE DOSE EQUIVALENT (mrem)	PERCENT OF DOE GUIDANCE LIMIT
WSCP/WSRP Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	Working at MHTD facility	Direct Exposure	2,000 hours	8 mrem/yr	N/A	1.82	1.82%
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	Working at MHTD facility	Air	2,000 hours	1.2 m^3/hour[a]	Rn-220 0.25 pCi/l; 0.5% equilibrium	0.83	0.83%
WSQ Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	Walking near WSQ perimeter	Direct Exposure	5 hours	9 mrem/yr	N/A	0.0051	0.0051%
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INTAKE RATE	CONCENTRATION	ESTIMATED EFFECTIVE DOSE EQUIVALENT (mrem)	PERCENT OF DOE GUIDANCE LIMIT
WSVP Hypothetical Individual	Liquid(B)	Consumption of fish from slough	Fish	N/A	6.5 g/day	0.005 pCi/g	0.0034	0.0034%
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INTAKE RATE	CONCENTRATION	COLLECTIVE POPULATION DOSE EQUIVALENT (person-rem)	PERCENT OF DOE GUIDANCE LIMIT
Collective Population	Liquid(B)	Fishing at Busch Lake 36 (population = 5,985)	Fish	N/A	0.55 g/day	0.038 pCi/g	0.16	N/A
	Liquid(C)	Swimming at Busch Lake 36 (population = 5,985)	Sediments	0.285 hr/person	200 mg/day	91.1 pCi/g	0.00035	N/A
			Water	0.285 hr/person	0.05 liters/hour	56 pCi/l	0.0013	N/A
	External	Working at MHTD Facility	Direct Exposure	2,000 hours	8 mrem/yr	N/A	0.016	N/A
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	Working at MHTD Facility	Air	2,000 hours	1.2 m^3/hr[a]	Rn-220 0.25 pCi/l; 0.5% equilibrium	0.007	N/A

N/A Indicates measurements for radioactivity for a media/exposure pathway at background levels.
WSCP Weldon Spring Chemical Plant.
WSRP Weldon Spring raffinate pits.
WSQ Weldon Spring Quarry.
WSVP Weldon Spring vicinity properties.
Multiply by 0.037 to convert pCi to Bq.

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

Multiply by 0.01 to convert mrem to mSv.
Multiply by 0.01 to convert person-rem to person-Sv.

(a) A breathing rate of 1.2 m^3/hour is used for an adult male engaged in strenuous activity. A breathing rate of 0.96 m^3/hour would be used for an adult male engaged in light activity. Reference values for adult females are 1.14 m^3/hour for strenuous activity and 0.91 m^3/hour for light activity.

The 1996 total effective dose equivalents (TEDEs) for hypothetical maximally exposed individuals near the chemical plant and raffinate pits, quarry, and vicinity properties are 2.7 mrem (0.027 mSv), 0.0051 mrem (0.051 μSv), and 0.0032 mrem (0.032 μSv), respectively. These values represent less than 3% of the DOE standard of 100 mrem (1 mSv) above background for all exposure pathways. In comparison, the annual average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem (3 mSv) (Ref. 71). The collective population dose equivalent is 0.19 person-rem (0.0017 person-Sv) for recreational users of the Busch Memorial Conservation Area and employees of the Missouri Highway and Transportation Department (MHTD) facility. Assumptions are detailed in the following sections.

5.5.1 Radiation Dose Equivalent From the Chemical Plant and Raffinate Pits to a Hypothetical Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical individual assumed to frequent the perimeter of the chemical plant and raffinate pits and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent due to the applicable pathway of airborne radioactive particulate inhalation assume a realistic residence time that is less than 100%. A full-time employee at the MHTD maintenance facility was considered to be the maximally exposed individual to airborne releases of radionuclides from the chemical plant area.

The low and high volume samplers near the MHTD facility indicated no above-background concentrations of airborne radioactive particulates from the WSSRAP. However, because both the annual average Rn-220 concentration and environmental TLD result (Stations RD-2004 and TD-2004) exceeded background levels for the year, a dose estimate was calculated based on these measurements.

The exposure scenario assumptions are as follows:

- Inhalation dose occurs to the maximally exposed individual while working outside the MHTD Facility near the Weldon Spring chemical plant perimeter for a total of 2,000 hours per year.

- Net Rn-220 concentration of 0.25 pCi/l (9.3E-3 Bq/l), measured at RD-2004 on the northeastern boundary of the chemical plant.

- Daughter equilibrium ratio of 0.5% for Rn-220, based on several months of measurements made during Raffinate Pit 4 debris consolidation activities in 1996.

- Net annual gamma exposure rate of 8 mrem/year (for continuous exposure), measured at TD-2004 at the northeastern boundary of the chemical plant. For 1996, a leap year, continuous exposure time is 8,784 hours.

- Effective dose equivalent conversion factor of 0.42 rem/WLM (4.2 mSv/WLM), implied by 10 CFR 835.

Based on the exposure scenario and assumptions described above, a maximally exposed individual working at the MHTD facility received a total effective dose equivalent of 2.7 mrem (0.027 mSv) from external exposure and inhalation of Rn-220 gas and progeny.

5.5.2 Radiation Dose From the Weldon Spring Quarry to a Hypothetical Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical individual assumed to frequent the perimeter of the Weldon Spring Quarry. The only private residence adjacent to the quarry site is monitored as a critical receptor, and all 1996 monitoring results indicated no above background exposure pathways. Therefore, all calculations of dose equivalent due to applicable pathways assume a realistic occupancy time of 5 hours/year, based on a hypothetical individual who hikes along the southeastern boundary of the quarry. The 5 hours/year assumption represents twice the value estimated for hikers at the Weldon Spring Conservation Area (Ref. 30).

Exposure scenario assumptions particular to this dose calculation are as follows:

- No contribution from ingestion pathways was assumed because access to the quarry was controlled by 24-hour security and a 2.4 m (8 ft) chain link fence

topped with barbed wire. Fishing, swimming, and drinking water from the quarry pond were not considered to be realistic exposure pathways.

- No contribution from inhalation pathways was assumed because quarry air particulate and radon gas monitoring stations indicated background concentrations for the year.

- The individual hiked around the southeastern perimeter of the quarry 5 hours/year.

- The net gamma radiation exposure (measured at TD-1003) was 9 mrem/year (0.09 mSv/year) above background. This value is based on continuous exposure (8,784 hours in 1996).

The total effective dose equivalent to the hypothetical maximally exposed individual at the quarry was 0.0051 mrem (5.1E-5 mSv) from direct gamma exposure.

5.5.3 Radiation Dose From Vicinity Properties to a Hypothetical Maximally Exposed Individual

This section discusses the estimated total effective dose equivalent to a hypothetical individual assumed to frequent the Femme Osage Slough, south of the quarry. This scenario provides a conservative but plausible exposure assessment. No private residences are adjacent to the slough (it is situated on land currently managed by the Missouri Department of Conservation (MDC) as part of the Weldon Spring Conservation Area); therefore, all calculations of dose equivalent due to the applicable pathways of fish and ingestion (Liquid B) assume a realistic occupancy time of 62.5 hours/year. This scenario uses the applicable exposure pathways listed in Table 5-1 and is based on a hypothetical individual who fished at the Femme Osage Slough in 1996.

Exposure scenario assumptions particular to this dose calculation include the following:

- Annual average radioactive particulate concentrations at the quarry perimeter were indistinguishable from background; therefore, no inhalation dose due to radioactive air particulates was calculated for an individual at the slough.

- No contribution to the estimated dose was included from radon progeny concentrations associated with the Airborne (B) pathway, because the slough is contaminated only with uranium and is covered with water. Consequently, above-background concentrations of radon are not expected at this location.

- The average total uranium concentration in a composite sunfish sample taken from the Femme Osage Slough was 0.005 pCi/g (1.9E-4 Bq/g) (see Section 9.3.1.1).

- The freshwater fish consumption rate was 6.5 g/day (0.23 oz/day) (Ref. 32).

- No contribution from pathway Liquid (C) was included because the stagnant water conditions made it unlikely that the slough would be used for recreational swimming.

- Dose equivalent conversion factor for ingestion of total uranium of 2.69E-4 mrem/pCi (Ref. 28).

The total effective dose equivalent to the maximally exposed individual at the vicinity properties from consumption of fish tissue at the Femme Osage Slough was 0.0032 mrem (0.032 μSv).

5.5.4 Collective Population Dose

This section discusses the estimated collective TEDE to the populations assumed to be exposed to radiation from the WSSRAP. Statistical testing at the 95% confidence level for all radioactive air particulate, radon gas, and gamma exposure measurements at critical receptor monitoring locations indicated that the only statistically significant results were for gamma radiation exposure at TD-2004 and Rn-220 concentrations at RD-2004, both located along the northeast WSCP perimeter near the MHTD facility.

Measurements made by M-type alpha track detectors and environmental thermoluminescent dosimeters (TLD) indicated above background results of both annual Rn-220 concentrations and gamma exposure at this location, necessitating a potential general population exposure scenario.

Another potential general population exposure is from the consumption of water, sediment, and fish from the August A. Busch Memorial Conservation Area. Three lakes at the conservation area receive runoff from the Weldon Spring site and are used for fishing and boating. Scenarios were developed and a dose assessment was performed for the users of the MHTD facility and the Busch Memorial Conservation Area in 1996.

The scenario used for the Busch Memorial Conservation Area is based on recreational use for fishing and boating activities. Only the ingestion pathways Liquid (B) and Liquid (C) were considered plausible for this assessment. Exposure scenario assumptions particular to this dose calculation are as follows:

- The MDC estimates that approximately 160,000 persons per year use the Busch Memorial Conservation Area (Ref. 30), which is adjacent to the chemical plant and raffinate pits area, while another 5,895 persons participate in recreational boating activities. Busch Lakes 34, 35, and 36 receive runoff from the chemical plant and raffinate pits area, and all three lakes are used for fishing and boating. Therefore, a population of 165,895 persons was assumed to have potential for exposure through ingestion of fish, water, and sediment from these lakes.

- The average time per fishing trip was 2.5 hours.

- The time spent to fish caught ratio is 0.4 fish/hour, and the ratio of fish caught to fish kept is 0.5. If each fish caught is consumed by a different person, the affected population would be 80,000 persons.

- The highest average total uranium concentration in a composite sunfish sample collected from Lake 36 was 0.038 pCi/g (1.4E-3 Bq/g) (see Section 9.3.1.1).

- The average time spent at the Busch Conservation Area per boating trip was approximately 5.7 hours (Ref. 30).

- Each of 5,895 visitors made only one visit to the area and spent 5% of the time swimming.

- Maximum water and sediment concentrations of total uranium were 56 pCi/l (2.1 Bq/l) (see Table 7-11) and 91.1 pCi/g (3.4 Bq/g), respectively (Ref. 59).

- No contribution from airborne pathways was included in the Busch Memorial Conservation Area dose estimates. Results from the measurements near the lakes indicated that there was no reason to suspect, at the 95% confidence level, that concentrations of airborne radioactive particulates or radon were greater than background levels.

For 1996, the estimated population dose equivalent for the Busch lakes scenario was 0.17 person-rem (1.7E-3 person-Sv).

The scenario used for the MHTD facility is the same as listed in Section 5.4.1. The estimated total collective population dose equivalent at the WSSRAP is 0.19 person-rem in 1996. Calculations are presented in Appendix B, Section D.

6 NESHAPS PROGRAM

This section provides information on 1996 annual atmospheric emissions of radionuclides, in accordance with the requirements of 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities.* Evaluations presented here include airborne emissions data and dose assessment and compliance information related to sources of radioactive particulate emissions at the Weldon Spring Site Remedial Action Project (WSSRAP).

6.1 NESHAPs Monitoring and Dose Assessment Highlights

- Results of National Emission Standards for Hazardous Air Pollutants (NESHAP) monitoring at the six critical receptor monitoring locations indicated, at the 95% confidence level, no reason to suspect that annual average gross alpha or radioisotopic air particulate concentrations were greater than background levels.

- The highest dose assessment was for a maximally exposed individual residing continuously in the Francis Howell High School. Results indicated an annual CEDE of 0.9 ± 1.58 mrem (0.009 ± 0.0158 mSv) for this individual in 1996.

- The 1996 collective population dose equivalent estimate for nine full-time employees of the MHTD and 160,000 users of the Busch Memorial Conservation Area was 0.19 person-rem (0.0019 person-Sv).

- Radon flux measurements performed in 1996 on the temporary storage area (TSA) averaged well below the limit of 20 pCi/m^2-S listed in 40 CFR 61, Subpart Q.

- Total Rn-220 emissions from the Weldon Spring site were estimated to be 128 Ci (4.74E12 Bq) in 1996, equating to a CEDE to the hypothetical maximally exposed individual of 0.83 mrem (8.3E-3 mSv). Off-site Rn-222 emissions in 1996 were negligible.

6.2 Facility Information

6.2.1 Site Description

Specific information about the Weldon Spring site can be found in Section 1 of this report.

6.2.2 Source Description

The Weldon Spring site is being remediated in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and the *National Environmental Policy Act* (NEPA). It no longer operates as a uranium and thorium processing plant and has been in mothball status since about 1966. Therefore, radionuclides are no longer emitted from the original uranium processing plant sources (i.e., stacks, vents, or pipes) described in 40 CFR 61, Subpart H.

Most airborne emissions of radionuclides at the Weldon Spring site result from wind dispersion of surface soils, temporary waste storage areas, or dust and dirt from building debris and fugitive dust generated during remedial actions. The two on-site water treatment plants and the chemical stabilization/ solidification (CSS) pilot facility, however, constitute potential emission points ("point sources").

The chemical plant buildings were contaminated with asbestos, hazardous chemical substances, and isotopes of uranium, radium, and thorium. (Building dismantlement was completed in 1994.) Concentrations in bulk samples collected from the buildings range from background levels to 20,000 pCi/g U-238, 190 pCi/g Ra-226, 5,400 pCi/g Ra-228, and 540 pCi/g Th-230 (Ref. 3).

Radiological and chemical (i.e., polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals, and inorganic ions) contaminants can also be found in the soil in several areas around the site. Most of the 87 ha (215 acres) of the chemical plant site have above background concentrations of uranium (> 1 pCi/g). Radionuclide concentrations range from 0.3 pCi/g to 2,259 pCi/g U-238, 0.2 pCi/g to 452 pCi/g Ra-226, 0.1 pCi/g to 155 pCi/g Ra-228

and 0.3 pCi/g to 123 pCi/g Th-230 (Ref. 21). Approximately 40 ha (100 acres) of 87 ha (215 acres) of soil have been remediated and wastes are stored in Ash Pond.

The raffinate pits are radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals. Radionuclides concentrations found in raffinate pit sludge range from <10 to 3,400 pCi/g total uranium, <8 to 34,000 pCi/g Th-230, <1 to 1,700 pCi/g Ra-226, <4 to 1,400 pCi/g Th-232, <4 to 1,400 pCi/g Ra-228, and <3 to 1,100 pCi/g Th-228 (Ref. 74).

The quarry bulk waste contains radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos. The radionuclide concentrations range from 3.0 to 1,600 pCi/g U-238, <1 to 2,780 pCi/g Ra-226, 0.7 to 36 pCi/g Th-232, <1 to 2,200 pCi/g Ra-228, and <1.0 to 6,800 pCi/g Th-230 (Ref. 2). The quarry bulk waste was removed and placed at the temporary storage area (TSA) in 1996.

6.3 Air Emission Data

Most airborne emissions of radionuclides at the Weldon Spring site result from wind dispersion of surface soils and fugitive dust generated during remedial actions. Modeling such emission sources is not practical because of the inability to adequately characterize the emission inventory. The amount of entrainment can be estimated from fugitive dust emission factors developed by the U.S. Environmental Protection Agency (EPA) for various materials handling activities, but it is generally recognized that those estimates contain uncertainties.

After evaluating the methods of assessing effective dose equivalents from radionuclide emissions from the Weldon Spring site, it was determined that monitoring air concentrations at critical receptors was the most accurate means of assessing effective dose equivalents to maximally exposed individuals. This alternative approach has been approved by EPA Region VII. The designation of the critical receptors and sampling procedures are described in Section 6.3.

6.3.1 Point Sources

Table 6-1 briefly describes the two chemical plant water treatment plants, the quarry water treatment plant, and the CSS pilot facility and lists their nearest receptor locations. Because critical receptor monitoring is performed at the WSSRAP, additional effluent monitoring under the requirements of 40 CFR 61 Subpart H and U.S. Department of Energy (DOE) Order 5400.5 is not required. In addition to critical receptor monitoring, engineering calculations have been performed to assess releases from the quarry and chemical plant water treatment plants and resulting dose equivalents to members of the public. These results indicate a dose equivalent of less than 0.1 mrem (0.001 mSv) at the nearest receptor location as provided in Table 6-1.

TABLE 6-1 WSSRAP Point Sources

	EFFLUENT CONTROL		NEAREST RECEPTOR	
POINT SOURCE I.D.	DESCRIPTION	EFFICIENCY	DESCRIPTION	DISTANCE
Site Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP	Administration Building	400 m
Quarry Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP	Residence	700 m
CSS Pilot Facility	High efficiency air particulate (HEPA) filtered	99.97% for 0.3 micron DOP	Administration Building	600 m

DOP Dioctylphthalate

6.3.2 Grouped Sources

The WSSRAP has not defined any grouped sources.

6.3.3 Non-Point Sources

The WSSRAP primary sources for emissions are diffuse sources that at the most basic level consist of two areas, a chemical plant area and a quarry area. Due to the many different and constantly changing activities within these areas, the WSSRAP has chosen to monitor airborne concentrations at nearby critical receptor locations to demonstrate compliance with the NESHAPs standard.

The quarry diffuse source is a 3.6 ha (9-acre) limestone quarry located approximately 6.4 km (4 mi) south-southwest of the chemical plant area. The quarry is essentially in a closed basin; surface water within the rim flows to the quarry floor and into a pond that covers approximately 0.2 ha (0.5 acre). The quarry was used as a disposal area for dinitrotoluene (DNT) and trinitrotoluene (TNT) process wastes; uranium, radium, and thorium residues; the associated decay products from on-site and off-site processing of uranium and thorium; and building rubble and soils from the demolition of a uranium processing facility in St. Louis, Missouri. A major remediation project involving the removal and controlled temporary storage of approximately 110,000 m^3 (144,000 yd^3) of contaminated bulk waste was started in 1993 and completed at the end of 1995. Residual radioactive contamination remains at the quarry and could be a potential source of airborne particulates.

The Weldon Spring Chemical Plant diffuse source encompasses 87 ha (215 acres) on which the Ash Pond storage area (APSA), four raffinate pits, the temporary storage area (TSA), and the material staging area (MSA) are located. Airborne emissions from the chemical plant result from windblown resuspension of radioactive particulates from site soils and chemical plant building material and debris, and resuspension of radioactive particulates from site operations such as building foundation removal and soil excavation. During 1996, no NESHAPs critical receptor monitors or perimeter air monitors indicated radioactive air particulate concentrations statistically greater than background levels. Therefore, monitoring data indicated that the concentration of radioactive air particulates released from both the Weldon Spring Chemical Plant and Quarry was at background levels.

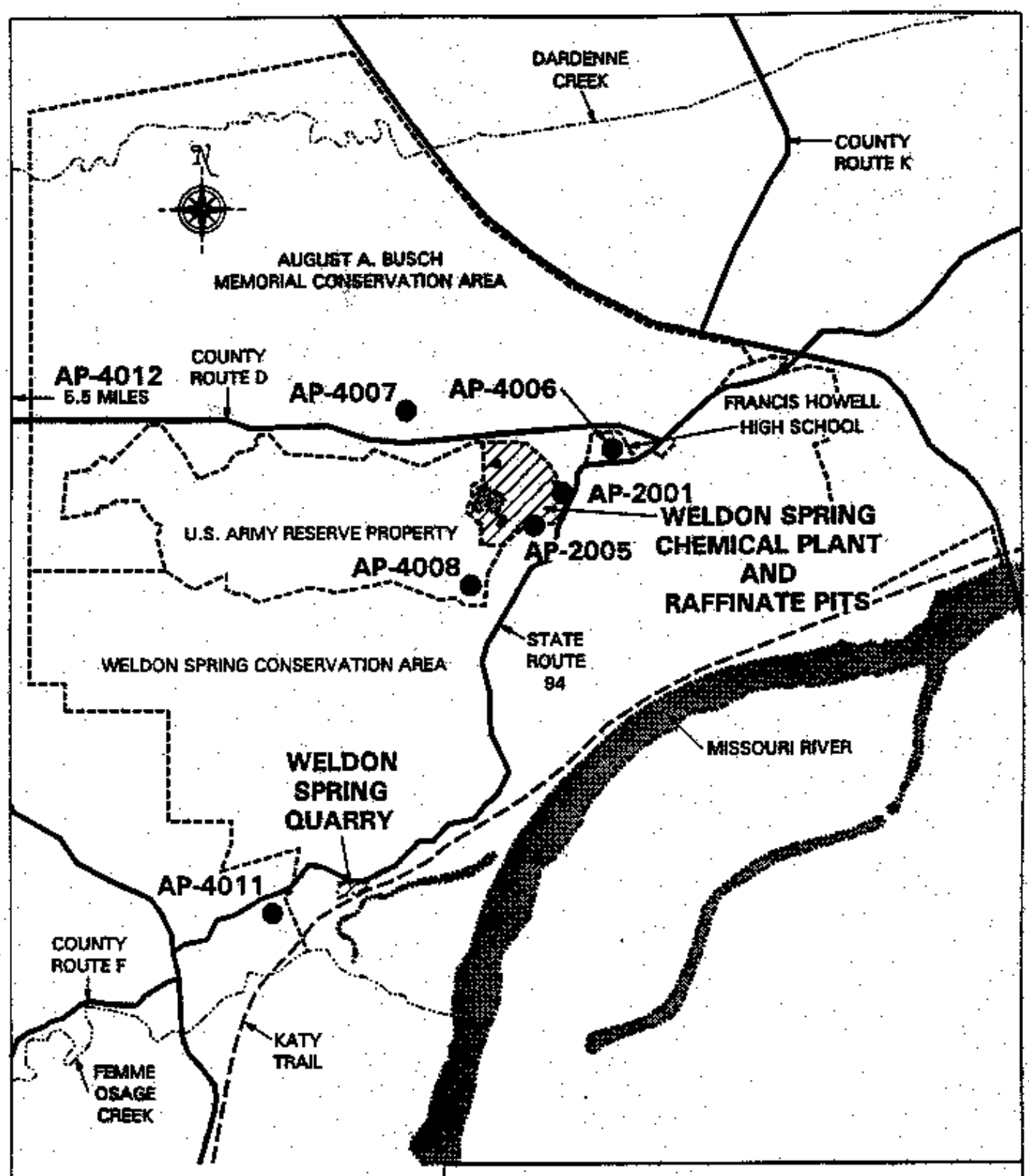
6.4 Dose Assessment

Due to the uncertainties associated with modeling airborne radionuclide emissions resulting from radioactive sources at the Weldon Spring site, the WSSRAP has chosen a more reliable method of critical receptor monitoring. As an alternate to relying on air-dispersion calculations for demonstrating compliance with applicable standards, these critical receptor locations are places where members of the public abide or reside and have a potential to encounter off-site concentrations of radioactive airborne particulates during WSSRAP remediation activities. The critical receptor monitoring methodology is described in the WSSRAP *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by EPA Region VII.

6.4.1 Sampling Procedure

As mentioned in Section 3.2.1.1 of this report, six designated critical receptor locations surrounding the Weldon Spring site have been selected in order to achieve compliance with NESHAPs requirements. The six locations were selected based on their proximity to the site (less than 1 km [0.62 mi]) and the probability that members of the public would spend at least 8 hours per day near them. The six critical receptor locations and the background monitoring location are shown in Figure 6-1 and are described in Table 6-2. They include: the common boundary of the Weldon Spring Chemical Plant and the Missouri Highway and Transportation Department (MHTD) maintenance facility (AP-2001); the WSSRAP administration building (AP-2005); Francis Howell High School (AP-4006); the August A. Busch Memorial Conservation Area (AP-4007); the Weldon Spring Training Area on the Department of the Army property (AP-4008); and 150 m (0.1 mi) from the residence nearest to the quarry (AP-4011). Daniel Boone Elementary School in New Melle, Missouri, is the designated background monitoring location (AP-4012). Technically, the WSSRAP administration building is considered an on-site receptor rather than a critical receptor because its occupants are not members of the general public, and the area is under DOE control. However, for reporting purposes, it is referred to as a "critical receptor."

Each critical receptor location includes a low volume air particulate sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples are collected on mixed cellulose ester membrane filters approximately 1.5 m (5 ft) above the ground, and are exchanged



LEGEND

● - MONITORING LOCATION

SCALE 0 1 MI / 0 1.6 KM

NESHAPS CRITICAL RECEPTOR MONITORING LOCATIONS

FIGURE 6-1

REPORT NO.: DOE/OR/21548-676		DOMIT NO.: A/VP/001/0195	
ORIGINATOR: SX	DRAWN BY: GLN	DATE: 3/20/97	

TABLE 6-2 Exposure Scenarios and NESHAPs Dose Estimates for 1996

CRITICAL RECEPTOR	SAMPLE ID	TOTAL INDIVIDUALS	EXPOSURE DURATION	ESTIMATED DOSE EQUIVALENT (mrem)/PERSON
MHTD facility	AP-2001	9	2,000 hr/yr	0.07 ± 0.23
WSSRAP administration building	AP-2005	275	2,500 hr/yr	0.15 ± 0.33
Francis Howell High School - Assessment 1	AP-4006	3,020	2,250 hr/yr	0.23 ± 0.41
Francis Howell High School - Assessment 2	AP-4006	1[a]	8,760 hr/yr	0.90 ± 1.58
Busch Memorial Conservation Area	AP-4007	25	2,500 hr/yr	0.03 ± 0.27
Weldon Spring Training Area	AP-4008	1[b]	2,000 hr/yr	0.08 ± 0.29
Nearest quarry residence	AP-4011	1[c]	8,760 hr/yr	0.49 ± 1.32

(a) One individual residing full-time on school properties.
(b) One employee working full-time on Army property.
(c) One individual living at residence.
hr/yr Hours per year.
Multiply by 0.01 to convert mrem to mSv.

on a weekly basis. High volume samples are collected on large glass fiber or membrane filters approximately 1.2 m (4 ft) above the ground, which are also exchanged weekly. It is the high volume sampling results that are used to demonstrate NESHAPs compliance at the WSSRAP.

At the beginning of each calendar quarter, the high volume filters collected over the previous quarter are composited to form seven distinct samples, one for each critical receptor location and background station. The high volume samples are analyzed for isotopic thorium, total uranium, Ra-226, and Ra-228. For reporting purposes, the background concentrations are subtracted from each sample concentration. If background concentrations are greater than the concentration of the critical receptor sample, a negative net concentration is reported.

6.4.2 Compliance Assessment

Based on the results of the high volume samples, a realistic exposure scenario and dose estimate was developed for each of the six critical receptor locations. The assumptions made for the dose estimates include:

- Breathing rate of 1.2 m^3/hour (42.4 ft^3/hour) provided in 10 CFR 20, *Standards for Protection Against Radiation.*
- 50-year committed effective dose equivalent conversion factors provided in EPA *Federal Guidance Report No. 11* (Ref. 28);
- Exposure duration listed in Table 6-2.

One-tailed Student's t-tests were performed at the 95 % confidence level for each station. The measurements for all the radioisotopes listed in Table 6-3 indicated that there were no annual values statistically above background levels at any of the critical receptors. However, NESHAPs isotopic air monitoring results and the calculated committed effective dose equivalent (CEDE) for each critical receptor are listed in Table 6-3. According to the exposure scenarios (Table 6-2), the maximum dose equivalent calculated was 0.9 ± 1.58 mrem (0.009 mSv) CEDE for an individual residing 8,760 hours/year in the Francis Howell High School. The doses for the entire year at each critical receptor location are comparable to those calculated for 1995 and

are well below the NESHAPs limit of 10 mrem (0.10 mSv) total effective dose equivalent per year.

6.5 Additional Information

No unplanned releases to the atmosphere occurred in 1996.

Releases from the WSSRAP are primarily due to diffuse sources. The dose equivalent estimates listed in Table 6-3 are based on critical receptor monitoring, and therefore estimate the dose due to both point source and diffuse source emissions.

Data quality review of precision and accuracy for the NESHAPs high volume samples established in the *Plan for Monitoring Radionuclides Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21) indicated that the data quality objectives (DQOs) for precision were met, however; the DQOs for accuracy were not met for the first and second quarters of 1996. Accuracy tests indicated failure of the Th-230 spiked samples to meet the known value objective of ±50% for 85% of the samples. The uranium spiked samples met this objective. Failure of the Th-230 spikes accuracy is believed to be caused by spike preparation problems rather than by laboratory analysis problems.

To remedy the problem with spike preparation and maintenance, a standardized (premixed) Th-230 solution was purchased and has been used for the spiking of NESHAPs air filters since the third quarter of 1996. This resulted in 100% of the Th-230 spiked filters meeting the DQO for accuracy in the third and fourth quarters of 1996. The accuracy obtained for third and fourth quarter spiked filters was within 20% of the spiked values.

6.6 Supplemental Information

Although not required by 40 CFR 61, this supplemental information is provided to assist the DOE in guidance development and in future interactions with the EPA. Information includes the following: collective population dose equivalent due to airborne releases of radionuclides, status of compliance with 40 CFR 61 Subparts Q and T, details of non-storage radon emissions, a discussion of radionuclide emission points, and the status of the site quality assurance program for radionuclide emissions measurements.

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1996

AP-2001	1st QUARTER		2nd QUARTER		3rd QUARTER		4th QUARTER		ANNUAL
Radionuclide	*Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-8.8E-11 ± N/A	0 ± N/A	8.6E-11 ± N/A	0.0052 ± N/A	1.65E-10 ± N/A	0.0100 ± N/A	-1.06E-10 ± N/A	0 ± N/A	0.0152 ± N/A
Ra-226	-1.7E-11 ± 1.08E-10	0 ± 0.004	1.84E-11 ± 5.57E-10	0.0001 ± 0.0023	-6.3E-11 ± 1.48E-10	0 ± 0.0006	7.05E-15 ± 1.66E-11	0.0001 ± 0.0001	0.0001 ± 0.0024
Ra-228	1.45E-10 ± 8.28E-10	0.0003 ± 0.0019	7.4E-11 ± 8.7E-10	0.0002 ± 0.0020	-2.5E-10 ± 7.13E-10	0 ± 0.0016	-5.58E-12 ± 8.13E-11	0 ± 0.0002	0.0005 ± 0.0032
Th-228	1.07E-11 ± 1.34E-10	0.0018 ± 0.0219	2.08E-11 ± 2.06E-10	0.0034 ± 0.0338	4.62E-11 ± 1.65E-10	0.0076 ± 0.0270	6.85E-12 ± 6.44E-11	0.0011 ± 0.0106	0.0138 ± 0.0496
Th-230	6.13E-11 ± 5.14E-10	0.0096 ± 0.0803	-2.4E-10 ± 6.49E-10	0 ± 0.1015	4.18E-11 ± 1.12E-10	0.0065 ± 0.0175	1.88E-11 ± 1.09E-10	0.0029 ± 0.0171	0.0190 ± 0.1317
Th-232	-1.7E-12 ± 1.49E-10	0 ± 0.1163	-4.9E-12 ± 2.29E-10	0 ± 0.1804	1.74E-11 ± 8.64E-11	0.0137 ± 0.0523	7.32E-12 ± 5.75E-11	0.0058 ± 0.0453	0.0195 ± 0.2255
CEDE		0.0117 ± 0.1430		0.0089 ± 0.2095		0.0376 ± 0.0814		0.0069 ± 0.0495	0.0662 ± 0.2658
AP-2005	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	4.75E-11 ± N/A	0.0098 ± N/A	1.67E-10 ± N/A	0.0126 ± N/A	7.58E-10 ± N/A	0.0571 ± N/A	-9.79E-11 ± N/A	0 ± N/A	0.0735 ± N/A
Ra-226	-5.2E-11 ± 1.29E-10	0 ± 0.0007	6.17E-12 ± 5.11E-10	0 ± 0.0026	-2.1E-11 ± 1.48E-10	0 ± 0.0008	6.68E-12 ± 1.65E-11	0 ± 0.0001	0. ± 0.0028
Ra-228	2.41E-10 ± 8.38E-10	0.0007 ± 0.0025	1.95E-10 ± 8.81E-10	0.0006 ± 0.0025	-2.9E-10 ± 6.76E-10	0 ± 0.0019	1.61E-11 ± 8.10E-11	0 ± 0.0002	0.0013 ± 0.0040
Th-228	2.48E-11 ± 1.33E-10	0.0051 ± 0.0272	-3.1E-11 ± 1.98E-10	0 ± 0.0401	3.76E-11 ± 1.11E-10	0.0077 ± 0.0227	-5.66E-12 ± 5.76E-11	0 ± 0.0118	0.0128 ± 0.0548
Th-230	0 ± 4.86E-10	0 ± 0.0947	-2.5E-10 ± 6.62E-10	0 ± 0.1294	6.97E-11 ± 9.74E-11	0.0136 ± 0.0190	9.18E-12 ± 1.03E-10	0.0018 ± 0.0202	0.0154 ± 0.1627
Th-232	8.07E-12 ± 1.48E-10	0.0079 ± 0.1434	-2E-11 ± 2.31E-10	0 ± 0.2271	3.98E-11 ± 8.00E-11	0.0389 ± 0.0590	5.04E-12 ± 5.60E-11	0.0050 ± 0.0551	0.0518 ± 0.2815
CEDE		0.0175 ± 0.1740		0.0132 ± 0.2645		0.1173 ± 0.0661		0.0068 ± 0.0598	0.1548 ± 0.3289

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1996 (Continued)

AP-4006[a]	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Net Concentration µCi/m[3]	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-1.4E-11 ± N/A	0.0009 ± N/A	3.54E-11 ± N/A	0.0024 ± N/A	2.92E-11 ± N/A	0.0020 ± N/A	-7E-11 ± N/A	0 ± N/A	0.0053 ± N/A
Ra-226	-4.5E-11 ± 1.38E-10	0 ± 0.0006	7.4E-11 ± 5.49E-10	0.0003 ± 0.0025	-6.9E-11 ± 1.51E-10	0 ± 0.0007	-9.98E-13 ± 1.78E-11	0 ± 0.0001	0.0003 ± 0.0027
Ra-228	3.57E-15 ± 8.25E-10	0.0001 ± 0.0021	9.31E-11 ± 8.43E-10	0.0002 ± 0.0022	-2.9E-10 ± 7.17E-10	0 ± 0.0018	1.47E-11 ± 8.47E-11	0 ± 0.0002	0.0003 ± 0.0036
Th-228	1.42E-11 ± 1.3E-10	0.0026 ± 0.0240	1.86E-11 ± 2.4E-10	0.0034 ± 0.0442	1.81E-10 ± 4.62E-10	0.0334 ± 0.0853	-1.92E-12 ± 5.94E-11	0 ± 0.0110	0.0394 ± 0.0986
Th-230	0 ± 4.67E-10	0 ± 0.0827	3.27E-11 ± 7.63E-10	0.0058 ± 0.1342	-6.9E-11 ± 1.87E-10	0 ± 0.0328	7.62E-12 ± 1.02E-10	0.0013 ± 0.0179	0.0071 ± 0.1620
Th-232	-6.2E-12 ± 1.38E-10	0 ± 0.1228	1.08E-10 ± 3.05E-10	0.0957 ± 0.2703	8.65E-11 ± 2.21E-10	0.0766 ± 0.1960	5.94E-12 ± 5.60E-11	0.0053 ± 0.0496	0.1778 ± 0.3591
CEDE		0.0036 ± 0.1495		0.1078 ± 0.3050		0.1120 ± 0.2163		0.0066 ± 0.0539	0.2300 ± 0.4064

AP-4006[b]	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (µCi/m[3])	Effective Dose Equivalent (mrem)	Net Concentration (µCi/m[3])	Effective Dose Equivalent (mrem)	Net Concentration (µCi/m[3])	Effective Dose Equivalent (mrem)	Net Concentration (µCi/m[3])	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.4E-11 ± N/A	0.0036 ± N/A	3.54E-11 ± N/A	0.0093 ± N/A	2.92E-11 ± N/A	0.0077 ± N/A	-7E-11 ± N/A	0 ± N/A	0.0206 ± N/A
Ra-226	-4.5E-11 ± 1.38E-10	0 ± 0.0025	7.4E-11 ± 5.49E-10	0.0013 ± 0.0099	-6.9E-11 ± 1.51E-10	0 ± 0.0027	-9.98E-13 ± 1.78E-11	0 ± 0.0003	0.0013 ± 0.0103
Ra-228	3.57E-15 ± 8.25E-10	0.0004 ± 0.0083	9.31E-11 ± 8.43E-10	0.0009 ± 0.0085	-2.9E-10 ± 7.17E-10	0 ± 0.0072	1.47E-11 ± 8.47E-11	0.0001 ± 0.008	0.0014 ± 0.0139
Th-228	1.42E-11 ± 1.3E-10	0.0102 ± 0.0933	1.86E-11 ± 2.4E-10	0.0134 ± 0.1721	1.81E-10 ± 4.62E-10	0.1298 ± 0.3318	-1.92E-12 ± 5.94E-11	0 ± 0.0426	0.1534 ± 0.3876
Th-230	0 ± 4.67E-10	0 ± 0.3196	3.27E-11 ± 7.63E-10	0.0224 ± 0.5221	-6.9E-11 ± 1.87E-10	0 ± 0.1277	7.62E-12 ± 1.02E-10	0.0051 ± 0.0695	0.0275 ± 0.6292
Th-232	-6.2E-12 ± 1.38E-10	0 ± 0.4759	1.08E-10 ± 3.05E-10	0.3724 ± 1.0513	8.65E-11 ± 2.21E-10	0.2980 ± 0.7624	5.94E-12 ± 5.60E-11	0.0205 ± 0.1931	0.6909 ± 1.3970
CEDE		0.0142 ± 0.5818		0.4194 ± 1.186		0.4355 ± 0.8413		0.0257 ± 0.2096	0.8950 ± 1.5800

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1996 (Continued)

AP-4007	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-3.5E-11 ± N/A	0 ± N/A	5.42E-11 ± N/A	0.0033 ± N/A	8.85E-12 ± N/A	0.0005 ± N/A	-1.03E-10 ± N/A	0 ± N/A	0.0038 ± N/A
Ra-226	-3.9E-11 ± 1.27E-10	0 ± 0.0006	1.98E-11 ± 6.06E-10	0.0001 ± 0.0025	-8.6E-11 ± 1.37E-10	0 ± 0.0008	-5.6E-12 ± 1.72E-11	0 ± 0.0001	0.0001 ± 0.0026
Ra-228	1.5E-10 ± 8.28E-10	0.0003 ± 0.0019	1.32E-10 ± 8.66E-10	0.0003 ± 0.0020	-1.7E-10 ± 6.79E-10	0 ± 0.0016	2.99E-12 ± 7.86E-11	0 ± 0.0002	0.0006 ± 0.0032
Th-228	-9.8E-12 ± 1.13E-10	0 ± 0.0186	-1.8E-12 ± 2.19E-10	0 ± 0.0360	3.66E-11 ± 9.0E-11	0.0060 ± 0.0148	-3.29E-12 ± 5.82E-11	0 ± 0.0095	0.0060 ± 0.0442
Th-230	2.68E-12 ± 4.91E-10	0.0004 ± 0.0768	-1.7E-10 ± 7.27E-10	0 ± 0.1136	2.87E-11 ± 7.68E-11	0.0045 ± 0.0120	-8.29E-12 ± 9.20E-11	0 ± 0.0144	0.0049 ± 0.1384
Th-232	-1.4E-12 ± 1.42E-10	0 ± 0.1113	-4.9E-12 ± 2.48E-10	0 ± 0.1954	2.01E-11 ± 4.58E-11	0.0158 ± 0.0361	-1.64E-11 ± 4.74E-11	0 ± 0.0373	0.0158 ± 0.2308
CEDE	0.0007 ± 0.1365		0.0037 ± 0.2289		0.0288 ± 0.0408		0 ± 0.0538		0.0312 ± 0.2728

AP-4008	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{3}$ [3]	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-6.7E-11 ± N/A	0 ± N/A	7.62E-11 ± N/A	0.0046 ± N/A	7.42E-11 ± N/A	0.0045 ± N/A	-5.44E-11 ± N/A	0 ± N/A	0.0091 ± N/A
Ra-226	-5.1E-11 ± 1.29E-10	0 ± 0.0005	8.39E-11 ± 5.5E-10	0.0003 ± 0.0023	-9.8E-11 ± 1.42E-10	0 ± 0.0008	-2.41E-12 ± 1.77E-11	0 ± 0.001	0.0003 ± 0.0026
Ra-228	2.8E-10 ± 8.35E-10	0.0008 ± 0.0019	4.15E-11 ± 8.77E-10	0.0001 ± 0.0020	-1.1E-10 ± 6.98E-10	0 ± 0.0016	6.69E-12 ± 8.29E-11	0 ± 0.0002	0.0007 ± 0.0032
Th-228	3.07E-11 ± 1.39E-10	0.0050 ± 0.0228	-8.7E-12 ± 2.17E-10	0 ± 0.0356	2.59E-11 ± 8.42E-11	0.0043 ± 0.0138	-8.41E-12 ± 5.63E-11	0 ± 0.0092	0.0093 ± 0.0454
Th-230	0 ± 4.97E-10	0 ± 0.0777	2E-10 ± 7.65E-10	0.03126 ± 0.1196	4.01E-12 ± 7.17E-11	0.0006 ± 0.0112	-1.34E-11 ± 9.04E-11	0 ± 0.0141	0.0319 ± 0.1438
Th-232	1.85E-11 ± 1.53E-10	0.0146 ± 0.1201	9.46E-12 ± 2.6E-10	0.0074 ± 0.2047	1.27E-11 ± 4.31E-11	0.0100 ± 0.0340	-9.08E-12 ± 4.86E-11	0 ± 0.0382	0.0320 ± 0.2428
CEDE	0.0202 ± 0.1448		0.0437 ± 0.2388		0.0184 ± 0.0383		0 ± 0.0419		0.0833 ± 0.2858

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1996 (Continued)

AP-4011	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration $\mu Ci/m^{[3]}$	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{[3]}$	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{[3]}$	Effective Dose Equivalent (mrem)	Net Concentration $\mu Ci/m^{[3]}$	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-2.6E-11 ± N/A	0 ± N/A	6.89E-12 ± N/A	0.0018 ± N/A	-1.8E-11 ± N/A	0 ± N/A	-8.01E-11 ± N/A	0 ± N/A	0.0018 ± N/A
Ra-226	-4.1E-11 ± 1.01E-10	0 ± 0.0018	3.44E-11 ± 5.38E-10	0.0008 ± 0.0097	-8.09E-11 ± 1.413E-10	0 ± 0.0026	3.77E-12 ± 1.84E-11	0.0001 ± 0.0003	0.0007 ± 0.0102
Ra-228	3.1E-11 ± 8.17E-10	0.0003 ± 0.0082	1.23E-10 ± 9.08E-10	0.0012 ± 0.0091	-1.55E-10 ± 6.79E-10	0 ± 0.0068	1.67E-11 ± 9.82E-11	0.0001 ± 0.0009	0.0016 ± 0.2291
Th-228	3.58E-12 ± 1.32E-10	0.0028 ± 0.0946	5.81E-11 ± 2.54E-10	0.0424 ± 0.1827	2.31E-11 ± 1.295E-10	0.0166 ± 0.0930	-4.99E-12 ± 5.45E-11	0 ± 0.0391	0.0616 ± 0.2281
Th-230	2.14E-11 ± 4.99E-10	0.0146 ± 0.3418	2.3E-10 ± 7.94E-10	0.1573 ± 0.5433	3.426E-11 ± 1.206E-10	0.0234 ± 0.0825	-3.68E-12 ± 9.07E-11	0 ± 0.0621	0.1953 ± 0.6502
Th-232	-4.3E-12 ± 1.46E-10	0 ± 0.5038	2.95E-11 ± 2.77E-10	0.1018 ± 0.9532	2.779E-11 ± 7.669E-11	0.0958 ± 0.2649	9.75E-12 ± 5.39E-11	0.0336 ± 0.1856	0.2310 ± 1.1256
CEDE		0.0175 ± 0.6162		0.3049 ± 1.1123		0.1358 ± 0.2922		0.0338 ± 0.1986	0.4920 ± 1.3188

AP-4012	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Radionuclide	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)
Total U	2.86E-10 ± N/A	2.34E-10 ± N/A	1.415E-10 ± N/A	1.75E-10 ± N/A	--
Ra-226	5.33E-11 ± 7.28E-11	9.6E-11 ± 4.66E-10	1.859E-10 ± 1.243E-10	1.29E-11 ± 1.33E-11	--
Ra-228	1.43E-10 ± 5.77E-10	2.52E-11 ± 8.23E-10	3.427E-10 ± 8.28E-10	5.59E-12 ± 5.86E-11	--
Th-228	9.77E-12 ± 9.61E-11	3.1E-11 ± 1.58E-10	7.784E-11 ± 7.233E-11	5.70E-11 ± 4.08E-11	--
Th-230	0 ± 3.82E-10	2.52E-10 ± 5.18E-10	1.051E-10 ± 5.972E-11	9.41E-11 ± 6.57E-11	--
Th-232	2.14E-11 ± 1.11E-10	5.74E-11 ± 1.81E-10	3.974E-11 ± 3.462E-11	4.97E-11 ± 3.57E-11	--

(a) Indicates AP-4006 Assessment 1 in Table 6-2.
(b) Indicates AP-4006 Assessment 2 in Table 6-2.
* Negative net concentration indicates that the isotopic concentration is lower than background level.
N/A Not available.
-- Background annual dose not calculated.
CEDE Committed Effective Dose Equivalent.
Multiply by 0.01 to convert mrem to mSv.
Multiply by 37,000 to convert $\mu Ci/m^3$ to Bq/m^3.

6.6.1 Collective Population Dose Equivalent

Statistical tests performed at the 95% confidence level for each NESHAPS monitoring result indicated no above-background concentrations. However, the total 1996 collective population dose equivalent was performed for locations that were considered exposure points. Exposure points are defined as locations where there is a potential for members of the public to be exposed to above-background concentrations of airborne radioactive particulate, radon gas concentrations, external gamma radiation, and radionuclides in food or water. All four pathways are addressed for the collective population dose estimate.

The statistical test at the 95% confidence level for all of the air particulate, radon gas, and gamma exposure measurements at the critical receptor monitoring locations indicated there were no elevated levels of exposure, except at stations TD-2004 and RD-2004.

This station is located at the Weldon Spring Chemical Plant perimeter and adjacent to the Missouri Highway Maintenance facility, which is just northeast of the chemical plant perimeter. Measurements of Rn-220 gas by the alpha track detectors and gamma exposure by the environmental thermoluminescent dosimeters (TLDs) indicated above background results, necessitating a general population exposure scenario.

Another potential general population exposure is from the consumption of water, sediment, and fish from the August A. Busch Memorial Conservation Area. Three lakes at the conservation area receive runoff from the Weldon Spring site and are used for fishing and boating. In 1996, scenarios were developed and dose assessments were performed for nine employees of the MHTD facility and 160,000 users of the Busch Memorial Conservation Area. The estimated total collective population dose equivalent was 0.19 person-rem (0.0019 person-Sv) in 1996. Calculations are presented in Appendix B, Section D.

6.6.2 Subparts Q and T of 40 CFR 61

The regulations contained in Subpart Q pertain to Rn-222 emissions from radium-containing storage or disposal facilities. Removal of the bulk waste from the quarry and placement in the temporary storage area (TSA) was completed in 1995. Radon flux measurements at the TSA were initiated in the second quarter of 1996 and were completed in

the first quarter of 1997, as scheduled. The average Rn-222 flux rate measurements were well below the limitation of 20 pCi/m^2/s listed in 40 CFR 61, Subpart Q. Additional information about these measurements is contained in Section 11.3 of this report.

The regulations contained in 40 CFR 61 Subpart T apply only to sites that are "...listed in, or designated by, the Secretary of Energy under Title I of the *Uranium Mill Tailings Control Act of 1978* or regulated under Title II of the *Uranium Mill Tailings Control Act of 1978*." Subpart T does not apply to the Weldon Spring site since it does not fall into the applicable categories.

6.6.3 Radon Emissions from WSSRAP Non-Storage Sources

6.6.3.1 Rn-220 Emissions. The Weldon Spring Quarry was used for disposal of a variety of radiologically and chemically contaminated wastes from the early 1940s to 1969. In December 1995, the transfer of quarry bulk waste to the temporary storage area (TSA) was completed. Included in the radiologically contaminated waste disposal inventory is at least 612 m^3 (800 cu yd) of Th-232 residues received from Cincinnati, Ohio in 1959 and 1966, and an unknown quantity of Th-232 contaminated residues, rubble, and equipment received since the shutdown of the chemical plant in 1966. Radiological characterizations of the quarry wastes were performed in 1984 and 1985. Ra-228 concentrations detected in the quarry wastes during characterization activities ranged from 1.0 pCi/g (0.037 Bq/g) to 2,200 pCi/g (81.4 Bq/g). Additional information about Th-232 wastes is contained in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 2).

Other potential Rn-220 sources are the TSA, which is currently storing quarry bulk wastes, and the four raffinate pits used for the storage of wastes from past uranium refinery operations. Radiological characterization of the raffinate pits waste indicated Ra-228 concentrations ranging from 4 pCi/g (0.148 Bq/g) to 1,400 pCi/g (51.8 Bq/g). Raffinate Pit 4 debris consolidation was conducted from April to December 1996. This work involved dewatering the pit and removing the debris within the pit. The debris, which include approximately 6,000 drums, was washed and placed in interim storage. Dredging of Raffinate Pit 2 sludge and transfer of the sludge to Raffinate Pit 3 was also performed in 1996. Dredging of Pit 2 resulted in increased Rn-220 emissions by exposing residual sludge to the atmosphere.

The chemical plant perimeter is monitored for radon gas at 10 locations using alpha track radon monitors. Statistical analysis of the results at the 95% confidence level indicated that two monitoring locations, RD-3001 and RD-3002, had annual Rn-220 concentrations greater than background levels. To estimate the airborne Rn-220 emissions from the chemical plant during 1996, the above background alpha-track radon detector Rn-220 results were incorporated into a series of box models. The box model approach provides conservative results and is used in place of Gaussian dispersion modeling, which is generally inappropriate for estimates involving close-in receptors. The estimated off-site Rn-220 release from the chemical plant was 128 Ci (4.74E12 Bq). This corresponds to a committed effective dose equivalent to the hypothetical maximally exposed individual of 0.83 mrem (8.3E-3 mSv). Calculations and assumptions are provided in Appendix B, Parts B and C.

6.6.3.2 Rn-222 Emissions. As stated in Section 6.5.3.1, the quarry was used for disposal of a variety of radiologically and chemically contaminated wastes from the early 1940s to 1969. The transfer of quarry bulk waste to the TSA at the chemical plant was completed in 1995. Included in the waste disposal inventory is demolition rubble from the Destrehan Street feed materials plant in St. Louis, Missouri. The waste contained less than 1 Ci (3.7E10 Bq) of Ra-226. Also, several buildings at the chemical plant were decontaminated and approximately 4,200 m^3 (5,500 cu yd) of waste materials were dumped in the quarry. The wastes contained uranium and its progeny. Radiological characterizations of the above material were performed in 1984 and 1985. Ra-226 concentrations detected in the waste during characterization ranged from 0.2 pCi/g (0.007 Bq/g) to 2,780 pCi/g (103 Bq/g). Additional information about Ra-226 waste removed from the quarry is contained in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 2).

The other primary non-storage source of Rn-222 during 1996 was the four raffinate pits that were used for the storage of waste resulting from past uranium refinery operations. Radiological characterization of the raffinate pits waste indicated Ra-226 concentrations ranging from 1 pCi/g (0.037 Bq/g) to 1,700 pCi/g (63 Bq/g). As stated in Section 6.5.3.1, the raffinate pit remedial activities have exposed radon-bearing waste to the atmosphere.

The chemical plant perimeter is monitored for radon gas at 10 locations. Statistical analysis of the monitoring results indicated that there was no reason to suspect at the 95% confidence level that radon concentrations were greater than background levels.

6.6.4 Effluent Monitoring Requirements

The site water treatment plant and the quarry water treatment plant were in operation during 1996 and were potential point sources of radioactive airborne particulates. The WSSRAP has developed a plan to continuously monitor air concentrations of radioactive particulates at designated critical receptor locations resulting from remedial activities, in accordance with 40 CFR 61.93, Paragraph (b)(5). This approach is contained in the report *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by EPA Region VII. The report includes a discussion of the WSSRAP quality assurance program for measurement of radionuclide emissions from the Weldon Spring site. This program conforms to the requirements of 40 CFR 61, Appendix B, Method 114, and ensures that emission measurements are representative and are of known precision and accuracy. Data quality objectives outlined by the quality assurance program are also discussed in Section 6.4.

7 SURFACE WATER PROTECTION

7.1 Highlights of the Surface Water Program

The following are highlights of the 1996 surface water program. These items, and others, are discussed in detail in this chapter.

- The mass of uranium migrating off site in storm water and treated effluent, 38.3 kg/yr (17.3 lbs/yr), was reduced by 1.7% over the 1995 mass of 39.02 kg/yr (17.7 lbs/yr.
- Thirty batches of water were released from the site and quarry water treatment plants during 1996 in compliance with all NPDES permit conditions.
- The overall results of the WET tests indicate that the site and quarry water treatment plant effluent was not toxic to test organisms during 1996.
- Total uranium levels in the Femme Osage Slough were within historical ranges.

7.2 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) is prescribed in the *Environmental Monitoring Plan* (Ref.42) and includes monitoring discharge points permitted under the National Pollutant Discharge Elimination System (NPDES) program and streams, ponds, and lakes under the surface water monitoring program.

The effluent, or NPDES, monitoring program at the Weldon Spring site establishes sampling requirements for discharge points (outfalls) at both the chemical plant and the quarry. The goals of this program are to maintain compliance with the NPDES permit requirements and to protect the health of downstream water users and the environment by characterizing water released from the site. In accordance with the WSSRAP policy that all surface water be closely monitored and treated, as necessary, to meet Federal and State requirements, the Project

Management Contractor (PMC) uses the water sample data to develop strategies to minimize the discharge of waterborne contaminants from the site.

In addition, the surface water monitoring program monitors off-site water bodies for uranium contamination and temporal changes in uranium levels. The data generated from this monitoring are used in conjunction with NPDES monitoring to measure the success of the project's goal to clean up the site with no increase in contaminant discharge or degradation of the off-site water bodies.

7.3 Applicable Standards

The WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Effluent discharges from the site for 1996 were authorized by three NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be monitored at outfalls listed in each permit. Each parameter is assigned either effluent limits or a "monitoring only" status, which means the concentrations are reported but not limited by the permit. Sampling frequencies and reporting requirements for the two major permits, MO-0107701 and MO-0108987, are summarized in Tables 7-1 and 7-2. These permits were reissued on March 4, 1994, and June 10, 1994, respectively. Permit MO-0107701 was revised on August 4, 1995.

The Borrow Area and Borrow Area haul road land disturbance storm water permit, MO-R100B69, issued September 1, 1994, has no specified monitoring or reporting requirements. A program was developed in the *Environmental Monitoring Plan* (Ref.42) for monitoring settleable solids and, under certain circumstances, oil and grease. The results of this monitoring were used to measure the effectiveness of erosion control and to improve controls, if required.

Effluent discharges are also regulated by Department of Energy (DOE) Order 5400.5, which calls for a best available technology evaluation if the annual average uranium concentration at an outfall exceeds the derived concentration guideline (DCG) for natural uranium (600 pCi/l [22.2 Bq/l]). Measures are also taken to keep uranium concentrations as low as reasonably achievable (ALARA).

TABLE 7-1 Weldon Spring Chemical Plant Storm and Sanitary Water (NPDES Permit MO-0107701) Monitoring Requirements

PARAMETER	LOCATION	
	NP-0002, NP-0003[d], NP-0005, NP-0010	NP-0006
Sampling Frequency	once/month	once/quarter
Flow	GPD (monitor only)	GPD (monitor only)[a]
Settleable Solids	1.0 ml/l/hr	---
TSS	mg/l (monitor only)[b]	30/45 mg/l[e]
Nitrate and Nitrite as N	mg/l (monitor only)	---
Uranium, total	mg/l (monitor only)*	---
Gross α	pCi/l (monitor only)	---
pH	6 - 9 standard units	6 - 9 standard units
Fecal coliform	---	400/1000 colonies/ 100 ml[c]
BOD	---	30/45 mg/l[e]

NOTE: Refer to Figure 7-1 for NPDES monitoring locations.

* Permit requires reporting in both mg/l and pCi/l and notification of MDNR if monthly average exceeds 2 mg/l or daily maximum exceeds 4 mg/l.

(a) Frequency is once/month.

(b) Limit is 50 mg/l if erosion control is not designed for a 1 in 10 year, 24-hour storm.

(c) Monthly average/daily maximum.

(d) NPDES permit MO-0107701 includes sampling of creosote constituents, Cu and Zn in the chipped wood storage area pond prior to discharge to Outfall NP-0003. See Table 7-2 for limits.

(e) Monthly average/weekly average.

--- Not Applicable.

TABLE 7-2 Treated Effluent Parameter Limits and Monitoring Requirements for Quarry Water Treatment Plant (NPDES Permit MO-0108987) and Site Water Treatment Plant (NPDES Permit MO-0107701)

PARAMETER	LOCATION NP-0007* NP-1001*	PARAMETER	LOCATION NP-0007* NP-1001*
Gross α	pCi/l[a]	Pb, total	0.10 mg/l
Gross ß	pCi/l[a]	Mn, total	0.10 mg/l
Uranium, total	pCi/l[a][b]	Hg, total	0.004 mg/l
Ra-226[c]	pCi/l[a]	Se, total	0.02 mg/l
Ra-228[c]	pCi/l[a]	Cyanide, Amenable	0.0075 mg/l
Th-230[c]	pCi/l[a]	2,4-DNT	0.22 µg/l
Th-232[c]	pCi/l[a]	Fluoride, total	4.0 mg/l
Flow	GPD[a]	Nitrate and Nitrite as N	20 mg/l[g]
COD	90/60 mg/l [e]	Sulfate as SO_4	500 mg/l
TSS	50/30 mg/l[e]	Chloride	mg/l[a]
pH	6-9 standard units	Priority Pollutants[f]	mg/l[a][h][n]
As, total	0.10 mg/l	Whole Effluent Toxicity	[i][j]
Cr, total	0.10 mg/l	Po-210[d]	pCi/l[a][h]
Cu[d][c]	1.00 mg/l	Ac-227[d]	pCi/l[a][h]
Cu-Site	1.0/0.66 mg/l[e][k]	Radon[d]	pCi/l[a][h]
Zn-Site	5.0/3.33 mg/l[e][k]	Creosote-site[l]	[m][k]

NOTE: Refer to Figure 7-2 for NPDES monitoring locations.
* Frequency = once per batch unless otherwise noted.

(a) Monitoring only.
(b) Water treatment plants designed for an average concentration of 30 pCi/l (1.11 Bq/l) and never to exceed concentrations of 100 pCi/l (3.7 Bq/l).
(c) Once/month.
(d) Quarry only.
(e) Daily maximum/monthly average.

TABLE 7-2 Treated Effluent Parameter Limits and Monitoring Requirements for Quarry Water Treatment Plant (NPDES Permit MO-0108987) and Site Water Treatment Plant (NPDES Permit MO-0107701) (Continued)

(f) Priority pollutants are listed in 40 CFR 122.21 Appendix D, Tables II and III.
(g) Limit applies to chemical plant; monitoring only at quarry.
(h) Annual monitoring.
(i) Quarterly monitoring.
(j) "No statistical difference between effluent and upstream results at 95% confidence level."
(k) Once per batch for each batch sampled within a period of 30 days following introduction of CWSA water (which has failed these limits) to the SWTP.
(l) Includes: acenaphthylene, acenaphthene, benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(a)pyrene, benzo (k) fluoranthene, chrysene, fluoranthene, fluorene, indeno (1,2,3-cd) pyrene, naphthalene, and phenanthrene.
(m) Daily maximum - 2.5 x Q.L., monthly average - 1.5 x Q.L. Q.L. - quantification level as set by most recent edition of Standard Methods (Q.L. taken as practical quantification limit (PQL)).
(n) Polychlorinated biphenyls (PCBs) have a limit of 1 μg/l.

The primary criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards for drinking water supplies established under the Missouri Clean Water Commission Regulation 10 CSR 20-7.031 and the U.S. Environmental Protection Agency primary and secondary maximum contaminant level concentrations for drinking water. A table of applicable water standards that includes contaminants routinely monitored in the surface water program can be found in Section 8.

Surface water, other than NPDES outfalls, is also monitored under the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates DCGs for ingestion of water.

7.4 Hydrology Description of the Site and Quarry

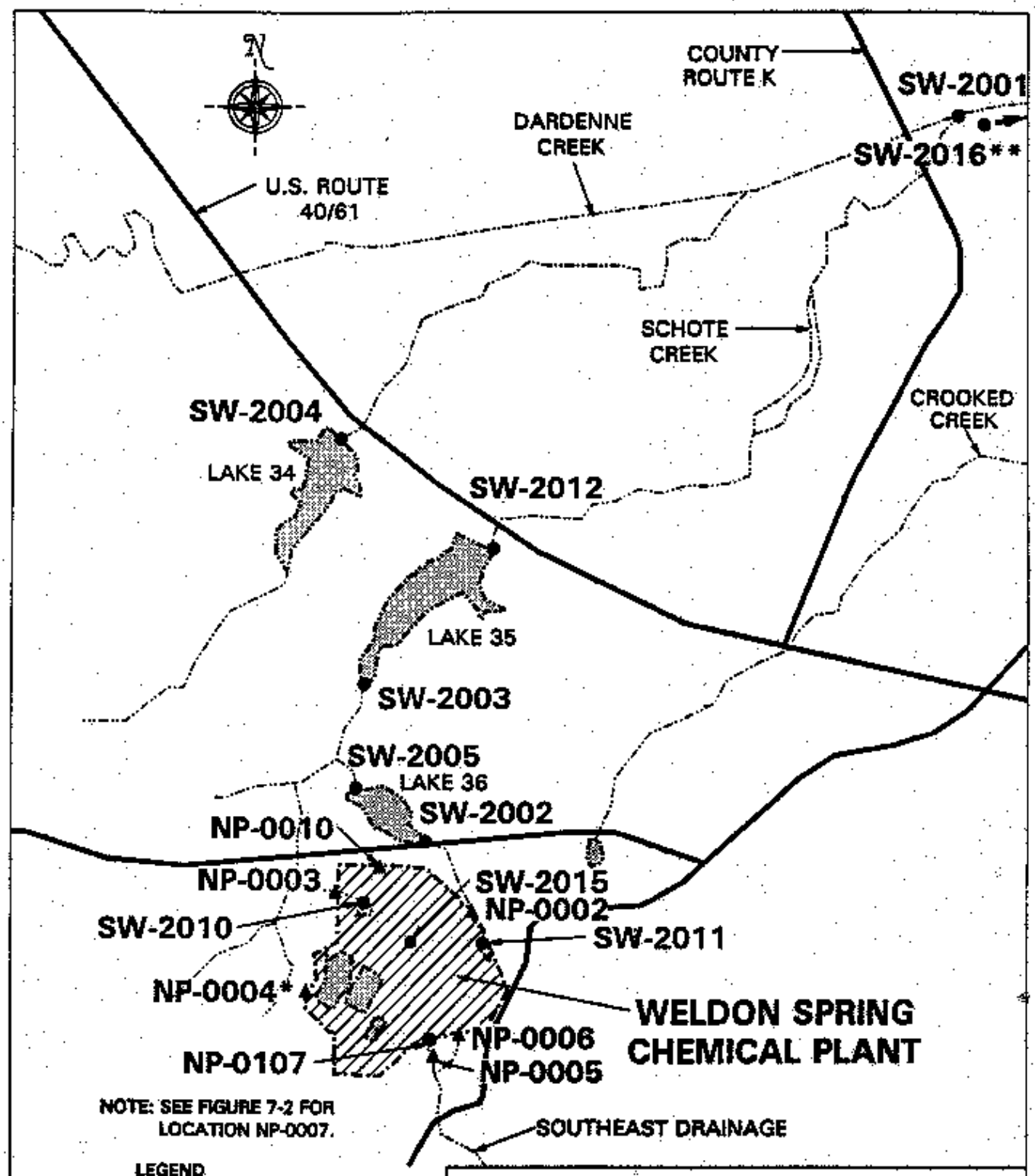
Separate surface water monitoring programs have been developed at the chemical plant and quarry due to differences in the topography and hydrologic conditions. Both programs take into account the mechanisms controlling surface water source areas.

7.4.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits

The chemical plant area is located on the Missouri-Mississippi Rivers surface drainage divide. The topography is gently undulating and generally slopes northward to the Mississippi River. Streams do not cross the property, but incipient drainageways convey surface water runoff to off-site streams. Surface drainage from the western portion of the site, which includes Ash Pond, drains to tributaries of Busch Lake 35 and then to Schote Creek, which in turn enters Dardenne Creek, ultimately draining to the Mississippi River (Figure 7-1). Ash Pond no longer accumulates water unless a valve is closed in the discharge structure. If Ash Pond runoff has a uranium concentration greater than 600 pCi/l, the valve is closed. If the ponded water is below 600 pCi/l after the runoff event it may be released, otherwise it is transferred for treatment.

Surface drainage from the north and east sections of the chemical plant, which includes Frog Pond, discharge to Dardenne Creek after flowing through Busch Lakes 35 and 36 and into Schote Creek (Figure 7-1). All storm water flow which previously entered Frog Pond has been diverted around Frog Pond except for runoff from the immediate vicinity. Runoff from the southern portion of the chemical plant site flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). During late 1995, two sedimentation ponds were constructed and placed in operation. One is upstream of Outfall NP-0003 and receives all the flow from the watershed, including Ash Pond, prior to discharging to the outfall. The other is in the northeast section of the site and receives all runoff from the watershed except that from the Project Management Contractor (PMC) and subcontractor parking lot.

The four raffinate pits, located in the southwestern portion of the chemical plant area, do not discharge to the surface and collect only direct precipitation. Water from the raffinate pits has been, and will be, treated at the site water treatment plant before release. The material staging area (MSA) basin (SW-2015) is a temporary holding pond that collects storm water runoff from the staging area. After monitoring for uranium and meeting the specified release level of less than 600 pCi/l (22.2 Bq/l), this impoundment is periodically pumped into the Ash Pond diversion channel, which flows to NPDES Outfall NP-0003 and then to Busch Lake 35.



NOTE: SEE FIGURE 7-2 FOR LOCATION NP-0007.

LEGEND

- ● - SURFACE WATER LOCATION
- ▲ - NPDES LOCATION
- * - DELETED FROM PERMIT
- ** - AT COUNTY ROUTE N, APPROXIMATELY 2 MILES

0 1/2 1 MI

0 .8 1.6 KM

SCALE

SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS

FIGURE 7-1

REPORT NO.:	DOE/OR/21548-676		EXHIBIT NO.:	A/VP/079/1193	
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	6/10/97

7.4.2 Weldon Spring Quarry

Surface water bodies in the quarry area are the Femme Osage Slough, the Little Femme Osage Creek, and the Femme Osage Creek (Figure 7-2). These water bodies do not receive direct runoff from the quarry, but are sampled to monitor potential changes due to the movement of contaminated groundwater from the fractured bedrock of the quarry through the fine-grained alluvial materials.

The Femme Osage Slough is located directly south of the quarry and is known to receive contaminated groundwater from the quarry through subsurface recharge. There is no natural surface flow from the slough; it is essentially land locked. The Little Femme Osage Creek is located west of the quarry and discharges into the Femme Osage Creek approximately 0.5 km (0.3 mi) southwest of the quarry. The Femme Osage Creek then flows into the Missouri River. Although there has been no evidence of impact from contaminated groundwater on the creeks via stream emergence, they are monitored to detect any changes in the system.

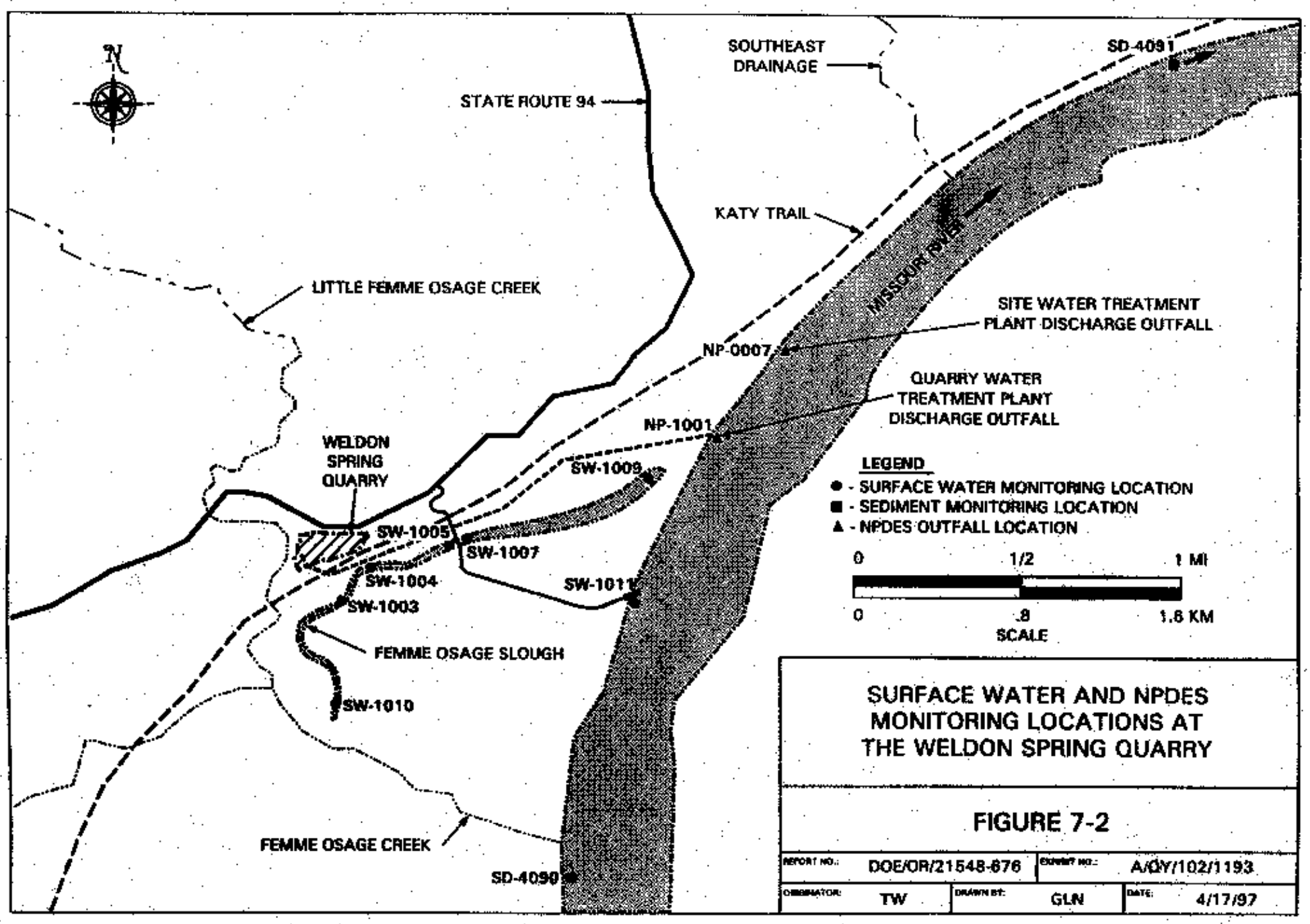
7.5 Monitoring

Sections 7.4.1 and 7.4.2 discuss monitoring requirements at NPDES outfalls and surface water locations at the chemical plant site and the quarry.

7.5.1 National Pollutant Discharge Elimination System Monitoring

The NPDES permits issued to the site identify the parameters to be monitored. The permit requirements are shown in Tables 7-1 and 7-2. Physical, chemical, and radiological parameters were monitored at all storm water outfalls, the quarry water treatment plant and site water treatment plant effluents. The *Environmental Monitoring Plan* (Ref.42) also reflects the requirements of the NPDES permits.

In addition to the permitted outfalls, samples were collected upstream of NPDES storm water Outfalls NP-0002, NP-0003, and NP-0005 from sampling locations SW-2011 (Frog Pond), SW-2010 (Ash Pond), and NP-0107 respectively. Quarterly samples were also collected from the MSA pond and Ash Pond, when possible, to monitor the effects of materials stored in those areas on contaminant levels in the storm water runoff.


N
STATE ROUTE 94
SOUTHEAST DRAINAGE
SD-4091
KATY TRAIL
MISSOURI RIVER
LITTLE FEMME OSAGE CREEK
SITE WATER TREATMENT PLANT DISCHARGE OUTFALL
NP-0007
QUARRY WATER TREATMENT PLANT DISCHARGE OUTFALL
NP-1001
WELDON SPRING QUARRY
SW-1009
SW-1005
SW-1007
SW-1004
SW-1011
SW-1003
FEMME OSAGE SLOUGH
SW-1010
FEMME OSAGE CREEK
SD-4090
LEGEND
● - SURFACE WATER MONITORING LOCATION
■ - SEDIMENT MONITORING LOCATION
▲ - NPDES OUTFALL LOCATION
0
1/2
1 MI
0
.8
1.6 KM
SCALE
SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY
FIGURE 7-2
REPORT NO.: DOE/OR/21548-676
DWG NO.: A/QY/102/1193
DESIGNATOR: TW
DRAWN BY: GLN
DATE: 4/17/97

7.5.2 Surface Water Monitoring

The following two subsections discuss surface water monitoring requirements at the chemical plant site and the quarry.

7.5.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits. Under the surface water monitoring program Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled quarterly for total uranium (Ref. 42). Samples were analyzed quarterly on the site Kinetic Phosphorescent Analyzer (KPA) and semi-annually at contract laboratories. This monitoring was conducted to measure the effects of surface water discharges from the site on downstream surface water. The raffinate pits were previously monitored as surface water, but are now monitored under treatment plant operations sampling. The MSA Pond, Ash Pond, and Frog Pond were also previously sampled under the surface water program, but they are now monitored in conjunction with the NPDES program because they discharge to NPDES permitted outfalls.

7.5.2.2 Weldon Spring Quarry. Seven locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the quarry. Two locations on the Little Femme Osage Creek and one location at the Femme Osage Creek were monitored to provide data to determine if there is impact on these surface waters from the quarry and contaminated sediment.

Surface water locations SW-1003, SW-1004, and SW-1005 (Figure 7-2) were monitored bimonthly for total uranium because of past significant contaminant levels in these areas, fluctuations in concentrations due to changes in water levels in the slough and groundwater potentiometric surface, and the potential for these surface water contaminants to impact groundwater south of the slough. The remaining locations were sampled quarterly to provide sufficient data to determine any changes in these areas. Locations SW-1003, SW-1004, and SW-1005 were also monitored quarterly for nitroaromatic compounds because these locations are downgradient from the area of greatest nitroaromatic groundwater contamination. Nitroaromatic monitoring was deleted from the remaining locations based on sufficient past data indicating no impact and no potential for impact without first detecting contaminants at surface water locations closer to the source.

7.6 Monitoring Results

Analytical results of the monitoring of surface water and NPDES outfalls are presented in the following subsections.

7.6.1 National Pollutant Discharge Elimination System Program Monitoring Results

Radiochemical, chemical and physical analytical results for NPDES outfalls are presented in subsections 7.5.1.1 and 7.5.1.2.

7.6.1.1 Radiochemical Analysis. The 1996 average uranium concentrations at the storm water discharge points ranged from 50.1 pCi/l (1.85 Bq/l) at NP-0010 to 107.0 pCi/l (3.96 Bq/l) at NP-0005, which are 7.4% and 15.7%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 67.8 pCi/l (2.51 Bq/l) at NP-0002 to 179.4 pCi/l (6.64 Bq/l) at NP-0005. The annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 7-3. Uranium concentration averages were calculated on a flow proportional basis except for Outfall NP-0010 where there is no totalizing flow meter. Flow weighted averages for uranium were calculated for the three major outfalls to give a more accurate estimate (than a straight average) of the total uranium that migrated off site during 1996. The averages were flow weighted by summing the total daily flows (gallon) for the days the samples were collected and summing the total activity (pCi) for the days the samples were collected. The sum of the activity for all samples was then divided by the sum of the flow for all samples, to give the flow-weighted average for the year.

The site water treatment plant (SWTP) and quarry water treatment plant (QWTP) were both in operation during 1996. Six batches were discharged from the QWTP and 24 batches were discharged from the SWTP. No daily maximum or monthly average limits are established for uranium; however, the design of the treatment plant is based on achieving an average of 30 pCi/l (1.11 Bq/l) uranium with a maximum never to exceed 100 pCi/l (3.7 Bq/l). The average uranium concentrations for the site and quarry water treatment plants were well below this level at 1.37 pCi/l (0.051 Bq/l) and 1.09 pCi/l (0.040 Bq/l), respectively (Table 7-5). In addition, the SWTP averaged 5.35 pCi/l (0.20 Bq/l) for gross alpha and 16.41 pCi/l (0.61 Bq/l) for gross beta. The QWTP averaged 2.57 pCi/l (0.10 Bq/l) and 5.21 pCi/l (0.19 Bq/l), respectively for these same parameters (Table 7-4). In addition to effluent monitoring, the

TABLE 7-3 1996 Annual Average NPDES Results for the Weldon Spring Chemical Plant Storm Water Outfalls

	LOCATIONS			
PARAMETERS	NP-0002	NP-0003	NP-0005	NP-0010
Number of sample events	13	13	12	10
pH range	(a)	(a)	(a)	(a)
Nitrate (as N) mg/l	0.6	2.9	0.4	1.9
Total suspended solids mg/l	399.3	126	108.6	3652
Settleable solids ml/l/hr	13/2(b)	13/0(b)	13/0(b)	13/3(b)**
Arsenic mg/l	0.00623	0.00466	0.00238	NS
Chromium mg/l	0.01283	0.00906	0.00642	NS
Lead mg/l	0.01247	0.00712	0.00362	NS
Thallium mg/l	0.00412	0.00138	0.00174	NS
Total uranium pCi/l	54*	88*	107*	50.1
Gross alpha pCi/l	67.8	90.8	179.4	115.0
Radium-226 pCi/l	1.4	0.76	2.45	NS
Radium-228 pCi/l	0.85	0.88	0.68	NS
Thorium-228 pCi/l	0.71	0.08	0.23	NS
Thorium-230 pCi/l	0.71	0.11	1.01	NS
Thorium-232 pCi/l	0.47	0.14	0.16	NS

(a) All pH readings were in the permitted range of 6.0 to 9.0.
(b) Top number is number of samples, bottom number is number of results above daily maximum limit of 1.0 ml/l/hr.
* Flow proportional averages.
** Includes two samples from NP-0116 (2/1).
NS Not Sampled.
Note: 1 pCi/l = 0.037 Bq/l.

NPDES permit for the quarry, MO-0108987, required that river sediment sampling be conducted upstream and downstream of the quarry water treatment plant outfall (NP-1001) annually. The river sediment was sampled for uranium at locations SD-4090 (upstream) and SD-4091 (downstream) (see Figure 7-2). The one-time sampling results were 2.3 pCi/g (0.09 Bq/l) at SD-4090 and 2.5 pCi/g (0.09 Bq/l) at SD-4091.

Radium and thorium were monitored once per month in both site and quarry water treatment batches. While there were some isolated incidents of levels elevated above past averages, they were below DCG levels and were within normal range in subsequent samples. Annual averages for radium and thorium at the SWTP and QWTP are shown in Table 7-4.

Ac-227, Po-210 and Rn-222 were monitored one time in 1996 (as required) in the quarry effluent. With a detection limit of 9.27 pCi/l (0.343 Bq/l), Ac-227 was not detected; Po-210 was detected at 0.19 pCi/l (0.007 Bq/l); and Rn-222 was measured at 2.3 pCi/l (0.085 Bq/l), which was below the detection limit (uncensored value).

TABLE 7-4 Site and Quarry Water Treatment Plant Annual Averages for Radium and Thorium (pCi/l)

PARAMETER	QUARRY WTP (NP-1001)	SITE WTP (NP-0007)
Ra-226	0.58 (1/6)	0.74 (3/15)
Ra-228	0.36 (5/6)	2.07 (7/15)
Th-228	0.12 (6/6)	0.17 (12/15)
Th-230	0.22 (4/6)	0.21 (8/15)
Th-232	0.08 (6/6)	0.06 (15/15)
Gross alpha	2.57 (1/6)	5.35 (9/24)
Gross beta	5.21 (0/6)	16.41 (4/24)

* Number of results below detection limit/total number of samples.
Note: 1 pCi/l = 0.037 Bq/l

TABLE 7-5 1996 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL	DRAINAGE AREA HECTARES (ACRES)	ESTIMATED % OF PRECIPITATION AS RUNOFF	AVERAGE CONCENTRATION (PCI/L)	TOTAL RAINFALL VOLUME Ml/yr (Mgal/yr)	TOTAL RUNOFF Ml/yr (Mgal/yr)	TOTAL U RELEASE (Ci/yr)	TOTAL U RELEASE (Kg/yr)
NP-0002	30.4 (75.1)	(b)	53.6*	339.83 (89.52)	180.66 (47.73)	9.7×10^{-3}	14.263
NP-0003	30.2 (74.6)	(b)	88.1*	338.60 (88.93)	147.01 (38.84)	12.97×10^{-3}	19.074
NP-0005	8.2 (20.2)	(b)	106.7*	91.14 (24.08)	25.28 (6.68)	2.70×10^{-3}	3.971
NP-0010	2.0 (5.0)	40[a]	50.1	22.56 (5.96)	9.05 (2.39)	0.452×10^{-3}	0.665
NP-0007	N/A	N/A	1.37	N/A	165.29 (43.67)	0.266×10^{-3}	0.332
NP-1001	N/A	N/A	1.09	N/A	21.95 (5.80)	0.024×10^{-3}	0.035
TOTAL	N/A	N/A	N/A	789.13 (208.49)	549.24 (145.11)	26.1×10^{-3}	38.340

(a) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 55).
(b) Total runoff measured from flow meters.
N/A Not Applicable.
Note: To convert from Ci/yr to Bq/yr multiply Ci/yr by 3.7×10^{10}
* Flow-weighted average.

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are presented in Table 7-5. The total volume of storm water at the three major outfalls was measured with totalizing flow meters. Where flow meters were not available, the flow was determined by total precipitation and runoff curve numbers cited in the U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 55). When flow meters were not operational for a period of time, runoff curve numbers were calculated using flow and precipitation data from periods when the meter was operational. Total uranium released from the treatment plants was calculated using flow meter and effluent concentration data. The estimated mass of uranium released off site in storm water and treated effluent during 1996 was 38.340 kg (84.34 lbs). This is a 1.7% reduction from the calculated amount released during 1995 (39.017 Kg [26.5 Ci]). This reduction may be attributed to the installation of sedimentation basins and the partial removal of foundations and contaminated soils during 1996.

Table 7-6 shows the annual average uranium concentrations of NPDES outfalls from 1991 to 1996. Concentrations in 1996 increased slightly at Outfall NP-0003 and decreased from 1995 concentrations at Outfalls NP-0002, NP-0005 and NP-0010. Historical trending of uranium for Outfalls NP-0002, NP-0003, and NP-0005 is discussed in Section 11.1. Radium and thorium were both periodically monitored at Outfalls NP-0002, NP-0003, and NP-0005 throughout the year to monitor the effects and effectiveness of soil and foundation removal. The parameters for each outfall are discussed in the succeeding paragraphs.

Outfall NP-0001 was the outlet of the abandoned process sewer outfall line. Outfall NP-0001 was physically eliminated during May 1994 and was officially eliminated from the permit on August 4, 1995.

The average uranium concentration for Outfall NP-0002 in 1996 was 53.6 pCi/l (2.0 Bq/l), reduced from the 1995 average of 124 pCi/l (4.6 Bq/l). This reduction is the result of the completion of a sedimentation basin late in 1995, and the removal of contaminated soil from the watershed throughout 1996. Radium and thorium concentrations were generally below baseline values (baseline values are discussed in Section 11.1.3). There were a few instances when the baseline values were exceeded, but the values remained well below the DCGs. Concentrations generally decreased throughout the year as the watershed was remediated.

TABLE 7-6 Six-Year Annual Average Uranium Concentrations at NPDES Outfalls

OUTFALL	ANNUAL AVERAGE TOTAL URANIUM (pCi/l)					
	1991	1992	1993	1994	1995	1996
NP-0001	475	516	1003*	1226*	[a]	[a]
NP-0002	158	228	230*	182*	124*	54*
NP-0003	456	478	607*	332*	67*	88*
NP-0004	6	6	9	12	[b]	[b]
NP-0005	581	296	133*	347*	128*	107*
NP-0010	--	--	--	82	107	50
NP-0007	--	--	0.363	0.74	0.46	1.37

TABLE 7-6 Six-Year Annual Average Uranium Concentrations at NPDES Outfalls (Continued)

OUTFALL	ANNUAL AVERAGE TOTAL URANIUM (pCi/l)					
	1991	1992	1993	1994	1995	1996
NP-1001	--	<0.0003	1.881	1.60	1.76	1.09

* Flow proportional average.
-- Not applicable.
(a) Outfall removed, flow diverted to NP-0005.
(b) Outfall removed from permit in 1995.

Annual average NPDES results for the chemical plant storm water outfalls are shown in Table 7-3.

The average uranium concentration for Outfall NP-0003 was 88.1 pCi/l (3.3 Bq/l), which was slightly greater than the 1995 average of 67 pCi/l (2.5 Bq/l). The slight increase is due to natural variation and the fact that there was little activity in the watershed except for Ash Pond. Ash Pond is being used to store contaminated soil and debris. Radium and thorium concentrations were generally below baseline values. There were a few instances of the baseline values being exceeded, but the values remained well below the DCG values. Annual average uranium concentrations are shown in Table 7-3 and baseline values are discussed in Section 11.1.3.

Outfall NP-0004 was eliminated from NPDES permit MO-0107701 on March 4, 1994. No samples were collected during 1996.

The annual average uranium concentration at Outfall NP-0005 for 1996 was 106.7 pCi/l (4.0 Bq/l), which was slightly less than the 1995 average of 128 pCi/l (4.7 Bq/l). The uranium concentrations at this location were highly variable early in 1996 due to the two sources that contributed to the outfall. The two sources were a sedimentation basin that has very low levels of uranium and an area that has high concentrations of uranium during low-flow runoff. The NP-0005 watershed was partially remediated, and the uranium concentrations at the outfall during the later part of the year were considerably lower. Radium and thorium concentrations were generally below baseline values. There were a few instances of the baseline values being

exceeded but the values remained well below the DCGs. Annual average NPDES results are shown in Table 7-3 and baseline values are discussed in Section 11.1.3.

Outfall NP-0010 was added to NPDES Permit MO-0107701 when it was reissued on March 4, 1994. This outfall is located at the west end of the north perimeter fence in the construction material staging area (CMSA), and drains a portion of the CMSA. The CMSA is used to store clean soil, gravel, and other construction material. Contaminated soil was removed and the CMSA was completed early in 1996. The annual average uranium concentration was 50 pCi/l (1.9 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and the 1995 average of 107 pCi/l (4.0 Bq/l). Uranium concentrations after March 1996 were all below 10 pCi/l. Radium and thorium were not suspected, and therefore, were not measured at NP-0010. The annual average NPDES results are reported in Table 7-3.

The MSA pond (SW-2015) was sampled quarterly for gross alpha, uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232 to monitor the contaminants in storm water runoff from the MSA. Monitoring also allowed determination of potential impacts on Outfall NP-0003. The uranium average was 134.8 pCi/l (5.0 Bq/l), slightly higher than the 1995 average of 110.1 pCi/l (4.1 Bq/l), but well below the release criteria of 600 pCi/l (22.2 Bq/l). Radium and thorium were measured at low levels, well below DCG values. The annual average radiological concentrations are reported in Table 7-7.

Ash Pond (SW-2010) was sampled quarterly, when water was present, for gross alpha, uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232 to monitor the effects of demolition debris and soil stored in Ash Pond on Ash Pond runoff and subsequently, on the downstream outfall, NP-0003. The pond was also monitored for uranium and gross alpha when the monthly NPDES sample was collected at Outfall NP-0003. Monitoring is performed in conjunction with the NPDES sampling at Outfall NP-0003. The uranium average at Ash Pond was 391 pCi/l (14.5 Bq/l), somewhat lower than the 1995 average of 475 pCi/l (17.6 Bq/l) and below the DCG of 600 pCi/l (22.2 Bq/l). Radium and thorium were measured at levels well below the DCG. Table 7-7 contains the annual average radiological concentrations.

Frog Pond was sampled for uranium and gross alpha, in conjunction with NPDES sampling at Outfall NP-0002. The uranium average for 1996 was 276.4 pCi/l (10.2 Bq/l), slightly less than the 1995 average of 286.7 pCi/l. During late 1995, Frog Pond was essentially

isolated by diverting potential inflow around the pond, and its role as a contributor to Outfall NP-0002 was greatly reduced. Other than runoff from the immediate area and direct precipitation, no water enters Frog Pond. Table 7-7 contains the annual average radiological concentrations.

TABLE 7-7 MSA, Ash Pond and Frog Pond - 1996 Annual Average Radiological Concentrations (pCi/l)

LOCATION PARAMETER	ASH POND SW-2010	MSA POND SW-2015	FROG POND SW-2011	NP-0107
Ra-226	2.4	0.5	NS	NS
Ra-228	2.1	1.6	NS	NS
Th-228	0.4	0.2	NS	NS
Th-230	0.9	0.4	NS	NS
Th-232	0.3	0.1	NS	NS
U	391	134.8	276.4	1027.3
Gross alpha	295	125	209.0	835.2

NS Not Sampled.

Location NP-0107 was sampled monthly in conjunction with NPDES sampling at Outfall NP-0005. In mid-1996, the watershed above NP-0107 was remediated and, because of excavation, no water flowed from the NP-0107 location. Any water removed from the watershed was pumped to the site water treatment plant sedimentation basin. The annual average for uranium for 1996 at NP-0107 was 1027.3 pCi/l (38 Bq/l) when water was flowing. After the watershed was remediated there was no longer any flow from NP-0107 because the flow had been diverted to the east of NP-0107. Uranium levels in runoff from the watershed were greatly reduced resulting in a reduction in uranium concentration downstream at Outfall NP-0005. Table 7-7 contains the annual average uranium concentrations.

7.6.1.2 Physical and Chemical Results.

Analytical results for physical and chemical (as opposed to radiochemical) parameters at NPDES outfalls are presented in Subsections 7.5.1.2.1 through 7.5.1.2.3.

7.6.1.2.1 Chemical Plant Storm Water. The annual averages for the physical and chemical parameters for storm water Outfalls NP-0002, NP-0003, NP-0005, and NP-0010 are shown in Table 7-3. In addition to the permitted parameters, arsenic, chromium, lead, thallium, radium and thorium were periodically monitored. Nitroaromatics and volatiles were also sampled, but less frequently. Because parameters with only one or two sample results were not present at reportable levels, they are not shown in Table 7-3. While some parameters were present above baseline levels (see Section 11.1.3), they were not above NPDES reporting levels.

Ash Pond (SW-2010) was sampled quarterly for polycyclic (or polynuclear) aromatic hydrocarbons (PAH), As, Cr, Tl, Pb, 2,4-dinitrotoluene (DNT), and 2,4,6-trinitrotoluene (TNT) to monitor the effect of demolition debris and soils in Ash Pond on contaminants in the Ash Pond storm water runoff. Metals were noted at levels slightly elevated over past results during September, but subsequent samples showed concentrations at normal levels. The elevated levels did not cause levels at Outfall NP-0003 to reach NPDES reporting levels. Should contaminant concentrations appear to be increasing, monitoring frequencies would be increased. If increased monitoring were to indicate that Ash Pond water would cause contaminant levels at Outfall NP-0003 to exceed permit limits or reporting levels, a valve in the Ash Pond discharge structure would be closed and the water retained. Analytical results are shown in Table 7-8.

The MSA Pond (SW-2015) was sampled quarterly for the same parameters as Ash Pond to monitor the effects of material stored at the MSA on storm water runoff to the pond. None of the contaminants were detected at levels elevated over past results. The monitoring results are used to determine whether MSA water would cause contaminant levels at Outfall NP-0003 to exceed permit limits or reporting levels. If it appeared that contaminant concentrations were increasing, then monitoring frequencies would be increased and water that would adversely affect Outfall NP-0003 would not be released. Analytical results are shown in Table 7-8.

TABLE 7-8 Ash and MSA Pond - 1996 Annual Average Chemical Concentrations (µg/l)

PARAMETER	LOCATION	
	ASH POND (SW-2010)	MSA POND (SW-2015)
PAHs	<23*	<10
As	24.7	1.6
Cr	64.1	2.3
Tl	2.2	1.6
Pb	47.1	4.9
PCBs	<1*	<1*
2,4-DNT	<0.20*	0.03
2,4,6-TNT	0.11	0.05

* All ND

7.6.1.2.2 Administration Building Sewage Treatment Plant. Monitoring results for sewage treatment plant Outfall NP-0006 are given in Table 7-9. All parameters were in compliance with the permitted limits.

7.6.1.2.3 Site and Quarry Water Treatment Plant Physical and Chemical Parameters. Physical and chemical parameters were all within permitted limits (where limits were assigned) for the site and quarry water treatment plants.

During 1996, whole effluent toxicity (WET) tests were required quarterly for both site water treatment plant, and quarry water treatment plant effluent. The WET test is a measure of toxicity without quantifying or identifying the toxic constituents. Tests were conducted on both Ceriodaphnia dubia (water flea) and Pimephales promelas (fathead minnow). The tests were conducted in effluents and in test controls of upstream river water and laboratory control water. No effluent samples failed the WET tests during 1996, indicating that the site and quarry water treatment plant effluents were not toxic to test organisms (see Table 7-2). Whole effluent toxicity test results are summarized in Table 7-10.

TABLE 7-9 NP-0006, Sewage Treatment Plant Outfall, Monthly Averages of Permitted Parameters

	PARAMETER[a] (PERMIT LIMITS)			
MONTH	TSS (30/45 mg/l)*	BOD (30/45 mg/l)*	FC[b] (400/1000 col/100 ml)**	pH (6.0-9.0 SU)
January	4.0	11.3	<1	(c)
April	6.0	9.2	<1	(c)
July	2.0	2.6	400	(c)
October	<2.0	3.6	<1	(c)

(a) One sample analyzed for each month noted.
(b) F.C - fecal coliform.
(c) pH values were between 6.0 and 9.0.
NS Not Sampled
* Monthly average/weekly average.
** Monthly average/daily maximum

TABLE 7-10 1996 Whole Effluent Toxicity Test Results for the Site and Quarry Water Treatment Plants

BATCH	DATE	DAPHNIA (D)% MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
S074	02/01/96	0	0	0,0	0,0
S080	05/09/96	0	0	0,0	0,0
S083	07/02/96	0	0	0,0	0,0
S091	10/17/96	0	0	0,0	0,0
Q043	02/28/96	0	0	0,0	0,0
Q045	05/07/96	0	0	5,0	5,0
Q046	06/27/96	0	0	0,0	0,0

TABLE 7-10 1996 Whole Effluent Toxicity Test Results for the Site and Quarry Water Treatment Plants (Continued)

BATCH	DATE	DAPHNIA (D)% MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
Q047	10/23/96	0	0	0,0	0,0

P Pimephales
D Daphnia (Ceriodaphnia)

7.6.2 Surface Water Monitoring Results

Analytical results for surface water monitoring locations at the chemical plant site and quarry are presented in Subsections 7.5.2.1 and 7.5.2.2.

7.6.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits. Average uranium levels at off-site surface water locations were slightly lower at some locations and slightly higher at others than the 1995 annual averages. These variable results are likely due to the various stages of disturbance and remediation in the watersheds during foundation and contaminated soil removal, and the beneficial effects of the sedimentation basins. Because the Busch Lakes are large bodies of water, reduction in uranium levels at the lakes and downstream will significantly lag behind reductions in uranium at the NPDES outfalls. Average annual uranium concentrations for surface water are shown in Table 7-11, along with the 1995 figures and the historic high for the location for comparison. Surface water locations are shown in Figure 7-1.

TABLE 7-11 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations*

LOCATION	AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-2001	(1.8) **1.4**	(2.4) **2.5**	(1.16) **0.3**	10 (1993)
SW-2002	(35.9) **29.5**	(40.3) **55.8**	(31.5) **7.9**	390 (1994)
SW-2003	(6.4) **15.3**	(8.3) **23.7**	(4.45) **5.8**	69 (1988)
SW-2004	(7.1) **14.1**	(7.9) **16.9**	(6.23) **7.3**	39 (1989)
SW-2005	(32.2) **27.8**	(35.6) **53.7**	(28.8) **13.0**	53.7 (1996)
SW-2012	[a] **6.5**	[a] **11.2**	[a] **2.8**	326 (1991)
SW-2016	(1.6) **2.0**	(2.0) **4.5**	(1.12) **0.8**	7.8 (1994)

* 1995 results are given in parenthesis.
Note 1: 1 pCi/l = 0.037 Bq/l.
Note 2: Four samples were collected from each location during the year.
(a) No sample collected, no flow from lake during 1995.

7.6.2.2 Weldon Spring Quarry.

Total Uranium. The average total uranium values continue to indicate that the highest levels are found in the portion of the Femme Osage Slough (SW-1003, SW-1004 SW-1005 and SW-1010) down-gradient of the quarry. The annual averages for the surface water locations are summarized in Table 7-12. The uranium levels in the Femme Osage Slough are within historical ranges.

Sampling in the Little Femme Osage Creek and the Femme Osage Creek was eliminated from the monitoring program because total uranium concentrations remained at background levels at these locations (SW-1001, SW-1002, and SW-1014) throughout the history of WSSRAP monitoring (1987 through 1995).

TABLE 7-12 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Monitoring Locations

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-1003	26.73	49.61	16.62	252 (1989)
SW-1004	34.24	77.59	17.35	4000 (1993)
SW-1005	16.46	27.48	8.47	116 (1991)
SW-1007	9.83	14.87	6.64	69 (1992)
SW-1009	6.25	7.92	1.85	28.6 (1991)
SW-1010	18.65	25.74	11.8	156 (1991)

Note: 1 pCi/l = 0.037 Bq/l

No new historic total uranium high concentrations were reported for quarry surface water during 1996.

Nitroaromatic Compounds

Nitroaromatic compounds were analyzed at SW-1003, SW-1004, and SW-1005 in the Femme Osage Slough. No detectable levels were observed for any of the six compounds monitored.

8 GROUNDWATER MONITORING

8.1 Highlights of the Groundwater Monitoring Program

The following are highlights of the 1996 groundwater monitoring program. These items, and others, are discussed in detail in this chapter.

- Previously reported elevated uranium concentrations in a newly installed well (MW-4024) located east of the chemical plant eastern perimeter have decreased to near background concentrations.

- Contaminant levels generally remained within historic ranges at all chemical plant locations. A new uranium high was measured at one off-site location, but subsequent uranium measurements at that location were within historical range.

- Monitoring results for Burgermeister Spring were generally within historical ranges. No new highs or lows were recorded, and no significant changes are apparent.

- Environmental monitoring indicates that the greatest amount of radiochemical and nitroaromatic contamination in the groundwater is present in the bedrock of the quarry rim and the alluvial materials and bedrock north of the Femme Osage Slough.

- Total uranium concentrations in groundwater remain within background ranges, and no detectable concentrations of nitroaromatic compounds were identified south of the slough or in any of the St. Charles County production wells.

- With the exception of MW-1031 (for uranium) nitroaromatic compounds and total uranium concentrations in groundwater continue to decrease at locations previously described as having downward trends at the quarry.

- Volatile organic compounds (trichloroethene and dichloroethene) have been detected in groundwater at the chemical plant and are currently under investigation to determine the source and extents of contamination.

- Data for 1996 indicate that bulk waste removal activities have decreased the level of nitroaromatic compounds in the groundwater at the quarry.

- Previous trending analyses for pre-1996 total uranium and nitroaromatic data from both the chemical plant and the quarry area which indicated stationary or downward trends once again exhibited stationary or downward concentrations for 1996.

8.2 Program Overview

The groundwater monitoring and protection program at the Weldon Spring Site Remedial Action Project (WSSRAP) includes sampling and analysis of water collected from wells at the Weldon Spring Chemical Plant and raffinate pits, the Weldon Spring Quarry, vicinity properties, and from selected springs in the vicinity of the Weldon Spring site. The groundwater protection program is formally defined in the *Groundwater Protection Program Management Plan* (Ref. 13). This document which describes groundwater protection practices and policies, is being revised during 1997 to include updated regulatory agency codes. The groundwater monitoring portion of the program is detailed in the *Environmental Monitoring Plan* (EMP) (Ref. 42).

Due to lithologic differences, including those geologic features that influence groundwater flow mechanics, and the geographical separation of the chemical plant and quarry areas, separate groundwater monitoring programs have been established for the two sites. Generalized geologic and hydrologic descriptions of the two sites are found in Section 1.3. A generalized stratigraphic column for reference is provided in Figure 8-1, and hydrogeologic descriptions of lithologies monitored for the program are in Section 8.3.

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (FT.)(1)	LITHOLOGY	PHYSICAL CHARACTERISTICS	HYDROSTRATIGRAHIC UNIT
QUATERNARY	HOLOCENE	ALLUVIUM	0 - 120		GRAVELLY, SILTY LOAM.	ALLUVIAL AQUIFER
	PLEISTOCENE	LOESS AND GLACIAL DRIFT (2)	10- 60	VARIABLE	SILTY CLAY, GRAVELLY CLAY, SILTY LOAM, OR LOAM OVER RESIDUUM FROM WEATHERED BEDROCK.	(UNSATURATED)(2)
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION (3)	0 - 15		LIMESTONE, LIMEY DOLOMITE, FINELY TO COARSELY CRYSTALINE, MASSIVELY BEDDED, AND THIN BEDDED SHALE.	
		WARSAW FORMATION (3)	60 - 80		SHALE AND THIN TO MEDIUM BEDDED FINELY CRYSTALINE LIMESTONE WITH INTERBEDDED CHERT.	
	OSAGEAN	BURLINGTON AND KEOKUK LIMESTONES	100 - 200		CHERTY LIMESTONE, VERY FINE TO VERY COARSELY CRYSTALINE, FOSSILIFEROUS, THICKLY BEDDED TO MASSIVE.	SHALLOW AQUIFER SYSTEM
		FERN GLEN LIMESTONE	45 - 70		CHERTY LIMESTONE, DOLOMITIC IN PART, VERY FINE TO VERY COARSELY CRYSTALINE, MEDIUM TO THICKLY BEDDED.	
	KINDERHOOKIAN	CHOUTEAU LIMESTONE	20 - 50		DOLOMITIC, ARGILLACEOUS LIMESTONE; FINELY CRYSTALINE; THIN TO MEDIUM BEDDED.	UPPER LEAKY CONFINING UNIT
DEVONIAN	UPPER	SULPHUR SPRINGS GROUP BUSHBERG SANDSTONE (4)	40 - 65		QUARTZ ARENITE, FINE TO MEDIUM GRAINED, FRIABLE.	
		LOWER PART OF SULPHUR SPRINGS GROUP			CALCAREOUS SILTSTONE, SANDSTONE, OOLITIC LIMESTONE, AND HARD CARBONACEOUS SHALE.	
ORDOVICIAN	CINCINNATIAN	MAQUOKETA SHALE (5)	10 - 30		CALCAREOUS TO DOLOMITIC SILTY SHALE AND MUDSTONE, THINLY LAMINATED TO MASSIVE.	
	CHAMPLAINIAN	KIMMSWICK LIMESTONE	70 - 100		LIMESTONE, COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED, FOSSILIFEROUS AND CHERTY NEAR BASE.	MIDDLE AQUIFER SYSTEM
		DECORAH GROUP	30 - 60		SHALE WITH THIN INTERBEDS OF VERY FINELY CRYSTALINE LIMESTONE.	LOWER CONFINING UNIT
		PLATTIN LIMESTONE	100 - 130		DOLOMITIC LIMESTONE, VERY FINELY CRYSTALLINE, FOSSILIFEROUS, THINLY BEDDED.	
		JOACHIM DOLOMITE	80 - 105		INTERBEDDED VERY FINELY CRYSTALLINE, THINLY BEDDED DOLOMITE; LIMESTONE; AND SHALE. SANDY AT BASE.	
		ST. PETER SANDSTONE	120 - 150		QUARTZ ARENITE, FINE TO MEDIUM GRAINED, MASSIVE.	DEEP AQUIFER SYSTEM
	CANADIAN	POWELL DOLOMITE	50 - 60		SANDY DOLOMITE, MEDIUM TO FINELY CRYSTALINE, MINOR CHERT AND SHALE.	
		COTTER DOLOMITE	200 - 250		ARGILLACEOUS, CHERTY DOLOMITE; FINE TO MEDIUM CRYSTALINE. INTERBEDDED WITH SHALE.	
		JEFFERSON CITY DOLOMITE	160 - 180		DOLOMITE, FINE TO MEDIUM CRYSTALINE.	
		ROUBIDOUX FORMATION	150 - 170		DOLOMITIC SANDSTONE.	
		GASCONADE DOLOMITE	250		CHERTY DOLOMITE AND ARENACEOUS DOLOMITE (GUNTER MEMBER).	
CAMBRIAN	UPPER	EMINENCE DOLOMITE	200		DOLOMITE, MEDIUM TO COARSELY CRYSTALLINE, MEDIUM BEDDED TO MASSIVE.	
		POTOSI DOLOMITE	100		DOLOMITE, FINE TO MEDIUM CRYSTALLINE, THICKLY BEDDED TO MASSIVE. DRUSY QUARTZ COMMON.	

(1) THICKNESS DATA SOURCES VARY. QUATERNARY UNIT THICKNESS BASED ON ON-SITE DRILLING AND TRENCHING. BURLINGTON AND KEOKUK THROUGH JOACHIM DOLOMITE BASED ON USGS WELLS MW-GS02 AND GS05. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMMELL (REF 64). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-89-262-GI (REF 53).

(2) GLACIAL DRIFT UNIT SATURATED IN NORTHERN PORTION OF ORDNANCE WORKS WHERE THIS UNIT BEHAVES LOCALLY AS A LEAKY CONFINING UNIT. (GEOLOGIC LOG)

(3) THE WARSAW AND SALEM FORMATIONS ARE CONSIDERED TO BE ABSENT FROM THE WELDON SPRING AREA DUE TO EROSION.

(4) THE SULPHUR SPRINGS GROUP ALSO INCLUDES THE BACHELOR SANDSTONE AND THE GLEN PARK LIMESTONE-MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY. (REF 53)

(5) THE MAQUOKETA SHALE IS NOT PRESENT IN THE WELDON SPRING AREA BASED ON GEOLOGIC LOGS.

GENERALIZED STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

FIGURE 8-1

REPORT NO.	DOE/OR/21548-676	EXHIBIT NO.	A/PI/047/0391
ORIGINATOR	RCC	DRAWN BY	SRS	DATE	4/17/97

8.3 Referenced Standards

Two criteria used to develop the criteria for the groundwater monitoring program are: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Water 1986* (Ref. 35), which is intended to protect public groundwater resources, and (2) the Missouri Drinking Water Standards (Ref. 36). These standards are mainly used for comparison of levels observed in the St. Charles County well field. Table 8-1 identifies EPA water quality standards and Missouri Drinking Water Standards for contaminants that are routinely monitored in the groundwater program. Maximum contaminant levels (MCLs) and other drinking water standards are used only as references by the WSSRAP. The affected groundwater does not represent a public drinking water supply as defined in 40 CFR, Part 141, Subpart A - General.

Groundwater is also monitored under the requirements of Department of Energy Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates derived concentration guidelines (DCGs) for ingestion of water equivalent to 100 mrem (1.0 mSv) effective dose equivalent, based on the consumption of 730 liters/year (193 gal/year) (Table 8-2). As specified in Department of Energy Order 5400.5, liquid effluent from U.S. Department of Energy (DOE) activities may not cause private or public drinking waters to exceed the radiological limit of an effective dose equivalent greater than 4 mrem (0.04 mSv/year) per year or 4% of the DCG.

Groundwater monitoring at the WSSRAP is a key component of the groundwater protection program. In addition to monitoring, the program integrates site-wide practices and policies in the interest of groundwater protection as specified by proposed Federal Code 10 CFR 834, which is expected to be enacted during 1997.

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it sits atop a local groundwater high and straddles the regional groundwater divide (Ref. 37). Background values for uranium, nitrate, and sulfate were developed by the U.S. Geological Survey (USGS) for the shallow aquifer (Ref. 37) and are used in lieu of these comparisons.

TABLE 8-1 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD	PARAMETER		LEVEL	REFERENCE STANDARD
Radio-chemical	Uranium total[a,c]	20 µg/l (13.6 pCi/l)	EPA	Metals	Fe[d]	300 µg/l	MDWS
	Gross α (adjusted)[c]	15 pCi/l	MDWS		Pb[e]	15 µg/l	MDNR
	Ra-226[b,c]	5 pCi/l	MDWS		Mn[d]	50 µg/l	MDWS
	Rn-222[a,c]	300 pCi/l	EPA		Hg[c]	2.0 µg/l	MDWS
Misc.	2,4-DNT[e]	0.11 µg/l	MDNR		Ni[c]	100 µg/l	MDWS
	TDS[d]	500 mg/l	MDWS		Se[c]	50 mg/l	MDWS
Metals	Sb[c]	6.0 µg/l	MDWS		Ag[d]	100 µg/l	MDWS
	As[c]	50 µg/l	MDWS		Zn[d]	5.0 mg/l	MDWS
	Ba[c]	2 mg/l	MDWS				
	Be[c]	4.0 µg/l	MDWS	Anions	Cl^-[d]	250 mg/l	MDWS
	Cd[c]	5 µg/l	MDWS		F^-[d]	2.0 mg/l	MDWS
	Cr[c]	100 µg/l	MDWS		NO_3[c]	10 mg/l	MDWS
	Cu[d]	1.0 mg/l	MDWS		SO_4[d]	250 mg/l	MDWS

(a) Proposed.
(b) Standard for combined Ra-226 and Ra-228.
(c) Primary maximum contaminant level.
(d) Secondary maximum contaminant level.
(e) Water Quality Standard for Groundwater.
EPA EPA Drinking Water Standards for Radionuclides.
MDNR Missouri Department of Natural Resources
MDWS Missouri Drinking Water Standard.

TABLE 8-2 Derived Concentration Guidelines for Discharge Waters

PARAMETER	DERIVED CONCENTRATION GUIDELINE
Natural Uranium	600 pCi/l
Ra-226	100 pCi/l
Ra-228	100 pCi/l
Th-230	300 pCi/l
Th-232	50 pCi/l

Note: 1 pCi/l = 0.037 Bq/l.

8.4 Weldon Spring Chemical Plant

8.4.1 Hydrogeologic Description

The Weldon Spring Chemical Plant is located in a transitional area between the Dissected Till Plains of the central lowlands province to the north and the Salem Plateau of the Ozark Plateaus physiographic province to the south.

The chemical plant is located on a groundwater divide from which groundwater flows north toward Dardenne Creek and then ultimately to the Mississippi River, or south to the Missouri River. Regional groundwater flow for St. Charles County is towards the east. Localized flow is controlled largely by topographic highs and streams and drainages. Groundwater movement is generally by diffuse flow with localized zones of discrete fracture-controlled flow.

The chemical plant and raffinate pit area lithologies consist of two major geologic units; unconsolidated surficial material and carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated. Thicknesses range from 6.1 m to 15.3 m (20 ft to 50 ft) (Ref. 3).

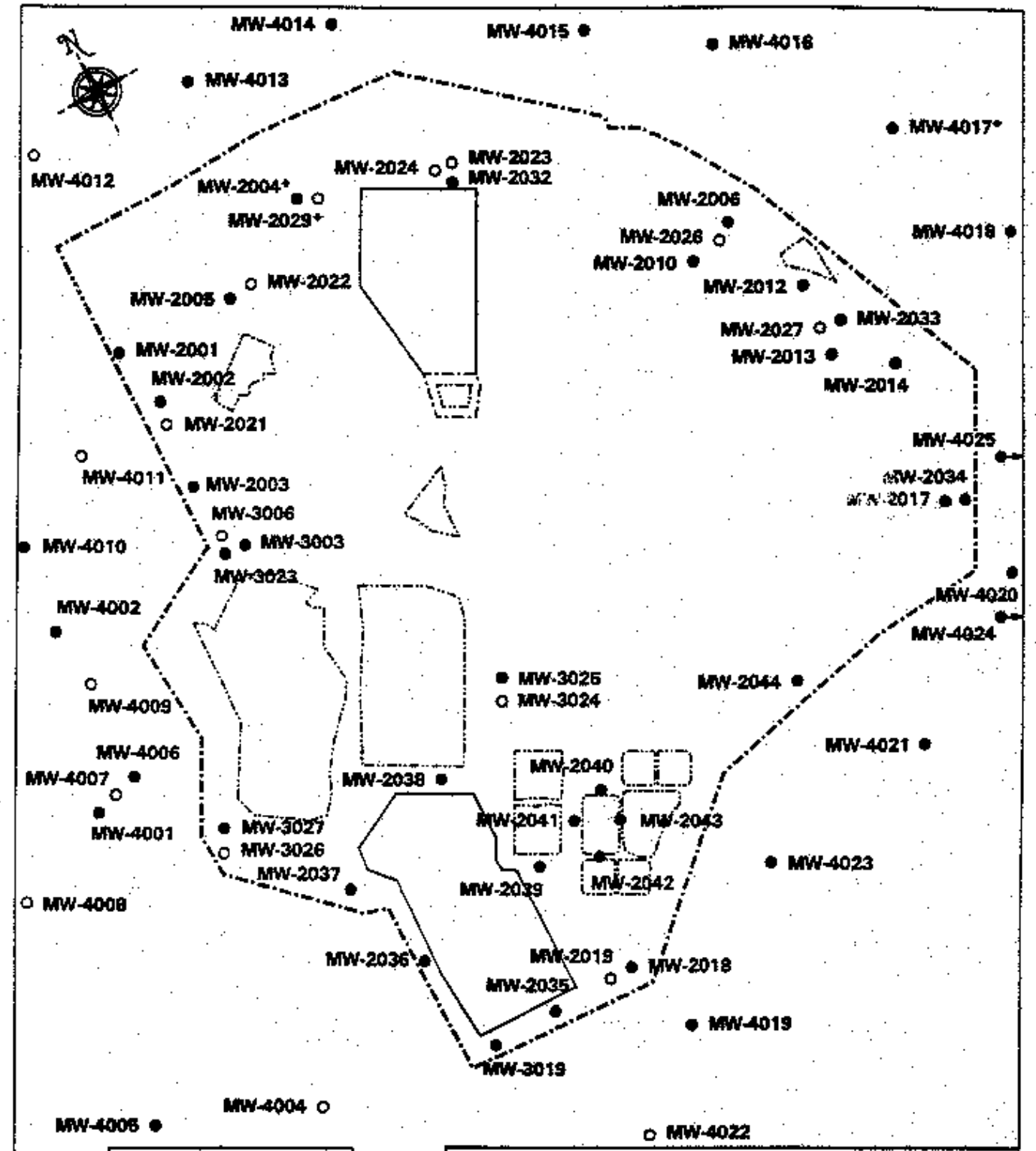
Potential groundwater impacts are assessed by monitoring groundwater from the monitoring well network at the site. The aquifer of concern beneath the chemical plant, raffinate

pits, and vicinity properties is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the uppermost bedrock unit) and the Fern Glen Limestone. The Burlington-Keokuk Limestone is composed of two different lithologic zones, a shallow weathered zone underlain by an unweathered zone. The weathered portion of this formation is highly fractured and exhibits solution voids and enlarged fractures. These features may also be found on a limited scale in the unweathered zone. The unweathered portion of the Burlington-Keokuk Limestone is thinly to massively bedded. Fracture densities are significantly less in the unweathered zone than in the weathered zone. Localized aquifer properties are controlled by fracture spacing, solution voids, and preglacial weathering, including structural troughs along the bedrock-unconsolidated material interface.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Of the 64 monitoring wells, 18 are completed (screened) in the unweathered zone. The wells in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. The remainder of the wells are open to the weathered unit of the bedrock where groundwater has the greatest potential for contaminant impact. Where possible, monitoring wells within the boundaries of the chemical plant are located close to potential contaminant sources to assess migration into the groundwater system. Additional wells are located outside the chemical plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 8-2).

Springs, a common feature in carbonate terrains, are present in the vicinity of the Weldon Spring site. Four springs are known to have been historically influenced by chemical plant discharge water potentially containing one or more of the contaminants of concern (Figure 8-3). Currently, Burgermeister Spring (SP-6301 on Figure 8-3) is monitored to determine contaminant off-site migration potential via spring transport.

The presence of elevated total uranium and nitrate levels at Burgermeister Spring, which is located 1.9 km (1.2 mi) north of the site, indicates that discrete flow paths are present in the vicinity of the site.



LEGEND
- ● WEATHERED ZONE
- ○ UNWEATHERED ZONE
- * ABANDONED IN 1995

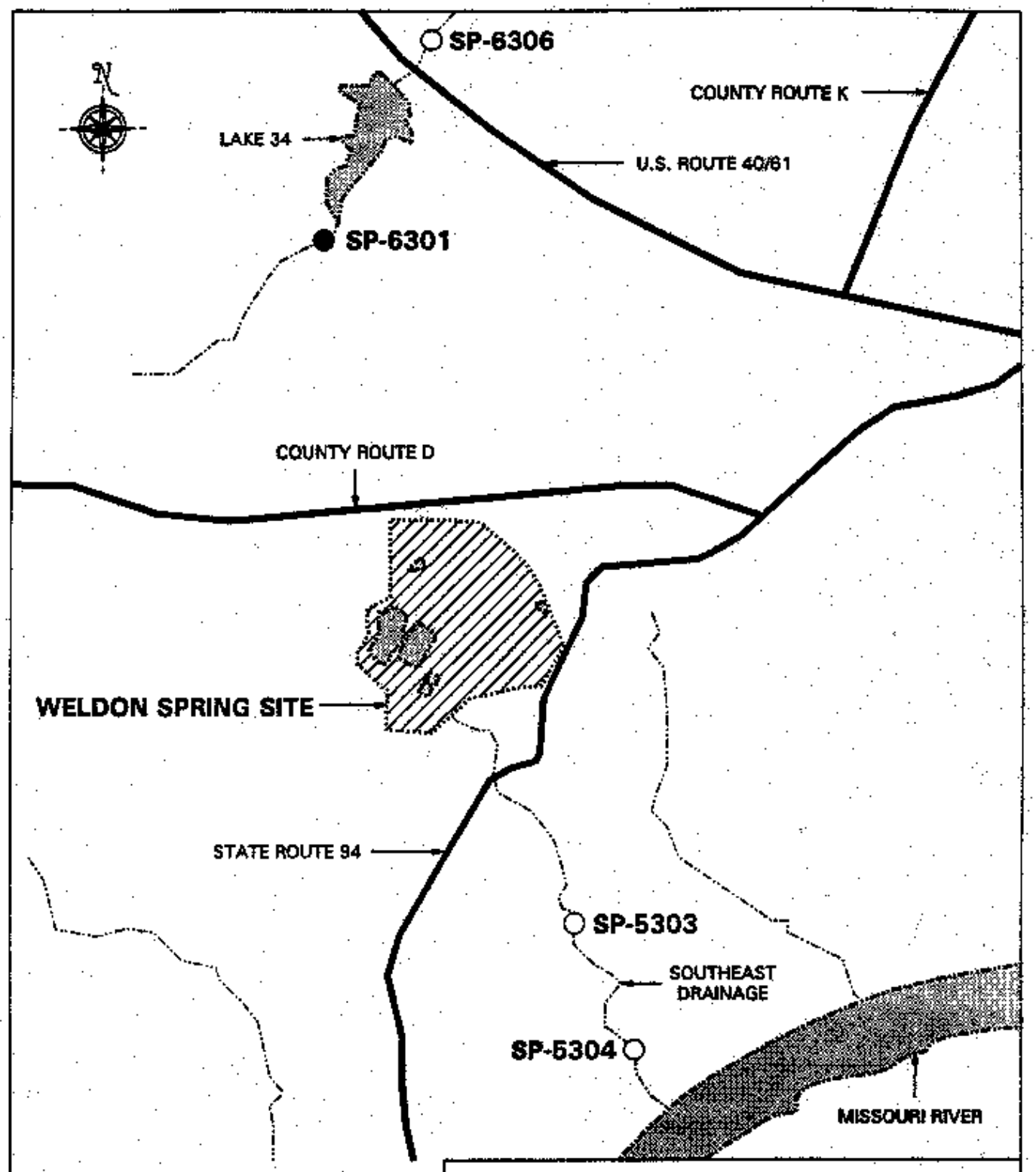
● MW-4003

0 500 1000 FT
0 152.4 304.8 M
SCALE

GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS AREA

FIGURE 8-2

REPORT NO.: DOE/OR/21548-876		EXHIBIT NO.: A/CP/077/1295	
ORIGINATOR: MT	DRAWN BY: GLN	DATE: 4/17/97	



LEGEND

● - SPRING SAMPLE LOCATION

○ - OTHER SPRING LOCATIONS

0 1 2 MI

0 1.6 3.2 KM

SCALE

SPRING MONITORING LOCATIONS IN THE WELDON SPRING SITE AREA

FIGURE 8-3

REPORT NO.: DOE/OR/21548-676		EXHIBIT NO.: A/VP/080/1193	
ORIGINATOR: MGL	DRAWN BY: GLN	DATE: 4/17/97	

8.4.2 Monitoring Program

8.4.2.1 Purpose. The 1996 groundwater monitoring program at the chemical plant and raffinate pits focused on monitoring contaminants and establishing baseline characterization of groundwater. Total uranium, nitroaromatic compounds, sulfate, volatile organic compounds, and nitrate were monitored annually at selected locations. Total uranium in groundwater was analyzed under the environmental monitoring program at the chemical plant to monitor potential groundwater uranium plume migration and to further establish baseline uranium concentrations prior to source removal during remedial action. Due to the heterogeneity of uranium distribution in soils across the site, all active locations in the chemical plant groundwater monitoring network were analyzed for total uranium.

Groundwater in the vicinity of the raffinate pits is impacted with elevated nitrate concentrations. The pits contain ore-refining impurities from uranium ore concentrates that were digested with nitric acid. The accumulation of aqueous phase waste (chiefly rainwater in contact with the raffinate) creates groundwater hydrostatic mounding beneath the pits, and nitrate-rich water impacts very localized portions of the bedrock aquifer in the raffinate pits vicinity. Some of the wastes generated and disposed of as raffinate contained isotopes of thorium and radium. Therefore, groundwater samples from selected locations near the raffinate pits were analyzed for nitrate, thorium and radium isotopes, and total uranium.

Prior to construction of the chemical plant, the site was part of a Department of Army Ordnance Works complex developed for the production of the nitroaromatic compounds trinitrotoluene (TNT) and dinitrotoluene (DNT) for explosives. One of the first nitroaromatic production lines was located within what is now the chemical plant area perimeter. Wastes generated from the initial operation of these early production lines were disposed of in open earthen pits which released contaminated seepage to groundwater. Wastewater containing nitroaromatic compounds was transported through wooden pipe networks. Discrete locations at the chemical plant are known (from previous sampling) to be impacted with nitroaromatics. Those locations, which were previously determined to have detectable concentrations of nitroaromatics in groundwater, were sampled and analyzed for these compounds in 1996.

Groundwater moves by both diffuse and discrete flow components under the chemical plant. In order to monitor the discrete flow component, Burgermeister Spring was monitored

during 1996 for total uranium, nitroaromatic compounds, nitrate, sulfate, and geochemical parameters. The spring was sampled during high- and base-flow conditions to monitor the potential impacts to the spring recharge from surface water runoff in the vicinity of the chemical plant.

8.4.2.2 Scope. All monitoring wells (except those completed in the unweathered zone) were sampled annually and analyzed for total uranium. Monitoring wells around the raffinate pits and chemical plant buildings were also analyzed annually for Ra-226, Ra-228, Th-228, Th-230, Th-232, and nitrate. Nitroaromatics were analyzed in groundwater from locations that have historically shown detectable concentrations of these compounds. A summary of monitoring locations and analytes may be found in the 1996 *Environmental Monitoring Plan* (EMP) (Ref. 42).

The EMP includes provisions for initiation of special environmental studies if evidence or conditions arise that warrant investigation beyond the scope of the EMP sampling schedule. A special, or unscheduled, groundwater sampling event was initiated in April 1996 in response to discovery and disturbance of submerged, discarded drums during dewatering of Raffinate Pit 4. Further, volatile compounds were detected in air headspace of the raw sludge tank that was being used to contain sludge dredged from Raffinate Pit 3 for chemical stabilization and solidification (CSS) pilot study purposes. Due to the presence of the drums and volatile compounds detected during sludge dredging, a groundwater volatile organic compounds (VOCs) investigation was implemented during 1996.

Burgermeister Spring (SP-6301) was monitored quarterly for metals, nitrate, sulfate, VOCs and geochemical constituents. The spring was monitored at low flow to measure the groundwater component of spring discharge. It was sampled twice at high flow for uranium, nitrate, and sulfate to evaluate the differences between low flow and high flow. To monitor the spring, samples were collected twice at low flow because the groundwater component of the spring flow was more significant at low flow than at high flow.

8.4.3 Chemical Plant and Raffinate Pit Monitoring Results

8.4.3.1 Groundwater Monitoring Wells. In 1996, the measured concentrations for uranium, nitrate, sulfate, and nitroaromatic compounds generally remained within historical

ranges at all monitoring wells and springs in the chemical plant area. Although new highs and lows were measured at some locations, these values generally differed from the mean by less than two standard deviations. The groundwater data, particularly from locations where new high values were reported, will continue to be carefully reviewed to determine if remedial actions at the WSSRAP are affecting groundwater quality. Volatile organic compounds were detected during 1996 in groundwater in the vicinity of the raffinate pits. The source of these compounds is being investigated.

Data for all parameters analyzed during the 1996 monitoring period are presented in the *Quarterly Environmental Data Summaries*. The monitoring data for contaminants of concern (uranium, radiological parameters, nitrate, sulfate, and nitroaromatics) are summarized and compared with background levels and water quality standards in the following paragraphs. Data values are presented as reported by the analytical laboratories. Comparisons to drinking water standards are not intended to imply that groundwater from WSSRAP monitoring wells must be in compliance with drinking water standards.

Radiochemical Parameters. Total uranium, which is measured at all monitoring wells, continues to impact groundwater near the raffinate pits. In 1996, groundwater from 12 monitoring well locations exceeded the average background level of 2.9 pCi/l (0.11 Bq/l) as calculated by the USGS (Ref. 37). These values can be found in Table 8-3. Of these, only two locations exceeded or equaled the proposed MCL of 20 μg/l (13.6 pCi/l). A new high for uranium was recorded during 1996 at MW-3023 (12.9 pCi/l). The MW-2017 uranium values, which had steadily increased during the previous 3 years, show a decrease for 1996. In 1995, uranium values in a newly installed well (MW-4024) indicated that the uranium plume extends farther east off site than previously identified. Uranium levels at this location (southeast of the site entrance across State Route 94) in 1996 are significantly lower (8.6 pCi/l in 1996 compared to 60.3 pCi/l in 1995) than previously reported.

TABLE 8-3 Annual Averages for Total Uranium (pCi/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE (pCi/l)	LOCATION	AVERAGE (pCi/l)	LOCATION	AVERAGE (pCi/l)
MW-2017	13.4	MW-2032	5.00	MW-4021	3.22
MW-3003	15.9	MW-3023	12.9	MW-4010	4.30
MW-4005	5.83	MW-3024	3.01	MW-4022	3.61
MW-4020	13.9	MW-4016	3.60	MW-4024	8.67

Note 1: Background uranium concentrations equals 2.9 pCi/l.
Note 2: 1 pCi/l = 0.037 Bq/l.

The other radiological parameters (Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta) that are measured annually in the raffinate pit wells (MW-3000 series and MW-2044) were below the MCL values. These annual averages can be found in Table 8-4.

Table 8-4 Annual Averages for Radiological Isotope (pCi/l) at the Weldon Spring Chemical Plant

LOCATION	RA-226 (pCi/l)	RA-228 (pCi/l)	TH-230 (pCi/l)	TH-232 (pCi/l)	GROSS ALPHA (pCi/l)	GROSS BETA (pCi/l)
MW-2035	0.28	(0.41)	(0.10)	<0.10	NA	NA
MW-2036	0.53	(0.16)	(0.08)	<0.12	NA	NA
MW-2037	<0.27	(0.67)	<0.12	(0.05)	NA	NA
MW-2038	0.36	1.57	<0.13	(0.01)	NA	NA
MW-2039	(0.15)	(0.45)	<0.11	<0.09	NA	NA
MW-2040	0.75	<0.63	(0.03)	(0.09)	NA	NA
MW-2041	0.53	(0.20)	<0.10	(0.01)	NA	NA
MW-2042	0.34	(0.44)	<0.11	<0.09	NA	NA
MW-2043	(0.13)	(0.82)	<0.14	(0.02)	NA	NA

Table 8-4 Annual Averages for Radiological Isotope (pCi/l) at the Weldon Spring Chemical Plant (Continued)

LOCATION	RA-226 (pCi/l)	RA-228 (pCi/l)	TH-230 (pCi/l)	TH-232 (pCi/l)	GROSS ALPHA (pCi/l)	GROSS BETA (pCi/l)
MW-2044	0.30	(0.35)	(0.09)	(0.08)	(2.2)	(3.7)
MW-3003	0.12	(0.04)	0.19	(0.02)	2.39	2.78
MW-3019	0.96	1.76	0.19	<0.10	1.64	4.45
MW-3023	(0.02)	<0.80	0.16	(0.07)	6.58	9.52
MW-3024	0.30	(0.44)	1.16	1.40	(7.00)	22.0
MW-3025	(0.40)	<0.73	NA	NA	(0.49)	14.5
MW-3026	0.48	2.33	0.21	(0.05)	4.39	28.1
MW-3027	0.36	(0.30)	0.26	(0.20)	7.00	5.86

Note 1: Averages in parentheses are estimates below quantification limits.
NA Not Analyzed.

Nitrate and Sulfate. In 1996, nitrate and sulfate were measured at 20 monitoring wells in the chemical plant area that previously exceeded the reference levels. Nitrate levels exceeded the calculated background value (1.6 mg/l) at 18 locations. The drinking water standard (10 mg/l) was exceeded at 15 of those locations (Table 8-5). Average sulfate levels exceeded background (32 mg/l) at 13 locations; one of these (MW-2017) was above the secondary water quality standard (250 mg/l) (Table 8-6).

Trend analysis, which was conducted using 1994 to 1995 data (Section 8.3.4) for the previous annual *Site Environmental Report* (Ref. 15), detected no upward nitrate trends. The 1996 nitrate data indicate no increases in nitrate levels for all monitored locations with the exceptions of MW-2001 and MW-2005, which increased in nitrate from 46 mg/l to 58 mg/l, and from 63 mg/l to 76 mg/l, respectively. These locations, which did not show upward trends in the previously reported trend analysis, will be analyzed further if 1997 data indicates increasing

TABLE 8-5 Annual for Nitrate (mg/l) Levels Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	LOCATION	AVERAGE	LOCATION	AVERAGE
MW-2001*	58.0	MW-2002*	104	MW-2003*	309
MW-2005*	76.0	MW-2036	2.83	MW-2037	199
MW-2038*	619	MW-2039*	36.1	MW-2040*	172
MW-2041*	178	MW-2042	4.95	MW-2043	6.06
MW-3003*	389	MW-3023*	208	MW-3024*	350
MW-3026*	221	MW-3027*	61.8	MW-4011*	176

* Exceeded the nitrate drinking water quality standard of 10 mg/l at least once during 1996.

TABLE 8-6 Annual Averages for Sulfate (mg/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	LOCATION	AVERAGE	LOCATION	AVERAGE
MW-2002	120	MW-2003	100	MW-2006	9.2
MW-2012	58.0	MW-2014	38.0	MW-2010	41.0
MW-2017*	820	MW-2037	141	MW-2038	107
MW-2039	42.2	MW-2041	37.7	MW-2042	33.5
MW-4011	85.7				

Note 1: Background sulfate concentration equals 32 mg/l.
* Exceeded the sulfate secondary drinking water quality standard of 250 mg/l at least once during 1995.

concentrations. Additional groundwater trending will be performed as analytical results become available. The groundwater results are not trended annually for the chemical plant because, at most monitoring locations, sampling frequency has been decreased (annual) to a level that cannot justify frequent trending.

Sulfate analytical results show no significant (>5%) increases at any of the monitored locations during 1996, with the exception of MW-2037 and MW-2040, which increased 8.5%

and 38%, respectively. These monitoring wells are located in the southern one-third of the site. The increases are not believed to be related to any site operations, but the locations will be carefully monitored to identify any increasing trends.

Nitroaromatic Compounds. Nitroaromatic compounds, which are not naturally occurring compounds, were detected in 25 monitoring wells (Table 8-7). New highs were recorded at MW-2043 for 2,4-DNT and at MW-4015, MW-2037, and MW-2038 for 1,3,5-trinitrobenzene (TNB). The highs at MW-2043, MW-2037, and MW-2038 were within the normal range of variation for these locations; however, the increases at MW-4015 were significant. Levels rose from an average of 1.7 μg/l in 1995 to 5.4 μg/l in 1996. The drinking water standard for 2,4-DNT of 0.11 μg/l was equalled or exceeded in 10 locations at the chemical plant (see Table 8-7), all of which are in the northern one-third of the site or along the western perimeter. There is no primary standard for 1,3,5-TNB. Elevated nitroaromatics in groundwater underlying the northern portion of the site are most likely attributable to a wastewater impoundment which was located along the northern site perimeter during the early active production of TNT and DNT during the 1940's.

TABLE 8-7 Annual 1996 Averages for Monitoring Locations with at Least One Detectable Concentration of Nitroaromatic Compounds (μg/l) at the Weldon Spring Chemical Plant

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2001	.055	<0.090	<0.030	0.092	0.044	<0.040
MW-2002	<0.030	<0.090	<0.030	0.040	0.240	<0.030
MW-2003	<0.030	<0.090	<0.030	0.098	0.450	<0.030
MW-2005	<0.030	<0.090	<0.030	0.039	0.070	<0.040
MW-2006	6.3	<0.090	<0.030	0.097	1.20	0.050
MW-2010	0.16	<0.090	0.19	0.096	0.51	<0.040
MW-2012	1.70	<0.090	0.44	0.085	6.30	<0.040
MW-2013	6.1	<0.090	0.72	0.37	2.10	<0.040
MW-2014	4.5	<0.090	<0.030	0.150	0.56	<0.040

TABLE 8-7 Annual 1996 Averages for Monitoring Locations with at Least One Detectable Concentration of Nitroaromatic Compounds (µg/l) at the Weldon Spring Chemical Plant (Continued)

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2032	3.90	<0.018	7.40	0.11	2.90	<0.040
MW-2033	3.60	<0.090	1.30	0.45	1.50	<0.040
MW-2037	0.21	<0.090	<0.030	0.49	0.090	<0.060
MW-2038	0.27	<0.090	<0.030	1.40	1.45	0.035
MW-2043	<0.030	<0.090	<0.030	0.08	<0.010	<0.030
MW-3003	<0.030	<0.090	<0.030	0.11	0.26	<0.040
MW-3023	<0.030	<0.090	<0.060	5.10	4.90	<0.040
MW-3024	<0.030	<0.090	<0.030	0.14	0.49	<0.040
MW-3025	<0.030	<0.090	<0.030	0.089	0.32	<0.040
MW-3026	0.058	<0.090	<0.030	0.036	0.018	<0.040
MW-3027	0.059	<0.090	<0.030	0.040	0.026	<0.040
MW-4001	50.0	<0.090	1.60	0.12	2.50	<0.06
MW-4002	<0.030	<0.090	0.40	0.042	0.16	<0.040
MW-4006	17	<0.090	<0.030	0.095	2.30	<0.040
MW-4011	<0.030	<0.090	<0.030	<0.030	0.034	<0.040
MW-4015	5.40	<0.090	<0.030	0.079	0.87	<0.030

The trend analysis (Section 8.3.4) performed during the previous year using 1994-1995 data indicated that there were no upward or downward trends at any monitoring locations, and with the exception of MW-4015, the analytical results remained within normal ranges. Therefore, trend analysis was not performed using 1996 data. If the 1,3,5-TNB concentrations at MW-4015 remain elevated during 1997, this location will be analyzed for trend significance.

Volatile Organic Compounds. The VOC groundwater investigation was initiated when dewatering activities in Raffinate Pit 4 exposed approximately 2,000 previously-submerged drums of waste. Whether the wastes from the drums impacted groundwater remains uncertain. The uncertainty is due to the small quantity of groundwater data from monitoring wells in the vicinity of Raffinate Pits 3 and 4.

Database searches were conducted for 13 monitoring wells nearest the pits to evaluate analytical results for polychlorinated biphenyls (PCBs) and pesticides, volatile and semi-volatile compounds, and any petroleum product compounds. Selection of these analytes was based upon contents of raffinate pit drums. Of these 13 selected monitoring locations, seven had previously been analyzed for at least one of the above-listed compounds. Detectable contaminants were previously reported at four of those seven locations. These are MW-2003 (PCB and pesticide and volatile and semi-volatile) MW-4001 (PCB and pesticide and volatile and semi-volatile), MW-4002 (PCB and pesticide), and MW-4006 (PCB and pesticide and volatile and semi-volatile). These historical data are from samples collected in 1987-1988, and appear to be of questionable quality because each of the positive detections was reported exactly at the detection limit or slightly below MDL. In addition, data from this era were not subject to validation.

A VOC detection during operation of the CSS pilot plant in 1995 also prompted the VOC groundwater investigation. Hexane was detected in vapor headspace in the raw sludge sample hopper which contained sludge dredged from Raffinate Pit 3. Hexane, a priority pollutant solvent used for uranium purification extraction, is most likely physically isolated from volatilization and biological degradation in free-product pockets or interstitially within the sludges then released upon disturbance of the sludges during dredging. Hexane was screened in groundwater samples collected from two locations in the Raffinate Pit 3 vicinity, MW-2038 and MW-3025. These locations are routinely sampled for the EMP, but VOCs are not included in the analyses for EMP purposes. The screening was intended to provide documentation that the potential source of hexane has not entered the uppermost groundwater system. Hexane was not detected in either sample, but trichloroethane (TCE) was detected at both locations (766 μg/l at MW-2038 and 11.0 μg/l at MW-3025) and dichloroethene (DCE) was detected in one sample (22.7 μg/l at MW-2038).

To determine the extents of VOC groundwater impact, several sampling events, including one site-wide sampling, were conducted during 1996. At some locations additional analytes

included PCB/pesticides, volatiles/semi-volatiles, and total petroleum hydrocarbons. The analyte selections were based upon previous groundwater analytical results and the drum waste inventory descriptions. This expanded investigation was implemented in June 1996.

Analytical results confirmed the presence of TCE at both previously sampled locations along the south and east sides of the Raffinate Pits 3 and 4 vicinity (TCE 9000 μg/l at MW-2038 and 15 μg/l at MW-3025), and the presence of DCE at MW-2038 (340 μg/l) at additional locations near the raffinate pits. No PCBs or petroleum hydrocarbons were detected. The investigation was focused on VOCs following the June 1996 sampling and is summarized in the following.

VOCs were detected at seven locations in groundwater at the chemical plant during 1996. The chlorinated solvent compounds TCE and 1,2-DCE, which do not naturally occur, were reported above detection limits as primarily TCE east and south of Raffinate Pits 3 and 4 (MW-2037, MW-2038, MW-3024, and MW-3025); and DCE south of the former Frog Pond location (MW-2013). VOCs below quantification limits were reported at two monitoring locations, MW-2032 (west-northwest of Frog Pond) and MW-4001 (west of Raffinate Pit 4). Table 8-8 summarizes analytical results for samples collected for VOC analysis at the chemical plant during 1996.

TABLE 8-8 Summary of TCE and DCE Groundwater Detections in 1996

LOCATION	APR. 96	JUN. 96	SEP.96	OCT-NOV. 96	DEC. 96
MW-2013TCE	NS	NS	(1.0)	(2.0)	NS
DCE	NS	NS	16	16	NS
MW-2023TCE	NS	NS	ND	NS	NS
DCE	NS	NS	(3.0)	NS	NS
MW-2037TCE	NS.	NS	570 & 810	1100	1100
DCE			25	(2.0)	ND
MW-2038TCE	766	9000	573 & 1050	1000,890&910	860
DCE	22.7	39.0	14 & 12.6	(3),(3) & (3)	ND

TABLE 8-8 Summary of TCE and DCE Groundwater Detections in 1996 (Continued)

LOCATION	APR. 96	JUN. 96	SEP.96	OCT-NOV. 96	DEC. 96
MW-3024TCE	NS	NS	59.8	NS	ND
DCE			(0.97)		ND
MW-3025TCE	11.0	15.0	NS	29	27
DCE	ND	ND		ND	ND
MW-4001TCE	NS	NS	(2.9)	NS	(3)
DCE			ND		ND

ND Results were below quantification limits.
NS Not sampled.
( ) Estimated value below quantification limits.
Note: Values reported in $\mu g/l$

The source of the VOCs remained unknown as the investigation continued throughout 1996. It is suspected that the source of the TCE and DCE is from 208 liter (55-gallon) drums discarded along the southeast shore of Raffinate Pit 4, and/or that these solvent components are trapped in pockets of sludge which isolates the VOCs from volatilization or microbial degradation. Due to the limited areal extent of groundwater impact, it is possible that the VOC introduction to groundwater is a recent event which may be a response to remedial action in Raffinate Pit 4 or sludge dredging in Raffinate Pit 3. The investigation is expected to continue throughout 1997.

Groundwater Overview. With few exceptions, contaminant levels remained within historical ranges at the monitoring wells sampled under the environmental monitoring program. Because contaminant levels have displayed only minor variability over the historical monitoring period, trend analysis is not conducted annually for the chemical plant monitoring wells. Uranium, sulfate, and nitrate contamination continue to be concentrated in the area surrounding the raffinate pits with a small area of elevated uranium and sulfate located near the eastern boundary of the site. Pockets of nitroaromatic contaminated groundwater continue to be present in the vicinity of Frog Pond, along the northern perimeter of the site, near Raffinate Pit 4, and

west of the raffinate pits on the Weldon Spring Ordnance Works property. The source of VOC contamination south and east of Raffinate Pit 3 remains under investigation.

8.4.3.2 Springs. Burgermeister Spring was the only location (SP-6301) monitored for the 1996 environmental monitoring program. This location is a perennial spring and is a localized emergence of groundwater impacted by a recognizable contribution of contaminants from the chemical plant throughout the year, with the highest concentrations of contaminants occurring during base flow stages. During high flow conditions, surface water recharge along the path of the subsurface flow mixes with contaminated flow from the site, and the concentrations are effectively lowered. The spring was monitored during both high and base stages during 1996.

Uranium, nitrate, and nitroaromatics were within expected (historical) ranges during 1996. The mean concentrations for nitrate and sulfate during base flow are 16.5 mg/l and 45.6 mg/l, respectively. These concentrations for high stage flow are 1.2 mg/l and 30.0 mg/l, respectively. These results indicate that groundwater is a more significant contributor to the spring discharge during base flow. The concentrations for these parameters are lower during high flow due to surface water contribution. Base flow concentrations for nitrate ranged between 4.54 mg/l and 36 mg/l. Base flow sulfate ranged between 33.6 mg/l and 55 mg/l for 1996.

Uranium concentrations analyzed in samples from the spring were between 6.5 pCi/l (0.24 Bq/l) and 122 pCi/l (4.51 Bq/l), with a mean value of 81.23 pCi/l (3.01 Bq/l). These values are within the historical range for uranium.

Nitroaromatics were analyzed in samples from base stage flow only. The concentrations of detected nitroaromatic compounds are within historical ranges. These compounds include 2,4,6-Trinitrotoluene (0.04 μg/l), 2,4-Dinitrotoluene (0.05 μg/l) and 2,6-Dinitrotoluene (0.12 μg/l).

VOCs were monitored at the spring during the latter half of 1996 to assess the potential for off-site migration of TCE that was detected in groundwater in the vicinity of the raffinate pits. No VOCs were detected during 1996 at the spring.

Monitoring of Burgermeister Spring will continue for the duration of the project to determine whether remediation activities across the northern half of the chemical plant impact the local groundwater quality.

8.4.4 Chemical Plant Trend Analyses

Statistical Methods

Statistical tests for time-dependent trends were previously performed on historical and 1995 groundwater data representing select groundwater wells. The constituents and locations that were selected for trending included total uranium, nitroaromatic compounds, and nitrate in samples from the chemical plant wells. These previous trend analyses, which were reported in the *1995 Annual Site Environmental Report* (Ref. 15), were performed individually for each monitoring well and contaminant. The specific locations, parameters, and time periods selected for trending analyses are presented in Tables 8-9 through 8-11. The selected locations, parameters, and time periods were based on the historical site environmental remediation activities, historical groundwater monitoring data, and knowledge of the site processes. The number of observations and number of data reported as below the detection limit for each data set are also shown in the summary tables. The trend methods and results are presented once again in this *1996 Annual Site Environmental Report*, because 1996 groundwater monitoring data are being compared to those trends previously reported. A discussion of the results follows the trend data presentation. Additional trend analyses, which incorporate the 1996 chemical plant data, will be performed in subsequent annual reports when additional data are available.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. This program was selected because it can easily facilitate missing data and does not require the data to conform to a particular distribution. The nonparametric method is valid for scenarios where there are a high number of non-detect data points. Further discussion of this trend analysis is presented in the *Site Environmental Report for 1995* (Ref. 15).

Trend analyses are intended to statistically indicate the presence of an upward or downward trend in contaminant concentration and should not be used as predicting future

concentrations. The trend analyses should be used to identify site locations which may require close scrutiny during future monitoring.

Nitroaromatic Compounds

No upward trends at the chemical plant for nitroaromatic compounds were suggested by the trend analysis for 1994-1995 data. Locations for which upward trends were detected using 1991-1994 data (west of Ash Pond, south of Raffinate Pit 3, and along the northern perimeter of the site) have stabilized. A summary of nitroaromatic trend analysis for the chemical plant is found in Table 8-9.

Total Uranium

Groundwater uranium analytical results were trended at locations representing all areas of the chemical plant. No upward trends were detected. The uranium trend analysis is summarized in Table 8-10.

Nitrate

Nitrate concentrations were trended at locations along site perimeters and in the immediate vicinity of the raffinate pits. Locations that previously (1991-1994) showed upward trends have stabilized. These stabilized locations include the raffinate pit monitoring wells. No upward trends were detected. The nitrate trend analyses are summarized in Table 8-11.

8.5 Weldon Spring Quarry

8.5.1 Hydrogeology

The geology of the quarry area is separated into three units; upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 2). Three Ordovician-age formations comprise the bedrock at the quarry: The Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium along the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium

TABLE 8-9 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2001	West of Ash Pond	2,4-DNT	11	3	0	0	U	(a)	0.02	--	0.01, 0.02	--
		2,6-DNT	11	3	0	0	S	(a)	(b)	--	-0.01, 0.01	--
MW2002	West of Ash Pond	2,4-DNT	11	3	0	0	S	(a)	0.01	--	-0.00, 0.01	--
		2,6-DNT	11	3	0	0	S	(a)	0.05	--	-0.06, 0.13	--
MW2005	North Dump Area	2,4-DNT	9	3	1	0	S	(a)	-0.01	--	-0.01, 0.01	--
		2,6-DNT	9	3	1	0	S	(a)	-0.01	--	-0.03, 0.01	--
MW2006	Northwest of Frog Pond	2,4-DNT	10	4	3	1	S	S	0.02	-0.09	-0.02, 0.07	N too small
		2,6-DNT	10	4	0	0	S	S	-0.20	-0.80	-0.67, 0.04	N too small
MW2010	West of Frog Pond	2,4-DNT	10	4	1	0	S	S	0.01	0.01	-0.00, 0.02	N too small
		2,6-DNT	10	4	0	0	D	S	-0.12	0.29	-0.21, -0.06	N too small
		2,4,6-TNT	10	4	1	0	S	S	-0.01	-0.03	-0.06, 0.06	N too small
MW2012	Southwest of Frog Pond	2,4-DNT	10	4	1	0	S	S	-0.01	-0.02	-0.21, 0.01	N too small
		2,6-DNT	10	4	1	0	D	S	-0.10	-0.55	-1.49, -0.06	N too small
		2,4,6-TNT	10	4	1	0	D	S	-0.08	-0.07	-0.20, -0.01	N too small
MW2013	South of Frog Pond	2,4-DNT	10	4	0	0	D	S	-0.04	0.09	-0.16, 0.00	N too small
		2,6-DNT	10	4	0	0	D	S	-6.80	-0.50	-8.95, -2.41	N too small
		2,4,6-TNT	10	4	0	0	D	S	-0.27	0.21	-0.47, -0.10	N too small

TABLE 8-9 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2014	Southeast of Frog Pond	2,4-DNT	11	4	1	0	U	S	0.02	-0.03	0.01, 0.03	N too small
		2,6-DNT	12	4	0	0	D	S	-0.19	0.01	-0.27, -0.07	N too small
MW2030	North Side of Chem Plant	2,4-DNT	12	6	0	0	S	S	0.02	-0.10	-0.03, 0.04	N too small, 0.02
		2,6-DNT	12	6	0	0	S	S	-1.40	-4.00	-5.39, 2.00	N too small, 3.80
		2,4,6-TNT	12	6	0	0	U	S	4.95	1.00	2.75, 6.00	N too small, 8.64
MW2032	MSA/CMSA Area	2,4-DNT	10	2	0	0	S	(a)	0.02	--	-0.01, 0.04	--
		2,6-DNT	10	3	0	0	S	(a)	-0.15	--	-0.60, 0.20	--
		2,4,6-TNT	10	3	0	0	S	(a)	0.95	--	-0.42, 3.96	--
MW2033	Southeast Frog Pond	2,4-DNT	13	5	0	0	S	S	0.01	0.26	-0.06, 0.01	N too small, 0.07
		2,6-DNT	13	5	0	0	D	S	-2.85	2.40	-4.78, -0.80	N too small, 0.50
		2,4,6-TNT	13	5	0	0	S	S	-1.00	0.35	-0.72, 0.30	N too small, 0.12

TABLE 8-9 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2037	West TSA-South Raffinate Pit 4	2,4-DNT	9	9	0	0	S	D	(b)	-0.09	-0.10, 0.05	-0.18, -0.04
		2,6-DNT	9	9	0	0	S	S	-0.02	-0.02	-0.04, 0.00	-0.04, 0.01
		2,4,6-TNT	9	9	14	9	S	(c)	(b)	--	0.00, 0.00	--
MW2038	South Raffinate Pit 3	2,4-DNT	9	9	0	0	S	D	0.10	-0.20	0.00, 0.30	-0.30, -0.05
		2,6-DNT	9	9	0	0	U	D	0.03	-0.04	0.00, 0.06	-0.07, -0.01
		2,4,6-TNT	9	9	9	9	(c)	(c)	--	--	--	--
MW3003	North Raffinate Pit 4	2,4-DNT	9	3	0	0	S	(a)	(b)	--	-0.03, 0.02	--
		2,6-DNT	9	3	0	0	S	(a)	(b)	--	-0.04, 0.03	--
MW3023	North Raffinate Pit 4	2,4-DNT	13	5	0	0	S	S	-1.00	-0.10	-1.50, 0.19	N too small
		2,6-DNT	13	5	0	0	D	S	-1.64	0.30	-2.10, -0.82	N too small
MW3025	East Raffinate Pit 3	2,4-DNT	5	8	0	0	S	S	0.03	-0.01	N too small	-0.04, 0.02
		2,6-DNT	5	8	0	0	S	S	0.09	-0.01	N too small	-0.08, 0.07
MW3027	SW Raffinate Pit 4	2,4-DNT	5	8	0	0	S	S	0.03	0.01	N too small	-0.01, 0.02
		2,6-DNT	5	8	0	0	S	S	0.02	0.02	N too small	-0.02, 0.01

TABLE 8-9 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1996	1991-1994	1994-1995	1991-1994	1994-1996	1991-1994	1994-1996
MW4001	West Perimeter, Raffinate Pit 4	2,4-DNT	13	4	1	0	D	S	-1.83	-0.04	-2.89, 1.34	N too small
		2,6-DNT	13	4	1	0	D	S	-0.73	-0.65	-1.50, -0.08	N too small
		2,4,6-TNT	13	4	2	0	S	S	0.07	-0.10	-0.60, 0.25	N too small, 0.00
MW4002	West Perimeter, Raffinate Pit 4	2,4-DNT	12	4	5	2	S	(a)	0.00	--	-0.03, 0.01	--
		2,6-DNT	12	4	1	0	S	S	0.01	0.06	-0.28, 0.16	N too small
		2,4,6-TNT	12	4	1	1	S	S	0.13	0.65	-0.17, 0.50	N too small
MW4006	West Perimeter, Raffinate Pit 4	2,4-DNT	12	4	2	0	S	S	-0.03	0.02	-0.08, 0.01	N too small
		2,6-DNT	12	4	1	0	D	S	-0.78	-0.05	-1.42, -0.40	N too small
MW4011 **	West Perimeter Ash Pond	2,4-DNT	9	3	9	3	(c)	(a)	--	--	--	--
		2,6-DNT	9	3	8	0	(c)	(a)	--	--	--	--

TABLE 8-9 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW4013	North-Northwest Perimeter	2,4-DNT	11	3	0	0	S	(a)	0.01	--	-0.01, 0.01	--
		2,6-DNT	11	3	0	0	S	(a)	-0.25	--	-0.59, 0.01	--
		2,4,6-TNT	11	3	0	0	S	(a)	0.00	--	-0.01, 0.00	--
MW4014	North Perimeter	2,4-DNT	9	3	8	1	(c)	(a)	0.00	--	0.00, 0.00	--
		2,6-DNT	9	3	0	1	U	(a)	0.02	--	0.00, 0.03	--
MW4015	North-Northeast Perimeter	2,4-DNT	10	4	0	0	S	S	-0.01	0.04	-0.09, 0.03	N too small
		2,6-DNT	10	4	0	0	S	S	-0.19	0.12	-0.45, 0.03	N too small
MW4023	South-Southeast Perimeter	2,4-DNT	8	2	0	0	S	(a)	-0.01	--	-0.03, 0.01	--
		2,6-DNT	8	2	0	0	S	(a)	-0.01	--	-0.02, -0.00	--

D Downward.
S Stationary.
U Upward.
(a) Location not selected for trending.
(b) Trend direction stationary; therefore, no slope to data.
(c) No detectable concentrations reported for time period; therefore, no trending performed.
* All wells are completed in the weathered upper zone of the Burlington-Keokuk limestone, with the exception of MW4011.
** MW4011 is completed in the unweathered zone of the Burlington-Keokuk limestone.

TABLE 8-10 Chemical Plant Groundwater Wells Total Uranium Trend Analysis Summary

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2003	North of Raffinate Pit 4	11	3	2	0	U	(a)	0.58	--	0.10, 0.99	--
MW2004	North Dump Area	9	1	1	0	S	(a)	0.11	--	-0.04, 0.28	--
MW2015	Center of Chemical Plant	9	3	1	0	S	(a)	0.37	--	-0.85, 0.60	--
MW2017	East Side Chemical Plant	10	4	0	0	U	S	1.85	1.00	0.80, 3.35	N too small
MW2018	South Side Chemical Plant	10	3	1	0	U	(a)	0.32	--	0.07, 0.61	--
MW2030	North Side Chemical Plant	14	6	0	0	S	S	1.50	-0.65	-0.34, 3.20	N too small, 0.71
MW2032	MSA/CMSA Area	11	3	1	0	S	(a)	0.10	--	-1.49, 1.38	--
MW2033	Southeast Frog Pond	14	6	2	0	S	S	0.10	-0.12	-0.16, 0.32	N too small, 0.66
MW2039	South Raffinate Pits 1 & 2	9	8	0	0	S	S	0.22	-0.15	-0.05, 1.02	-1.07, 2.92
MW3003	North Raffinate Pit 4	14	7	0	0	D	S	-2.00	0.45	-3.50, -0.16	-5.24, 6.28
MW3019	South of all Raffinate Pits	9	4	1	0	S	(a)	0.30	--	-2.41, 0.44	--
MW3023	North Raffinate Pit 4	13	6	0	0	S	S	0.20	0.63	-0.88, 0.93	N too small, 4.61
MW3025	East Raffinate Pit 3	4	7	0	0	S	D	0.16	-0.29	N too small	-1.25, -0.06
MW3027	Southwest Raffinate Pit 4	5	8	0	0	S	S	0.58	-0.43	N too small	-33.53, 0.02

TABLE 8-10 Chemical Plant Groundwater Wells Total Uranium Trend Analysis Summary (Continued)

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW4001	West Perimeter, Raffinate Pit 4	9	4	1	0	S	S	-0.18	0.01	-0.70, 0.10	N too small
MW4002	West Perimeter, Raffinate Pit 4	9	3	4	0	S	(a)	0.02	–	-0.13, 0.44	–
MW4005	Southwest Perimeter	9	4	1	0	S	S	-0.41	0.04	-4.08, 0.29	N too small
MW4013	North-Northwest Perimeter	10	4	2	1	S	(a)	0.01	--	-0.24, 0.41	--
MW4015	North-Northeast Perimeter	10	4	3	1	S	(a)	-0.09	--	-0.37, 0.34	--
MW4016	East-Northeast Perimeter	9	3	4	0	S	(a)	-0.09	--	-0.40, 0.23	--
MW4019	South Perimeter	10	4	0	0	S	S	-0.16	0.12	-0.89, 0.16	N too small
MW4020	East-Southeast Perimeter	14	8	0	0	D	S	-1.20	-1.19	-2.86, 0.00	-12.09, 1.94
MW4021	Southeast Perimeter	12	4	0	0	S	S	-0.85	-1.38	-2.35, 0.45	N too small
MW4023	South-Southeast Perimeter	9	4	2	0	S	S	0.65	-0.55	-0.10, 0.50	N too small

D Downward.
S Stationary.
U Upward.
(a) Location not selected for trending.
(b) Trend direction stationary; therefore, no slope to data.
(c) No detectable concentrations reported for time period; therefore, no trending performed.
* All wells are completed in the weathered upper zone of the Burlington-Keokuk limestone.

TABLE 8-11 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2001	West of Ash Pond	13	4	0	0	U	S	6.02	8.75	3.75, 8.77	N too small
MW2002	West of Ash Pond	14	4	0	0	S	S	-21.667	-60.00	-95.70, 12.04	N too small
MW2003	North of Raffinate Pit 4	14	4	0	0	S	S	23.57	66.50	-48.04, 110.63	N too small
MW2005	North Dump Area	10	4	0	0	S	S	-1.650	-10.00	-34.69, 5.95	N too small
MW2012	Southwest of Frog Pond	9	3	0	0	S	(a)	-0.095	--	-0.33, 0.13	--
MW2032	MSA/CMSA Area	11	3	0	0	S	(a)	-5.283	--	-23.62, 14.61	--
MW2037	West TSA-South Raffinate Pit 4	9	9	0	0	S	D	-95.500	-29.50	-236.02, 31.17	-270.59, -5.81
MW2038	South Raffinate Pit 3	9	9	0	0	D	S	-516.000	-76.00	-931.57, -372.64	-140.19, 380.00
MW2039	South Raffinate Pits 1 & 2	9	8	0	0	S	S	-12.200	-12.50	-40.04, 12.79	-25.49, 1.46
MW3003	North Raffinate Pit 4	12	4	0	0	S	S	-1.750	71.50	-69.29, 71.71	N too small
MW3023	North Raffinate Pit 4	14	4	0	0	D	S	-38.000	-99.00	-67.40, -14.65	N too small
MW3025	East Raffinate Pit 3	5	8	0	0	S	S	-309.00	-13.00	N too small	-209.93, 113.22
MW3027	Southwest Raffinate Pit 4	5	8	0	0	S	S	-19.000	-2.75	N too small	-15.40, 3.25
MW4001	West Perimeter, Raffinate Pit 4	10	4	1	0	U	S	3.88	-8.25	-1.34, 6.34	N too small
MW4002	West Perimeter, Raffinate Pit 4	9	3	0	0	S	(a)	0.73	--	-0.35, 3.22	--

TABLE 8-11 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary (Continued)

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW4006	West Perimeter, Raffinate Pit 4	9	3	0	0	U	(a)	1.03	--	0.07, 1.80	--
MW4011 **	West Perimeter Ash Pond	10	4	0	0	U	S	26.05	34.50	15.17, 43.15	N too small
MW4013	North-Northwest Perimeter	11	3	0	0	S	(a)	-0.417	--	-33.37, 20.47	--
MW4014	North Perimeter	9	3	0	0	S	(a)	1.11	--	-0.17, 2.92	--
MW4015	North-Northeast Perimeter	10	4	0	0	S	S	0.30	0.90	-0.17, 0.98	N too small
MW4018	East-Northeast Perimeter	9	3	0	0	S	(a)	-0.065	--	-3.46, 0.64	--
MW4020	East-Southeast Perimeter	9	4	4	3	S	(a)	0.01	--	-0.07, 0.26	--
MW4023	South-Southeast Perimeter	10	3	0	0	S	(a)	0.50	--	-0.47, 1.77	--

D Downward.
S Stationary.
U Upward.
(a) Location not selected for trending.
(b) Trend direction stationary; therefore, no slope to data.
(c) No detectable concentrations reported for time period; therefore, no trending performed.
* All wells are completed in the weathered upper zone of the Burlington-Keokuk limestone with the exception of MW-4011.
** MW4011 is completed in the unweathered zone of the Burlington-Keokuk limestone.

thickness increases with distance from the bluff towards the river where the maximum thickness is approximately 31 m (100 ft). The alluvium is truncated at the erosional contact with the Ordovician bedrock bluff (Kimmswick, Decorah, and Plattin formations) which also composes the rim wall of the quarry. The bedrock unit underlying the alluvial materials is the Decorah Group. Primary sediments between the bluff and the Femme Osage Slough are inorganic and organic intermixed and interlayered clays, silts, and sands with some organics.

The uppermost groundwater flow systems at the quarry are composed of alluvial and bedrock aquifers. The alluvial aquifer is predominantly controlled by recharge from the Missouri River and the bedrock aquifer is chiefly recharged by precipitation and overland runoff.

At the quarry, 17 monitoring wells are screened within either the Kimmswick-Decorah (upper unit) or Plattin Formations (lower unit) to monitor contaminants near the quarry within the bedrock (Figure 8-4). Twelve monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. Three other monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration. Two monitoring wells, one in the Kimmswick-Decorah Formation and one in the Plattin Formation, were installed north of the quarry to monitor upgradient groundwater quality.

There are 36 monitoring wells completed into the alluvium at the quarry and to the Missouri River. The wells west of the quarry monitor the uppermost water bearing unit below the quarry water treatment plant equalization basin and effluent ponds. The alluvium monitoring wells north of the Femme Osage Slough monitor contaminant migration south of the quarry, while those south of the slough monitor for possible migration of contaminants toward the well field. The St. Charles County monitoring wells, the RMW series wells, are designed to provide an early warning of contaminant migration toward the county production well field. The county production wells are monitored to verify the quality of the municipal well field water supply.

Monitoring wells MW-1042 (Plattin) and MW-1043 (Decorah) provide upgradient groundwater quality data for the central portion of the quarry. These wells were installed in 1995 as part of the quarry residuals operable unit. Monitoring wells MW-1034 (Kimmswick-Decorah) and MW-1035 (alluvium) are upgradient of the southwestern portion of the quarry. These upgradient wells provide an assessment of groundwater quality in these materials and

provide background data. Eight groundwater monitoring wells located in the Darst Bottom area approximately 1.6 km (1 mi) southwest of the St. Charles County well field by the U.S. Geological Survey are utilized to study the upgradient characteristics of the Missouri River alluvium in the vicinity of the quarry. These wells provide a reference for background values in the well field area and have been sampled by both the USGS (1992) and the DOE (1994). A summary of background values used at the quarry is provided in Table 8-12.

TABLE 8-12 Mean Background Values for Quarry Groundwater Monitoring Locations

PARAMETER		KIMMSWICK/ DECORAH FORMATIONS[a]	ALLUVIAL/ UNCONSOLIDATED MATERIALS[b]	MISSOURI RIVER ALLUVIUM[c]
Total Uranium (pCi/l)	Mean	2.35	0.67	2.03
	95% C.I.*	-1.18; 5.88	-0.83; 2.16	-2.71; 6.78
Radium-226 (pCi/l)	Mean	0.18	0.50	1.41
	95% C.I.*	±0.78**	±0.77**	±1.71**
Radium-228 (pCi/l)	Mean	0.77	0.48	1.59
	95% C.I.*	±2.06**	±2.06**	±13.1**
Thorium-228 (pCi/l)	Mean	0.26	0.39	0.24
	95% C.I.*	±0.94**	±1.03**	±1.72**
Thorium-230 (pCi/l)	Mean	0.93	0.32	0.69
	95% C.I.*	±0.55**	±0.94**	±2.93**
Thorium-232 (pCi/l)	Mean	0.26	0.12	0.20
	95% C.I.*	±0.92**	±0.86**	±1.68**
Gross α (pCi/l)	Mean	6.75	1	1.54
	95% C.I.*	±6.85**	±3.5**	±16.6**
Gross ß (pCi/l)	Mean	5.77	5.9	3.0
	95% C.I.*	±5.06**	±2.5	±13.9**
Nitroaromatic Compounds	Mean	No detects	No detects	Not analyzed

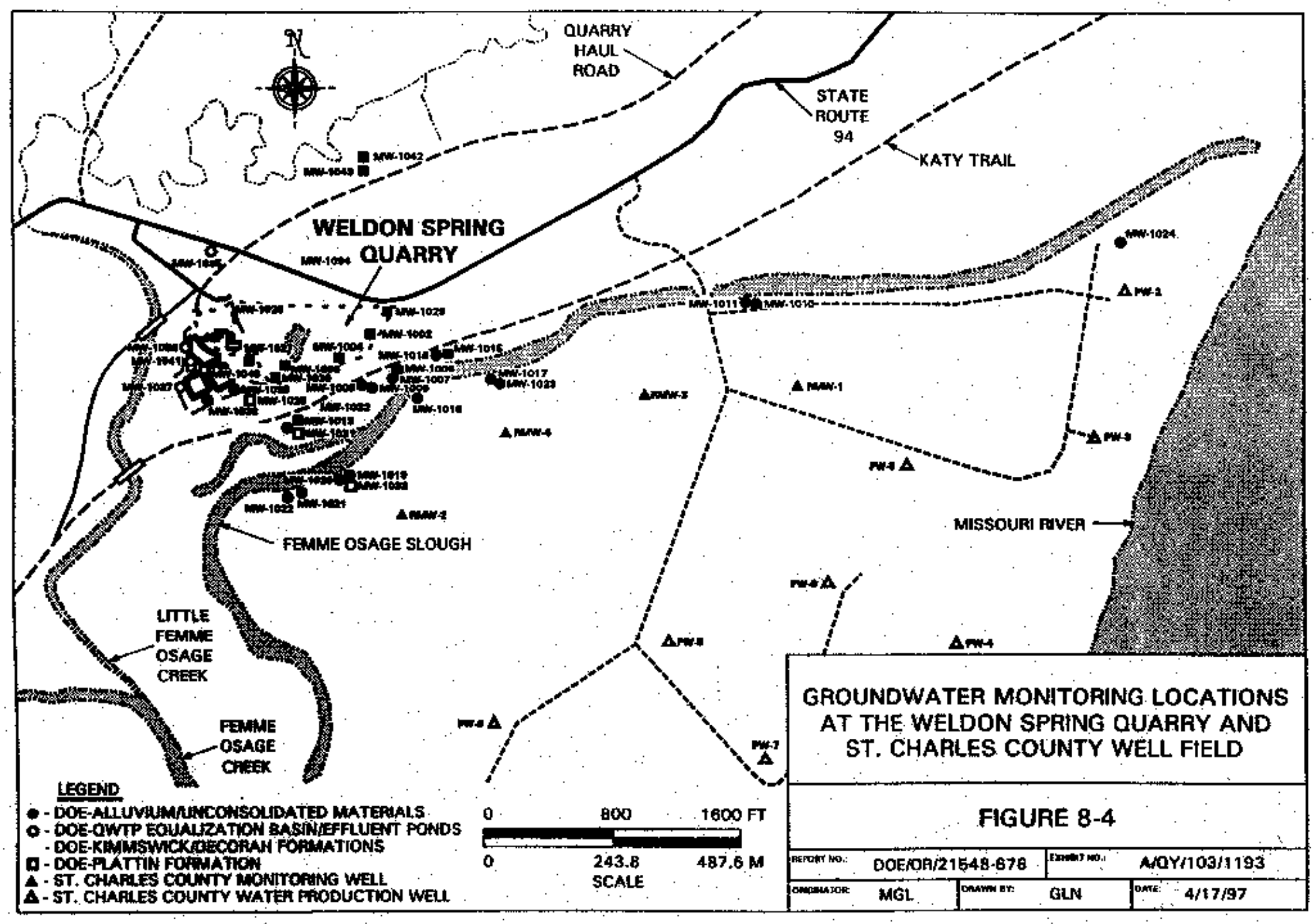
TABLE 8-12 Mean Background Values for Quarry Groundwater Monitoring Locations (Continued)

PARAMETER		KIMMSWICK/ DECORAH FORMATIONS[a]	ALLUVIAL/ UNCONSOLIDATED MATERIALS[b]	MISSOURI RIVER ALLUVIUM[c]
Arsenic (µg/l)	Mean	1.38	1.53	4.08
	95% C.I.*	-0.94; 3.70	-0.99; 4.04	-1.29; 9.46
Barium (µg/l)	Mean	144.9	232.0	408.6
	95% C.I.*	110.0; 179.8	178.4; 285.6	137.1; 680.0
Nitrate (mg/l)	Mean	1.06	0.11	0.46
	95% C.I.*	-0.62; 2.73	-0.05; 0.26	-2.33; 3.24
Sulfate (mg/l)	Mean	82.3	38.8	37.1
	95% C.I.*	32.6; 132.0	23.1; 54.5	6.31; 68.0

(a) MW-1034 (DOE)
(b) MW-1035 (DOE)
(c) Darst Bottom Wells (USGS and DOE)
* 95% Confidence Interval about the mean
** Average radiological error

8.5.2 Monitoring Program

Groundwater monitoring is performed in both the alluvial and bedrock aquifers at the quarry (Figure 8-4). Three separate monitoring programs were employed for the quarry in 1996. The first program addressed sampling the Department of Energy wells and monitoring the quarry area to determine contaminant migration and the effects of quarry dewatering and bulk waste removal, which began in mid-1993 and were completed in late-1995. The frequency of sampling for each location was based on the distance of the well from the source or migration pathway. Monitoring wells on the quarry rim were sampled bimonthly for total uranium and nitroaromatic compounds, due to the changes in concentrations over time, to better establish the trend in concentrations at these locations, and to monitor the effects of quarry dewatering and bulk waste removal activities on the groundwater system. All locations were sampled at least



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY AND ST. CHARLES COUNTY WELL FIELD

FIGURE 8-4

REPORT NO.:	DOE/OR/21548-678	EXHIBIT NO.:	A/QY/103/1193		
ORIGINATOR:	MGL	DRAWN BY:	GLN	DATE:	4/17/97

annually for radiochemical parameters and were qualitatively analyzed for nitroaromatic degradation products.

The second program monitors the St. Charles County well field and the associated water treatment plant. Active production wells, the St. Charles County RMW-series monitoring wells, and untreated and treated water from the County's public drinking water treatment plant were sampled quarterly or semiannually for selected parameters. This portion of the monitoring program was developed by representatives of the Department of Energy, several State regulatory agencies, and St. Charles County.

The third program monitors the equalization basin and the two effluent ponds at the quarry water treatment plant (Figure 8-4). Monitoring wells MW-1035 through MW-1037, MW-1040, and MW-1041 were sampled quarterly and annually for selected parameters. The monitoring program was initially developed to meet the substantive requirements of 40 CFR Part 264, Subpart F, and 10 CSR Part 25.7, which require the monitoring of contaminants of concern in the groundwater beneath storage facilities. The contaminants of concern were derived from the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 40) and the *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 41). This is discussed in Section 8.5.1.

8.5.3 Weldon Spring Quarry Monitoring Results

8.5.3.1 Quarry. Radiochemical Parameters. All groundwater monitoring wells at the quarry were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta. The uranium values continue to indicate that the highest levels occur in the bedrock downgradient from the quarry and in the alluvial material north of the Femme Osage Slough. The annual averages for the locations that exceed background are summarized in Table 8-13.

TABLE 8-13 Annual Averages for Total Uranium (pCi/l) Above Average Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1002	4.37	5.99	3.42
MW-1004	2642	2810	2350
MW-1005	6150	6920	5380
MW-1006	2880	3150	2610
MW-1007	185.6	330	41.2
MW-1008	3810	4170	3450
MW-1009	2.18	2.18	2.18
MW-1013	747	768	726
MW-1014	953	996	910
MW-1015	272	310	234
MW-1016	175	184	166
MW-1027	317.5	388	247
MW-1030	46.38	53.1	36.2
MW-1031	174.3	240	128
MW-1032	936.5	1040	840
MW-1038	4.63	5.9	3.36

Note 1: 1 pCi/l = 0.037 Bq/l.

The proposed U.S. Environmental Protection Agency total uranium drinking water standard of 20 μg/l (13.6 pCi/l) was exceeded at MW-1004, MW-1005, MW-1006, MW-1007, MW-1008, MW-1013, MW-1014, MW-1015, MW-1016, MW-1027, MW-1030, MW-1031, and MW-1032. All of these monitoring wells are located north of the Femme Osage Slough and have no direct impact on the drinking water sources in the Missouri River alluvium. The 4% of DCG for total uranium in discharge water, 24 pCi/l (0.89 Bq/l), was exceeded at MW-1004, MW-1005, MW-1006, MW-1007, MW-1008, MW-1013, MW-1014, MW-1015, MW-1016, MW-1027, MW-1030, MW-1031, and MW-1032; however, these wells are not located near any drinking water sources.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed in 1996 at all groundwater monitoring locations at the quarry. Elevated radium levels were observed at 11 locations. It is suspected that the elevated isotopic values in these wells resulted from bulk waste removal activities. Early 1994 operational data from the quarry pond had shown elevated levels of isotopes of radium and thorium in the runoff from waste removal operations and groundwater collected in the pond, which likely was due to disturbance of bulk wastes in the quarry. These levels began to decrease late in 1995 when bulk waste activities were completed. Fluctuations of isotope concentrations were observed during 1996, and are most likely responses to groundwater gradient changes (the quarry sump was not pumped during 1996).

Monitoring well MW-1004 is located on the rim of the southeastern quarry wall. Monitoring wells MW-1027 and MW-1030 are located in the center of the quarry. Concentrations for 1996, which exceed background levels in these wells, may be due to washdown of the quarry floor and walls or due to groundwater backflow to the quarry following quarry pond dewatering. The remainder of the wells with annual averages exceeding background values are located in the alluvium along the Femme Osage Slough. These locations are MW-1011, MW-1021, and MW-1024. The 1996 annual averages from above background locations are summarized in Table 8-14.

TABLE 8-14 Isotopic Radionuclide (pCi/l) Concentration Annual Averages That Exceeded Two Standard Deviations (Upper 95% Confidence Interval) of Mean Background at the Weldon Spring Quarry

LOCATION	RA-226	RA-228	TH-230	TH-232
MW-1007	--	7.25	--	--
MW-1008	--	12.8	--	--
MW-1009	--	3.21	--	--
MW-1013	--	4.97	--	--
MW-1014	1.57	5.77	--	--
MW-1015	--	3.59	--	--
MW-1016	--	5.53	--	--
MW-1023	2.17	--	--	--

TABLE 8-14 Isotopic Radionuclide (pCi/l) Concentration Annual Averages That Exceeded Two Standard Deviations (Upper 95% Confidence Interval) of Mean Background at the Weldon Spring Quarry (Continued)

LOCATION	RA-226	RA-228	TH-230	TH-232
MW-1030	1.40	--	--	--
MW-1031	--	4.73	--	--

Note 1: Values reported in activity.
Note 2: 1 pCi/l = 0.037 Bq/l.

Nitroaromatic Compounds. In 1996, samples from all quarry monitoring wells were analyzed for nitroaromatic compounds. Eleven locations yielded detectable concentrations of at least one of the six compounds analyzed during the 1996 sampling period. None of these concentrations indicate increasing impacts. These monitoring wells, which have historically been impacted with nitroaromatics, are situated in the alluvial materials or bedrock downgradient of the quarry and north of the Femme Osage Slough. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for these locations is provided in Table 8-15.

The Missouri drinking water quality standard for 2,4-DNT (0.11 μg/l) was exceeded at MW-1004, MW-1006, and MW-1027. These locations are north of the Femme Osage Slough. No MCLs have been established for the other nitroaromatic compounds.

TABLE 8-15 Annual Averages for Detectable Concentrations of Nitroaromatic Compounds (μg/l) at the Weldon Spring Quarry

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-1002	64.2	0.26	14.4	0.09	7.50	<0.03
MW-1004	0.43	<0.09	2.73	0.13	0.43	<0.03
MW-1006	43.1	<0.09	4.02	0.18	0.83	<0.03
MW-1007	0.13	<0.09	0.04	<0.03	0.01	<0.03
MW-1008	0.05	<0.09	0.04	<0.03	0.01	<0.03

TABLE 8-15 Annual Averages for Detectable Concentrations of Nitroaromatic Compounds (μg/l) at the Weldon Spring Quarry (Continued)

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-1013	<0.03	<0.09	<0.03	0.03	0.01	<0.03
MW-1015	3.75	0.11	1.60	<0.03	0.15	<0.03
MW-1016	0.25	<0.09	0.14	<0.03	0.03	<0.03
MW-1027	0.04	<0.09	0.30	2.13	1.13	<0.03
MW-1030	<0.03	<0.09	<0.03	<0.03	0.02	<0.03
MW-1032	<0.03	<0.09	<0.03	<0.03	0.01	<0.03

Sulfate. Groundwater analyses in 1996 indicated sulfate levels were elevated in the monitoring wells in the bedrock of the quarry rim and in the alluvial materials north of the Femme Osage Slough. Fourteen wells exceeded average background levels for sulfate. These wells are situated north of the slough, with the exception of MW-1018 located south of the slough, downgradient of the area of greatest groundwater impact. Only two locations (MW-1005 and MW-1006) exceeded the secondary MCL of 250 mg/l. The annual averages for these wells are summarized in Table 8-16.

TABLE 8-16 Annual Averages for Sulfate (mg/l) Above Average Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1004	128	140	116
MW-1005*	799	799	---
MW-1006*	278	353	233
MW-1007	42.5	121	0.52
MW-1008	181	260	147
MW-1009	182	194	155
MW-1013	100	108	90

TABLE 8-16 Annual Averages for Sulfate (mg/l) Above Average Background at the Weldon Spring Quarry (Continued)

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1014	102	110	93.5
MW-1015	133	159	123
MW-1016	146	164	136
MW-1018	92.0	98.0	86.0
MW-1027	91.0	98.1	78.0
MW-1031	117	146	77.6
MW-1032	233	250	219
MW-1042	155	191	134

* Exceeded secondary MCL of 250 mg/l.

8.5.3.2 St. Charles County Well Field

Radiochemical Parameters. The St. Charles County production wells and the RMW-series monitoring wells were sampled semiannually for the radiochemical parameters Ra-226, Ra-228, and isotopic thorium. Gross alpha, gross beta, and total uranium were analyzed quarterly. A summary of the radiochemical annual averages is provided in Table 8-17. The annual averages for total uranium in the well field remain at background. No production well exceeded the proposed groundwater standard of 20 μg/l (13.6 pCi/l).

TABLE 8-17 Summary of Annual Averages of Radiochemical Parameters (pCi/l) for the St. Charles County Well Field

LOCATION	TOTAL URANIUM	GROSS ALPHA	RA-226	RA-228	TH-230	TH-232
MW-1024	0.55	7.30	0.38	1.92	0.45	0.34
MW-RMW1	1.02	3.42	0.72	1.14	<0.13	(0.04)
MW-RMW2	5.99	6.86	0.24	1.26	<0.11	<0.1
MW-RMW3	0.69	2.76	0.51	1.01	<0.11	(0.03)
MW-RMW4	2.49	2.93	0.13	1.20	<0.13	<0.13
MW-PW02	0.13	2.40	0.65	1.22	<0.14	<0.10
MW-PW03	0.11	2.62	0.93	0.99	<0.13	<0.10
MW-PW04	0.09	1.01	0.81	0.93	<0.12	<0.10
MW-PW05	0.44	2.56	0.63	1.10	<0.11	<0.08
MW-PW06	0.15	1.81	0.56	0.91	<0.09	<0.08
MW-PW07	0.11	1.90	0.50	1.43	<0.08	<0.09
MW-PW08	0.31	6.78	0.84	1.59	<0.11	(0.04)
MW-PW09	0.42	1.92	0.88	1.89	<0.10	(0.01)
MW-RAWW	0.21	1.36	0.96	1.54	<0.12	(0.01)
MW-FINW	0.22	1.29	0.24	0.87	<0.11	(0.01)

Note 1: 1 pCi/l = 0.037 Bq/l.

The St. Charles County production wells, the RMW-series wells, and pretreated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant were sampled quarterly for gross alpha. The annual averages for these locations are within the statistical variation of background ranges for the Missouri River alluvium.

The Missouri Drinking Water Standard of 15 pCi/l (0.555 Bq/l) for gross alpha was not exceeded at any of the production wells. The St. Charles County treatment plant finished waters were in compliance with the gross alpha level of 10 pCi/l as established in 40 CFR 141 and endorsed in Department of Energy Order 5400.5.

The Missouri Drinking Water Standard of 5 pCi/l (0.185 Bq/l) for combined Ra-226 and Ra-228 was not exceeded at any of the St. Charles County production well locations. No water quality standards have been established for isotopic thorium in drinking water.

Nitroaromatic Compounds. The St. Charles County production wells and the RMW-series monitoring wells were sampled quarterly for the six nitroaromatic compounds. No detectable concentrations were observed at any of these locations.

Sulfate. The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for sulfate. The sulfate concentrations in the well field were slightly elevated for 1996 at MW-PW02, MW-PW03, MW-PW04, and MW-PW06. Most likely these levels are not related to any quarry operations. The elevated sulfate values are thought to reflect natural increases across the quarry area because a location upgradient monitoring location, MW-1035, has also been increasing in sulfate since 1994. The 1996 annual averages for the well field are summarized in Table 8-18. The secondary MCL for sulfate is 250 mg/l; this standard was not exceeded at any location in the well field.

TABLE 8-18 Annual Averages for Sulfate (mg/l), Arsenic (μg/l), and Barium (μg/l) in the St. Charles County Well Field

LOCATION	SULFATE	ARSENIC	BARIUM
MW-1024	4.48	8.30	347
MW-RMW1	29.1	19.1	545
MW-RMW2	19.1	107	348
MW-RMW3	62.5	36.2	397
MW-RMW4	42.9	17.1	225
MW-PW02	125	<3.0	373
MW-PW03	135	<3.0	349
MW-PW04	135	<3.0	324
MW-PW05	66.0	<3.0	440
MW-PW06	117	<3.0	405

TABLE 8-18 Annual Averages for Sulfate (mg/l), Arsenic (µg/l), and Barium (µg/l) in the St. Charles County Well Field (Continued)

LOCATION	SULFATE	ARSENIC	BARIUM
MW-PW07	60.0	<3.0	509
MW-PW08	39.0	5.05	469
MW-PW09	34.5	4.35	515
MW-RAWW	90.0	<3.0	428
MW-FINW	94.5	<3.0	77.7

8.5.4 Trend Analysis

Statistical tests for time-dependent trends at the Weldon Spring Quarry were performed on historical and current 1996 data from select groundwater wells. Trending was performed on total uranium, nitroaromatic, and sulfate data.

Trend analyses were performed at monitoring locations based on historical data or knowledge of the quarry groundwater system. Total uranium trends were analyzed at locations down-gradient of bulk waste sources and in areas of possible impact south of the slough. Nitroaromatic compounds were analyzed for locations down-gradient of bulk waste sources. Sulfate trend analyses were performed for locations down-gradient of bulk waste sources and all locations adjacent to the south side of the slough, due to recent changes in levels in sulfate in this area.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. The results of the TREND testing are shown in Tables 8-19 through 8-21.

The results of the TREND analyses indicate the potential presence of statistically-significant trends and their direction upward or downward. The slope of each identified trend was also estimated with the results reported in concentration units per year. A 95% confidence

interval about each slope line was calculated to indicate the variability (variance) in the values about this trend line. The trend testing output data are to be interpreted as screening indicators based on existing cumulative data. The results of the analyses are not intended to be used for the prediction of future concentrations. Rather, the data are to be used to indicate areas that should be more closely monitored in the future.

The TREND program was selected because it can easily facilitate missing data and does not require the data to conform to a particular distribution (such as a normal or lognormal distribution). The nonparametric method used in this program is valid for scenarios where there are a high number of non-detect data points. Data reported as trace concentrations or less than the detection limit can be used by assigning them a common value that is smaller than the smallest measured value in the data set (i.e., one-half the specified quantitation limit). This approach is valid since only the relative magnitudes of the data, rather than their measured values, are used in the method. The TREND program was also used in past analyses of the site groundwater data. Thus, use of the TREND program offered the advantage of maintaining continuity in the analysis methodology. The two-tailed version of the Mann-Kendall test was employed to detect either an upward or downward trend for each data set. In this approach, a test statistic, Z, is calculated. A positive value of Z indicates an upward trend. Likewise, a negative value of Z indicates a downward trend. The alpha value (or error limit) selected for testing was 0.05. In the two-tailed test at the 0.05 alpha level of significance, the null hypothesis of "no trend" was rejected if the absolute value of the Z statistic was greater than $Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ was obtained from a cumulative normal distribution table. Thus, the absolute value of the TREND output statistic, Z was compared to the table $Z_{.975}$ value of 1.96. If the absolute value of the Z output statistic was greater than 1.96, then a significant trend was reported.

One-half the specified quantitation limit (on the date of analysis) was used in the trend analysis for all data reported as below the detection limit. The purpose of using one-half the quantitation limit for non-detect data was to minimize the potential bias of the data. However, a consequence of this approach may be that in some instances the results may have been impacted by quantitation limits changing over time. The effect of varying quantitation limits is more likely to impact the trending analysis in instances where a large number of non-detect data are present within a given time series. The summary tables include the total number of data

observations and the total number of non-detect data points for each data set so that this factor may be considered.

Graphs presenting the contaminant concentration versus time for each contaminant per trending location were developed. These graphs were used to identify suspect data outliers only for each trending analysis and are not presented in this report. No statistical tests were conducted for suspect outliers. Data that were suspect were flagged and rechecked for potential data transcription errors. No obvious errors were identified. The results of two analyses, however, were eliminated from the data sets used in the TREND analyses. The data points that were deleted based on the data review consisted of sample analysis numbers GW-002-0394 and GW-1035-0394. The result for analysis GW-002-0394 (2,4-DNT concentration of 21.5μg/l) was deleted because the data was not validated and the result deviated greatly from the data set mean value (greater than three sigma). The result for analysis GW-1002-0394 (total uranium concentration of 26.8 pCi/l [0.99 Bq/l]) was deleted because laboratory cross contamination was suspected and reanalysis of the sample by another laboratory resulted in a reported concentration of <0.677 pCi/l (0.025 Bq/l). This second value was assigned for the TREND analysis. All other original data were included in the trending analyses.

In general, data collected between 1991 and 1994 were filtered using a 45-micron filter. Data collected in 1995 and 1996 were collected as non-filtered samples. In order to maintain continuity during the trending analyses, non-filtered data obtained between the years of 1991 and 1994 were omitted if both filtered and non-filtered data were reported for the same period of time. Similarly, filtered data collected in 1995 and 1996 were also omitted if both filtered and non-filtered data were reported for the same time periods. However, some of the data points from 1992 used in the trend analysis represented non-filtered samples (filtered samples were not collected for these periods). Subsequent trend analyses were conducted with omission of the non-filtered data collected during 1992 to determine whether the non-filtered data had any effect on the trend direction test results for data between the years 1991 and 1994. Overall, filtered and non-filtered sampling results appeared to be very similar in concentration. This was evaluated by comparing filtered versus non-filtered data for the same time period. Graphs were generated that presented the contaminant concentrations versus time for both cases. These graphs indicated that the difference between filtered and non-filtered concentrations for the same time periods was relatively minimal.

In order to maintain sufficient power of the statistical tests, the analyses were limited to data sets with four or more data points. Therefore, if fewer than four detected concentrations were present in a given time series for a contaminant, the data set was not analyzed. These data sets are designated with an (a) in the summary tables, Tables 8-19 through 8-21.

The linear slope of the trend was estimated for all data sets in which an upward or downward trend was identified. The slope was estimated using a nonparametric procedure included in the computer code for the TREND program. The estimates of the trend slope for all data sets with identified trends are provided in Tables 8-19 through 8-21. A $100(1-\alpha)\%$ two-sided confidence interval about the true slope was also obtained by the nonparametric technique. The upper and lower 95% confidence limit estimates of the slope are included in the far right columns of the summary tables.

Nitroaromatic Compound Trend Results

TREND analyses have been performed for the nitroaromatic data at the quarry since 1992. Eleven of the DOE monitoring locations were selected for TREND analyses based on the previously outlined criteria. Nitroaromatic analyses results are presented in Table 8-19. Based on the results of the analyses, no upward trends were identified in groundwater from the bedrock wells or alluvial wells that were analyzed for the 1994 to 1996 period. Nitroaromatic trend directions were downward in most wells that exhibited upward trends from 1991 to 1993. For the two locations that previously showed a potential upward trend for 2,4-DNT based on the 1994 and 1995 data (MW-1014 and MW-1027), the cumulative results for 1994 through 1996 indicate a stationary trend. The decreasing trends are likely the result of bulk waste removal at the quarry.

Total Uranium Trend Results

Total uranium trends for 1994-1996 data were stationary at all locations except two locations. Cumulative data for 1994 through 1996 for MW-1030 indicate a downward trend. Cumulative data for 1994 through 1996 for MW-1031 indicate an upward trend; these results are the same as the previous analysis of the 1994 through 1995 data for this well location. The only other location that showed a potential upward trend for total uranium based on 1994 and 1995 data, was MW-1014. Based on the cumulative data for 1994 to 1996, the trend has

changed to stationary at this location. The stationary and downward trends of the quarry rim wells (which are similar to nitroaromatic compound trends), may be due to bulk waste removal at the quarry. The uranium trend analyses are summarized in Table 8-20.

Sulfate Trend Analysis Results

As shown in Table 8-21, sulfate sampling data for 1994 through 1996 for six locations indicated an upward trend. Three of these locations (MW-1031, MW-1016, and MW-1035) previously displayed an upward trend based on the 1994 and 1995 data. The 1994 and 1995 data for the other three locations, which now show an upward trend for 1994 through 1996, previously indicated a stationary trend. The locations with upward trends, except for MW-1035, are north of the Femme Osage Slough. These locations include both bedrock and alluvial wells. It is possible that increases at these locations may be due to flooding during the last few years. The location of MW-1035 is hydraulically upgradient of the quarry. The location of MW-1035 was selected to represent background conditions. Data for two alluvial well locations (MW-1006 and MW-1008) indicated downward trends for 1994 through 1996. The results of all other analyses for this period indicated stationary trends. The sulfate analyses results are summarized in Table 8-21.

TABLE 8-19 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Alpha = 0.1)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
			1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/938	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW100 2	Bedrock - East Rim	2,4-DNT	19	27	5	1	U	D	0.12	-0.04	0.10, 0.17	-0.05, -0.03
		2,6-DNT	19	28	0	0	U	D	15.10	-4.75	6.03, 22.48	-6.00, -3.00
		1,3-DNB	19	28	1	2	U	D	0.24	-0.17	0.17, 0.35	-0.22, -0.11
		2,4,6-TNT	19	28	0	0	U	D	88.00	-30.00	66.50, 139.70	-43.98, -20.90
		1,3,5-TNB	19	28	0	0	U	D	608.75	-170.00		430.24, 800.00
		NB	–	28	--	27	--	(a)	--	(a)	--	(a)
MW1004	Bedrock - rim	2,4-DNT	19	29	0	0	S	S	0.30	0.001	-0.19, 0.08	-0.01, 0.01
		2,6-DNT	19	29	0	0	S	S	-0.35	-0.01	-1.20, 0.20	-0.08, 0.06
		1,3-DNB	19	29	19	28	(a)	(a)	(a)	(a)	(a)	(a)
		2,4,6-TNT	19	29	0	0	S	S	1.00	0.10	-2.56, 4.50	-0.66, 0.80
		1,3,5-TNB	19	29	0	0	S	S	0.56	-0.08	-0.50, 1.85	-0.29, 0.09
		NB	–	29	--	28	--	(a)	--	(a)	--	(a)

TABLE 8-19 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Alpha = 0.1) (Continued)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
			1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1005 (cont'd)	Bedrock - rim	2,4-DNT	17	18	1	13	D	D	-0.03	-0.002	-0.04, -0.02	-0.05, 0.00
		2,6-DNT	17	18	0	13	D	D	-0.01	-0.002	-0.02, -0.01	-0.02, 0.00
		1,3-DNB	--	18	--	18	--	(a)	--	(a)	--	(a)
		2,4,6-TNT	--	18	--	18	--	(a)	--	(a)	--	(a)
		1,3,5-TNB	--	18	--	18	--	(a)	--	(a)	--	(a)
		NB	--	18	--	19	--	(a)	--	(a)	--	(a)
MW1006	Alluvium - North of Slough	2,4-DNT	--	15	--	4	--	(a)	--	-0.09	--	-0.17, 0.04
		2,6-DNT	--	16	--	0	--	S	--	-0.38	--	-1.27, 0.02
		1,3-DNB	--	15	--	12	--	S	--	0.00	--	-0.04, 0.00
		2,4,6-TNT	--	15	--	1	--	S	--	-2.97	--	-7.92, -0.10
		1,3,5-TNB	--	16	--	0	--	S	--	-28.75	--	-69.38, -0.16
		NB	--	16	--	0	--	S	--	-28.75	--	-69.38, -0.16

TABLE 8-19 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Alpha = 0.1) (Continued)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
			1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1015	Bedrock - North of Slough	2,4-DNT	18	13	3	7	U	D	0.01	-0.01	0.00, 0.02	-0.02, -0.01
		2,6-DNT	18	13	0	1	D	D	-0.20	-0.04	-0.30, -0.04	-0.06, -0.02
		1,3-DNB	18	13	6	4	U	S	0.05	-0.05	0.00, 0.11	-0.08, 0.002
		2,4,6-TNT	18	13	0	0	S	D	-4.00	-0.90	-10.16, 1.77	-1.40, -0.44
		1,3,5-TNB	18	13	0	0	D	D	-46.50	-2.37	-106.62, 0.00	-4.12, -0.43
		NB	1	13	1	13	(a)	(a)	(a)	(a)	(a)	(a)
MW1016	Alluvium - North of Slough	2,4-DNT	–	13	–	13	–	(a)	–	(a)	–	(a)
		2,6-DNT	–	13	–	3	–	S	–	-0.004	–	-0.02, 0.01
		1,3-DNB	–	13	–	13	–	(a)	–	(a)	–	(a)
		2,4,6-TNT	–	13	–	4	–	S	–	-0.001	–	-0.08, 0.09
		1,3,5-TNB	–	13	–	3	–	S	–	-0.01	–	-0.37, 0.17
		NB	–	13	–	13	–	(a)	–	(a)	–	(a)

TABLE 8-19 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Alpha = 0.1) (Continued)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
			1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1027	Bedrock-rim	2,4-DNT	16	14	0	1	S	S	0.80	0.97	-2.70, 5.99	-0.21, 3.36
		2,6-DNT	16	14	0	1	S	S	-0.20	-0.25	-1.30, 0.90	-0.89, 0.26
		1,3-DNB	--	14	--	14	--	(a)	--	(a)	--	(a)
		2,4,6-TNT	16	14	0	1	S	D	2.63	-1.80	-8.00, 12.25	-2.69, -0.38
		1,3,5-TNB	--	14	--	8	--	D	--	-0.05	--	-0.08, -0.01
		NB	--	14	--	14	--	(a)	--	(a)	--	(a)
MW1030	Bedrock-rim	2,4-DNT	11	16	1	9	S	D	0.02	-0.01	0.00, 0.06	-0.03, -0.002
		2,6-DNT	11	16	6	8	U	D	0.05	-0.01	0.00, 0.09	-0.02, 0.00
		1,3-DNB	--	16	--	16	--	(a)	--	(a)	--	(a)
		2,4,6-TNT	11	16	8	11	(a)	S	(a)	0.00	(a)	-0.03, 0.00
		1,3,5-TNB	--	16	--	15	--	(a)	--	(a)	--	(a)
		NB	--	16	--	16	--	(a)	--	(a)	--	(a)

TABLE 8-19 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Alpha = 0.1) (Continued)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
			1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1032	Bedrock-North of Slough	2,4-DNT	15	13	0	6	S	S	0.08	0.02	-0.02, 0.18	-0.06, 0.00
		2,6-DNT	15	13	0	5	S	S	-0.04	-0.01	-0.27, 0.16	-0.03, 0.003
		1,3-DNB	--	13	--	13	--	(a)	--	(a)	--	(a)
		2,4,6-TNT	15	13	3	11	S	S	0.26	0.00	-0.12, 0.91	0.00, 0.00
		1,3,5-TNB	--	13	--	12	--	(a)	--	(a)	--	(a)
		NB		13	--	13	--	(a)	--	(a)	--	(a)
MW1034	Bedrock-background	2,4-DNT	--	8	--	8	--	(a)	--	(a)	--	(a)
		2,6-DNT	--	8	--	8	--	(a)	--	(a)	--	(a)
		1,3-DNB	--	8	--	8	--	(a)	--	(a)	--	(a)
		2,4,6-TNT	--	8	--	8	--	(a)	--	(a)	--	(a)
		1,3,5-TNB	--	8	--	8	--	(a)	--	(a)	--	(a)
		NB	--	8	--	8	--	(a)	--	(a)	--	(a)

TABLE 8-19 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Alpha = 0.1) (Continued)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
			1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/938	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1035	Alluvium-background	2,4-DNT	--	12	--	12	--	(a)	--	(a)	--	(a)
		2,6-DNT	--	12	--	12	--	(a)	--	(a)	--	(a)
		1,3-DNB	--	12	--	12	--	(a)	--	(a)	--	(a)
		2,4,6-TNT	--	12	--	12	--	(a)	--	(a)	--	(a)
		1,3,5-TNB	--	12	--	12	--	(a)	--	(a)	--	(a)
		NB	--	12	--	12	--	(a)	--	(a)	--	(a)

D	Downward
S	Stationary
U	Upward
(a)	No or only one detectable concentration reported for time period; therefore, no trending performed.
*	Inclusive
--	No data available. No samples collected.
2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
1,3-DNB	1,3-Dinitrobenzene
2,4,6-TNT	2,4,6-Trinitrotoluene
1,3,5-TNB	1,3,5-Trinitrobenzen
NB	Nitrobenzene

TABLE 8-20 Quarry Groundwater Wells-Total Uranium Trend Analysis Summary-(ALPHA-0.1)

WELL ID	LOCATION	No. OF OBSERVATIONS		No. OF NONDETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
		1/91-7/93*	1994 1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91 to 7/93 INCLUSIVE	1994-1996
MW1004	Bedrock-rim	19	20	0	0	S	S	-300.00	30.00	-909.98, 149.95	-200.76, 250.00
MW1005	Bedrock-rim	18	14	0	0	D	S	-360.00	1495.00	-4750, -200.00	-89.56, 2460.72
MW1006	Alluvium-North of Slough	--	10	--	0	--	S	--	-75.00	--	-429.23, 790.42
MW1007	Alluvium-North of Slough	16	11	0	0	S	S	90.25	-42.85	-9.006, 256.50	-325.48, 35.54
MW1008	Alluvium-North of Slough	--	11	--	0	--	S	--	395.00	--	-487.42, 993.43
MW1009	Alluvium-North of Slough	--	10	--	3	--	S	--	0.90	--	-4.25, 4.53
MW1013	Bedrock-North of Slough	--	10	--	0	--	S	--	0.00	--	-66.04, 83.39
MW1014	Alluvium-North of Slough	--	10	--	0	--	S	--	64.00	--	-19.74, 187.99
MW1015	Bedrock-North of Slough	18	10	0	0	D	S	-310.00	-35.00	-559.86, -49.47	-74.62, 2.87
MW1016	Alluvium-North of Slough	--	10	--	0	--	S	--	3.50	--	-11.69, 19.81
MW1023	Alluvium-South of Slough	--	11	--	6	--	S	--	0.41	--	-0.17, 1.00
MW1027	Bedrock-rim	19	11	0	0	S	S	-68.75	-17.50	-245.49, 47.00	-90.42, 61.65

TABLE 8-20 Quarry Groundwater Wells-Total Uranium Trend Analysis Summary-(ALPHA-0.05) (Continued)

WELL ID	LOCATION	No. OF OBSERVATIONS		No. OF NONDETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
		1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91 to 7/93 INCLUSIVE	1994-1996
MW1030	Bedrock-rim	14	17	2	0	S	D	0.37	-27.60	-1.91, 4.70	-56.71, -7.44
MW1031	Bedrock-North of Slough	--	12	--	0	--	U	--	69.77	--	48.72, 93.22
MW1032	Bedrock-North of Slough	16	12	0	0	U	S	348.00	96.50	74.00, 648.00	-14.86, 299.88
MW1034	Bedrock-Background	--	9	--	0	--	S	--	-0.73	--	-3.36, 0.23
MW1035	Alluvium-Background	--	13	--	5	--	S	--	0.018	--	-0.03, 0.12

D Downward
S Stationary
U Upward
(a) Location
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* Inclusive

TABLE 8-21 Quarry Groundwater Wells Sulfate Trend Analysis Summary

WELL ID	LOCATION	No. OF OBSERVATIONS		No. OF NONDETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
		1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1002	Bedrock - East rim	17	15	0	0	U	U	11.48	9.85	4.73, 18.10	6.00, 13.55
MW1004	Bedrock - rim	--	11	--	0	--	S	--	10.25	--	-21.22, 31.74
MW1006	Alluvium - North of Slough	--	11	--	0	--	D	--	-44.00	--	-69.92, -3.73
MW1007	Alluvium - North of Slough	14	11	1	0	U	S	54.95	-12.25	11.74, 98.93	-25.48, 17.86
MW1008	Alluvium - North of Slough	--	11	--	0	--	D	--	-37.00	--	-62.30, -6.16
MW1009	Alluvium - North of Slough	--	11	--	0	--	S	--	-1.75	--	-10.16, 8.16
MW1013	Bedrock - North of Slough	--	11	--	0	--	U	--	7.98	--	3.27, 13.38
MW1014	Alluvium - North of Slough	--	9	--	0	--	S	--	8.93	--	1.18, 18.06
MW1015	Bedrock - North of Slough	18	11	0	0	D	S	-70.00	3.50	-99.72, -34.85	-3.54, 17.00
MW1016	Alluvium - North of Slough	--	11	--	0	--	U	--	11.25	--	3.07, 21.74
MW1019	Alluvium - South of Slough	--	12	--	0	--	S	--	7.58	--	-8.81, 24.09

TABLE 8-21 Quarry Groundwater Wells Sulfate Trend Analysis Summary (Continued)

WELL ID	LOCATION	No. OF OBSERVATIONS		No. OF NONDETECT DATA		TREND DIRECTION		SLOPE (mg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)	
		1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996	1/91-7/93*	1994-1996
MW1020	Alluvium - South of Slough	--	12	--	2	--	S	--	-0.25	--	-2.41, -0.05
MW1021	Alluvium - South of Slough	--	11	--	7	--	S	--	-0.25	--	-2.41, -0.05
MW1023	Alluvium - South of Slough	--	12	--	3	--	S	--	0.09	--	-0.86, 0.90
MW1027	Bedrock - rim	16	9	0	0	S	S	0.25	10.00	-9.99, 8.70	-0.05, 21.20
MW1029	Bedrock - East rim	--	8	--	0	--	U	--	11.00	--	5.00, 23.75
MW1030	Bedrock - rim	15	10	1	0	S	S	-0.05	-2.50	-19.11, 25.68	-21.00, 6.93
MW1031	Bedrock - North of Slough	--	12	--	0	--	U	--	40.70	--	30.07, 57.23
MW1032	Bedrock - North of Slough	15	10	0	0	S	S	-3.00	9.00	-18.30, 13.80	-18.59, 54.82
MW1034	Bedrock - Background	--	12	--	0	--	S	--	-6.35	--	-13.12, -0.81
MW1035	Alluvium - Background	--	13	--	0	--	U	--	6.70	--	4.62, 8.90

D Downward
S Stationary
U Upward

TABLE 8-21 Quarry Groundwater Wells Sulfate Trend Analysis Summary (Continued)

(a) Location not selected for trending
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* Inclusive

8.6 Waste Treatment Facilities

8.6.1 Monitoring Program

Groundwater monitoring wells have been placed around three waste management units: the quarry and site water treatment plant equalization basins, and the temporary storage area (see Figures 8-2 and 8-4). These wells were installed to detect contaminants in the uppermost water units beneath these storage facilities in order to comply with the requirements of 40 CFR 264, Subpart F, and 10 CSR 264, Subpart F. The monitoring parameters were derived from previous evaluations performed and documented in the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 40) and the *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 41).

The detection monitoring program consists of quarterly sampling for the following parameters:

- Total uranium.
- Anions (nitrate, sulfate, chloride, and fluoride).
- Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver).
- Nitroaromatic compounds.

Annual sampling is performed for the following parameters:

- Radiochemical parameters (Ra-226, Ra-228, Th-230, Th-232, U-234, and U-238).
- Polychlorinated biphynels (PCBs).
- Polynuclear aromatic hydrocarbons (PAH).
- Pesticides (endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP Silvex).

Constituent concentrations at the monitoring wells were compared with previously determined baseline concentrations for each well. If there was statistically significant evidence of contamination (concentration exceeds baseline by three standard deviations), a program of increased monitoring and/or an evaluation of the leachate collected within the liners of the basins or storage area was initiated.

8.6.2 Site Water Treatment Plant and Temporary Storage Area Monitoring Results

Collection of baseline data for the wells surrounding the equalization basin for the site water treatment plant and the temporary storage area was completed in December of 1994. The baseline dataset for each monitoring well was established with a minimum of eight samples collected on a quarterly basis. A statistical summary of these baseline data for wells MW-2035 through MW-2043 can be found in Table 8-22. Monitoring data collected during 1996 were compared with the baseline data to identify significant changes in groundwater quality potentially attributable to operation of these facilities.

Primary and secondary drinking water standards were not exceeded, except for nitrate at well locations MW-2037 through MW-2042, mercury at locations MW-2037 and MW-2038, selenium at the MW-2041 location, and 2,4-DNT at locations MW-2037 and MW-2038. Elevated selenium and nitrate levels are potentially due to the facility's close proximity to the raffinate pits.

Baseline concentrations for lead were slightly exceeded at MW-2038, MW-2039 and MW-2040. These apparent concentration elevations are most likely attributable to changes in sample collection and preparation methodologies rather than actual groundwater conditions. Baseline values were established from analytical results of filtered samples collected during 1993 and 1994. Beginning in 1995, groundwater samples were no longer filtered due to a change in project sampling procedures pursuant to EPA sampling guidelines. Metals potentially adhering to suspended solids or precipitates, which had been filtered out prior to 1995, were not filtered from the 1996 samples. Despite the changes in the groundwater metals values, there is no evidence that the integrity of the water treatment facilities or temporary storage area (TSA) basins has been compromised. This negative evidence includes no elevated metals detected in collected leachate and no increased volume of leachate at these facilities.

Nitrate baseline was not exceeded at any location at the site water treatment facility equalization basin. All locations at the water treatment plant and TSA are stable or decreasing in nitrate concentrations. Sulfate baselines were not exceeded at any location. One location, MW-2038, in which sulfate concentrations had been steadily rising in 1993 to 1994, had apparently stabilized during 1995. None of the locations exceeded the drinking water standard of 250 mg/l.

TABLE 8-22 Baseline for the Detection Monitoring System at the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic (µg/l)	2.25	2.09	1.82	5.77	2.43	4.12	4.35	3.41	2.10
Barium (µg/l)	107	333	250	563	240	962	347	590	344
Cadmium (µg/l)	3.91	3.89	3.67	3.67	6.98	4.04	4.20	3.80	3.79
Chromium (µg/l)	4.21	4.33	3.83	3.83	14.1	14.1	18.4	6.62	4.52
Lead (µg/l)	4.08	2.17	1.65	1.65	1.50	3.30	8.53	2.40	2.81
Mercury (µg/l)	0.14	0.14	3.40	4.37	0.15	0.12	0.59	0.13	0.15
Selenium (µg/l)	4.71	1.86	20.0	24.9	24.5	9.42	96.6	4.11	7.11
Silver (µg/l)	5.78	6.07	6.08	6.08	13.8	5.40	10.3	6.18	4.96
Uranium (pCi/l)	1.93	1.64	2.17	2.32	4.12	4.64	8.35	3.33	2.34
Nitrate (mg/l)	2.05	5.03	668	2271	117	455	2256	13.8	8.03
Sulfate (mg/l)	6.89	5.64	177	132	54.6	27.9	196	39.5	20.8
1,3,5-TNB (µg/l)	0.02	0.02*	0.29	0.37	0.02	0.02	0.02	0.02	0.02

TABLE 8-22 Baseline for the Detection Monitoring System at the Weldon Spring Site Water Treatment Plant and Temporary Storage Area (Continued)

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
TNT (µg/l)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2,4-DNT (µg/l)	0.02	0.02	0.79	2.14	0.02	0.02	0.02	0.02	0.09
2,6-DNT (µg/l)	0.01	0.01	0.19	0.41	0.01	0.01	0.01	0.01	0.01

Note: 1 pCi/l = 0.037 Bq/l.

Nitroaromatic compounds were detected at locations MW-2037, MW-2038, and MW-2043. These detectable nitroaromatics were below baseline concentrations. There were no detections at the MW-2039 location which had 2,4-DNT and 2,6-DNT reported above baseline in 1996.

No PCBs or pesticides were reported above detection limits at any of the locations, and no concentrations of total uranium were above their respective baselines at any of the detection locations for the water treatment facility and TSA. The 1996 detection monitoring data for the site water treatment plant and the TSA are summarized in Table 8-23.

8.6.3 Quarry Water Treatment Plant Monitoring Results

Monitoring wells MW-1035 through MW-1039 were installed in 1991 to monitor the shallow groundwater in the vicinity of the quarry water treatment plant. In 1993, two additional monitoring wells, MW-1040 and MW-1041, were installed closer to the equalization basin to better monitor the waste storage unit. Baseline has been established for these newer wells utilizing 1994 and 1995 quarterly data. Monitoring wells MW-1038 and MW-1039 were deleted from this monitoring program because they were located cross gradient from the equalization basin at a distance too far to adequately monitor the basin and are possibly downgradient of contaminant sources in the quarry.

The concentrations at the wells were compared to baseline for the parameters. The baseline parameters for each well are presented in Table 8-24 and the summary of detection monitoring results is given in Table 8-25. Samples were also analyzed for nitroaromatic compounds, pesticides, and PCBs. The baselines and analytical results are not shown in either table because these compounds do not naturally occur and have not been detected in the monitoring system.

The results of the comparison of the monitoring data to baseline indicated that monitoring well MW-1035 exceeded background for Ra-228, and MW-1037 exceeded baseline for isotopic thorium during 1996. These minor exceedances are within error limits of the analytical methods and are questionable. Total uranium levels remain within baseline for all wells at the water treatment facility detection monitoring network.

TABLE 8-23 Summary of the 1996 Detection Monitoring Data for the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETERS		MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic µg/l	Average max/min	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0
Barium µg/l	Average max/min	97.1 110/90.3	284 291/277	74.1 80.8/70.4	177 190/169	224 233/214	664 782/530	257 274/230	517 523/509	311 330/268
Cadmium µg/l	Average max/min	<DL <3.0/<1.0	<DL <3.0/<1.0	<DL <3.0/1.0	<DL <2.0/1.0	<DL <3.0/<1.0	<DL <2.0/<0.2	<DL <3.0/<1.0	<DL <2.0/<0.2	<DL <2.0/<0.2
Chromium µg/l	Average max/min	1.33 1.5/<2.0	<DL <4.0/<1.0	<DL <4.0/<1.0	1.03 1.6/<2.0	7.63 8.0/7.3	21.4 29.2/17.9	<DL <4.0/<2.0	1.18 1.4/<2.0	2.50 3.1/2.2
Lead µg/l	Average max/min	1.7 1.7/<1.0	<DL <2.0/<1.0	<DL <2.0/<1.0	1.60 4.7/<1.0	2.10 3.3/<2.0	7.13 13.1/4.1	1.00 1.00/<1.00	1.58 3.4/<2.0	1.48 2.4/<2.0
Mercury µg/l	Average max/min	<DL <0.2/<0.1	<DL <0.2/<0.1	2.63 3.3/2.4	2.85 4.1/1.7	<DL <0.2/<0.1	<DL <0.2/<0.1	0.16 0.26/<0.1	0.10 0.1/<0.1	<DL <0.2/<0.1
Selenium µg/l	Average max/min	<DL <4.0/<2.5	<DL <4.0/<2.5	3.33 4.8/<3.0	11.4 12.3/10.4	8.0 10.1/6.1	5.33 7.7/3.6	15.7 21.5/10.5	<DL <5.0/<2.0	2.43 2.8/<3.0
Silver µg/l	Average max/min	1.77 2.8/<1.0	<DL <4.0/<0.7	<DL <4.0/<1.0	1.0 1.0/<0.7	<DL <4.0/<1.0	1.0 1.5/<1.0	<DL <4.0/<1.0	<DL <1.00	<DL <1.00
Total Uranium pCi/l	Average max/min	0.48 0.63/0.39	0.73 0.78/0.68	1.28 1.47/1.16	1.28 1.84/1.13	2.98 3.19/2.86	2.35 2.62/1.87	3.94 4.46/3.64	2.65 2.97/2.32	3.06 8.28/1.48
Nitrate mg/l	Average max/min	0.44 0.5/0.38	2.83 3.0/2.6	198 252/52	619 840/150	36.1 56.2/17	172 305/69	178 253/86	4.95 7.1/2.2	6.08 8.0/2.7
Sulfate mg/l	Average max/min	1.82 2.0/1.82	4.30 3.99/<1.0	141 166/130	107 118/88.6	29.1 50.4/3.0	13.7 17.4/9.24	37.7 48.7/32	27.7 33.23	15.3 16.5/14
TNT µg/l	Average max/min	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03

TABLE 8-23 Summary of the 1996 Detection Monitoring Data for the Weldon Spring Site Water Treatment Plant and Temporary Storage Area (Continued)

PARAMETERS		MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
2,4-DNT µg/l	Average max/min	<DL <0.03	<DL <0.03	0.49 0.52/0.43	1.53 1.7/1.3	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	0.08 0.09/0.06
2,6-DNT µg/l	Average max/min	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01

TABLE 8-24 Baseline for the Detection Monitoring System at the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	2.66	9.70	3.08	12.0	7.56
U-234 (pCi/l)	12.1	(a)	4.95	10.8	5.79
U-238 (pCi/l)	13.2	(a)	3.25	6.72	3.45
Ra-226 (pCi/l)	1.32	0.25	0.72	2.17	1.47
Ra-228 (pCi/l)	0.81	1.00	1.58	1.79	1.25
Th-230 (pCi/l)	1.23	2.94	0.48	0.88	1.41
Th-232 (pCi/l)	0.35	0.34	0.40	0.39	0.35
Chloride (mg/l)	6.82	102	11.8	16.0	8.34
Fluoride (mg/l)	0.28	0.18	0.71	0.12	0.26
Nitrate (mg/l)	0.37	0.32	0.82	0.28	0.32

TABLE 8-24 Baseline for the Detection Monitoring System at the Weldon Spring Quarry Water Treatment Plant (Continued)

PARAMETER	MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Sulfate (mg/l)	70.0	82.0	55.5	186	52.8
Arsenic (µg/l)	6.09	4.71	5.50	9.83	6.64
Barium (µg/l)	315	351	752	330	553
Cadmium (µg/l)	3.18	3.61	3.44	3.96	3.67
Chromium (µg/l)	4.81	7.57	7.57	19.6	15.5
Lead (µg/l)	1.59	2.06	2.06	2.72	5.84
Mercury (µg/l)	0.18	0.20	0.17	0.42	0.58
Selenium (µg/l)	7.81	3.63	5.09	5.63	5.28
Silver (µg/l)	4.99	4.78	4.78	5.69	8.45

(a) No data available for determination of baseline.
Note: 1 pCi/l = 0.037 Bq/l.

TABLE 8-25 Summary of the 1996 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant

PARAMETER		MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	average	<DL	5.79	2.84	2.65	6.17
	max/min	<0.7/<0.2	10.5/1.66	7.66/1.06	5.90/0.62	7.59/4.98
Ra-226 (pCi/l)	average	0.49	0.14	0.47	0.82	0.98
	max/min	-	-	-	-	-
Ra-228 (pCi/l)	average	1.33	0.49	1.32	0.86	0.79
	max/min	-	-	-	-	-
Th-228 (pCi/l)	average	0.26	<0.22	1.18	0.47	<0.25
	max/min	-	-	-	-	-
Th-230 (pCi/l)	average	0.23	<0.11	0.57	0.43	<0.12
	max/min	-	-	-	-	-
Chloride (mg/l)	average	29.2	287	4.54	24.6	4.97
	max/min	37.6/11.9	518/120	5.6/2.6	31/17	6.2/3.83
Fluoride (mg/l)	average	0.18	0.20	0.37	0.17	0.16
	max/min	0.28/<0.25	0.27/<0.2	0.40/<0.20	0.18/0.14	0.18/0.13
Nitrate (mg/l)	average	0.05	0.16	0.25	0.73	0.06
	max/min	0.06/<0.05	0.3/<0.1	0.43/0.10	2.8/<0.05	0.99/<0.05
Sulfate (mg/l)	average	50.7	95.2	286	249	48.12
	max/min	59.0/40.4	150/58	390/180	301/190	52.4/41.2

TABLE 8-25 Summary of the 1996 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant (Continued)

PARAMETER		MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Arsenic (µg/l)	average	1.81	2.83	3.33	2.12	1.27
	max/min	4.2/<2.0	4.6/<2.0	7.8/<2.0	4.2/<2.0	1.5/<2.0
Barium (µg/l)	average	279	217	220	257	378
	max/min	318/250	256/178	432/138	361/208	440/336
Cadmium (µg/l)	average	<DL	<DL	<DL	1.60	1.65
	max/min	<2.4/<1.0	<4.0/<1.0	<4.0/<1.0	2.8/<1.0	4.3/<1.0
Chromium (µg/l)	average	3.11	13.7	8.30	5.61	<DL
	max/min	8.0/<2.0	47.7/4.0	13.8/4.70	18.4/<3.0	<4.1/<2.0
Lead (µg/l)	average	1.81	0.80	6.44	3.42	<DL
	max/min	4.5/<1.0	0.67/<2.0	17.2/2.1	11.5/<1.0	<2.0/<0.6
Mercury (µg/l)	average	0.66	<DL	<DL	<DL	<DL
	max/min	2.4/<0.2	<0.2/<0.1	<0.2/<0.1	<0.2/<0.1	<0.2/<0.1
Selenium (µg/l)	average	<DL	<DL	1.84	1.84	<DL
	max/min	<3.9/<1.5	<4.0/<1.5	3.0/<1.5	3.0/<1.5	<4.0/<1.5
Silver (µg/l)	average	1.68	<DL	1.90	<DL	<DL
	max/min	1.9/<1.0	<5.9/<1.0	1.4/<3.0	<5.9/<1.0	<5.9/<1.0

(a) Location sampled once during 1995; therefore no maximum or minimum reported.
Note: 1 pCi/l = 0.037 Bq/l.

Monitoring wells MW-1036, MW-1037, MW-1040 and MW-1041 had levels that exceeded baseline for sulfate during 1996. These increases reflect a regional sulfate increase in the quarry vicinity and are not believed to be due to contamination.

Chloride baseline concentrations were exceeded in samples collected from monitoring wells MW-1035, MW-1036, and MW-1040. The sources of these excursions are unknown, but it is unlikely that the water treatment facility is contributing to the chloride concentrations because one of the wells, MW-1035, is hydraulically upgradient from the facility. Monitoring wells MW-1037 and MW-1041 do not exceed baseline and are located closer to the treatment facility than MW-1035. A potential source of chloride is the deicing agent applied to Missouri State Route 94, which is routed along the northern perimeter upgradient of the quarry water treatment facility.

Metals concentrations exceeded baselines in four of the detection monitoring wells. Chromium levels approximately exceeded baseline in MW-1036 and MW-1037 wells and lead baseline was exceeded in wells MW-1035 and MW-1040 during this period. A potential source of the elevated metals concentration is the stainless steel casings and screens used in the construction of the detection wells. Chromium and lead can be leached from stainless steel. It is possible that such a phenomenon occurred during 1996 when chloride levels were elevated, due to the use of salts for deicing, or diluted hydrochloric acid, which was used to decontaminate remediation equipment. Either salts or acid can corrode steel. The leachate collection and monitoring program at the water treatment facility indicates there are no problems with the lined impoundments.

The remainder of the monitoring parameters remained within baseline for each well. No detectable concentrations of nitroaromatic compounds, PCBs, polycyclic (or polynuclear) aromatic hydrocarbons, or pesticides were reported for 1996.

9 BIOLOGICAL MONITORING PROGRAM

9.1 1996 Biological Program Highlights

Following is the highlight of the 1996 biological monitoring program. This item, and others, are further discussed in this chapter.

- Total uranium concentrations in fish fillet samples from the Femme Osage Slough and Busch Lakes 34, 35, and 36 remained within the range of historical values and showed no indications of increased uranium accumulation in fish tissues.

9.2 Program Description

Many of the biological sampling activities directed by DOE Orders 5400.1 and 5400.5 such as preoperational monitoring, effluent monitoring, and environmental surveillance are used to support the *National Environmental Policy Act* (NEPA) and *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) biological monitoring program and may include the collection and analysis of water, soil, foodstuffs, and biota samples.

Activities for the biological monitoring program are selected from the results of pathway analyses. Exposure pathways identified for human and ecological receptors are identified in Section 2.1 of the *Environmental Monitoring Plan* (Ref. 42). Complete pathways are those that show a link between one or more contaminant sources, through one or more environmental transport processes, to a human or ecological exposure point. These exposure pathways are used to direct biological sampling activities and determine the type of data that needs to be gathered, documented, and reported.

Results of biological monitoring also provide data for the human ingestion pathways and dose calculations to native aquatic organisms. The remaining pathways are monitored to support biological risk assessment studies and compliance with environmental surveillance requirements.

9.3 Applicable Standards

DOE Order 5400.5 addresses the protection of native aquatic organisms from the potential bioaccumulation of radionuclides. The Order states that the dose absorbed by such organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.

The biological monitoring program provides supporting data on the possible ingestion of biota by humans for the dose estimates in Section 5. These calculations were based on the guideline given in DOE Order 5400.5 that members of the public should not be exposed to radiation sources as a consequence of all routine DOE activities in any one year that could cause an annual effective dose equivalent greater than 100 mrem (1 mSv).

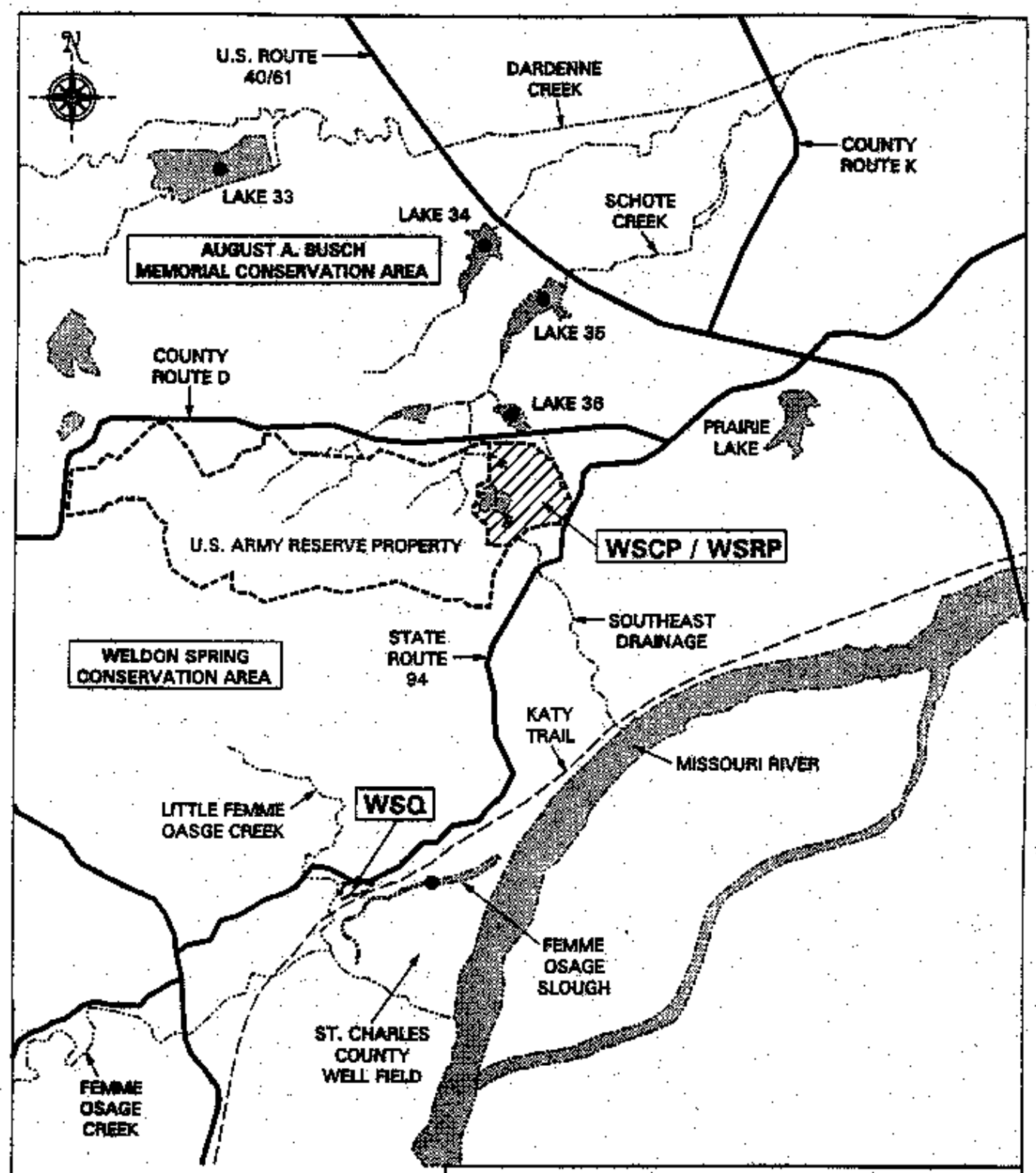
9.4 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the Weldon Spring site by aquatic pathways. Contaminated surface water runoff from the site to off-site lakes and streams provide the main route of exposure to biota. Studies have been conducted to determine the uptake of contaminants on biota at on-site and off-site properties. The main contaminant monitored in off-site surface water is uranium.

9.4.1 Fish

The *Environmental Monitoring Plan* (Ref. 42) requires that fish samples from the Femme Osage Slough and Busch Lakes 34, 35, and 36 be collected every other year or if annual average uranium concentrations in lake waters are found to be statistically higher than the average concentration found in lakes from previous years. In 1996, a scheduled collection year, the Weldon Spring Site Remedial Action Project (WSSRAP) sampled fish from these locations (shown on Figure 9-1) in conjunction with the Missouri Department of Conservation.

Fish samples consisted of game species such as largemouth bass, crappie, sunfish, and catfish. Samples were prepared as fillets, and were analyzed for total uranium. Uranium concentrations in fish fillets from the various sampling locations are shown in Table 9-1. Total uranium concentrations in fish sampled in 1996 were within historic ranges and showed no



FISH SAMPLING LOCATIONS

FIGURE 9-1

REPORT NO.: DOE/OR/21548-676		EXHIBIT NO.: A/VP/025/0396	
ORIGINATOR: ED	DRAWN BY: GLN	DATE: 4/17/97	

TABLE 9-1 Uranium in Fish Fillet Samples (1996) in pCi/g

LOCATION	SUNFISH	BASS	CATFISH	CRAPPIE	CARP
Lake 34	0.00328	0.00163	0.00188	0.000687	NS
Lake 35	0.0190	0.000687	0.00398	0.00237	NS
Lake 36	0.038	0.00220	0.00491	0.00254	NS
Femme Osage Slough	0.00498	0.00229	0.00255	0.00367	0.00303
Lake 33*	0.00103	0.00369	0.00379	0.000790	0.00455

* Background location.
NS Not sampled.

increase in uranium accumulation in fish tissues. Surface water uranium concentrations were also within historic ranges at these locations. Therefore, the next scheduled fish sampling event will take place during Calendar Year 1998, as described in the *Environmental Monitoring Plan* (Ref. 42).

9.4.2 Terrestrial Monitoring

The *Environmental Monitoring Plan* (Ref. 42) stipulated that monitoring of terrestrial foodstuffs would be conducted only if annual average air monitoring results indicate above background concentrations of radionuclides at critical receptor sites. Since annual air monitoring results did not show above background air monitoring results, foodstuff sampling did not take place in 1996.

10 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

10.1 Quality Assurance Highlights

- Average relative percent differences calculated for groundwater, surface water and springs were within the 20% criterion recommended by the CLP.
- Trip blanks analyzed for volatile organic compounds did not exceed the recommend CLP criterion.
- The data validation program accepted 92.5% of the data selected for validation qualifying in 1996.

10.2 Program Overview

The environmental quality assurance program includes management of the quality assurance and quality control programs, plans, and procedures governing environmental monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP) and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the WSSRAP and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides the WSSRAP with reliable, accurate, and precise monitoring data. The program furnishes guidance and directives to detect and prevent quality problems from the time a sample is collected until the associated data are evaluated and utilized. Key elements in achieving the goals of this program are compliance with the quality assurance program and environmental quality assurance program procedures, personnel training, compliance audits, use of quality control samples, complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness.

10.2.1 Quality Assurance Program

The *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 22) establishes the quality assurance program for activities performed by the Project Management Contractor (PMC). The QAP requires compliance with the criteria of DOE Order 5700.6C.

10.2.2 Environmental Quality Assurance Project Plan

The quality assurance requirements for WSSRAP environmental data operations are addressed in the WSSRAP *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 44). The EQAPjP outlines the appropriate requirements of EPA QA/R-5 (Ref. 65) for characterization and routine monitoring at the WSSRAP. The EQAPjP does not supersede the QAP, but rather expands on the specific requirements of environmental monitoring and characterization activities.

The primary purpose of this document is to specify the quality assurance requirements for environmental data operations of the WSSRAP. The EQAPjP is also supported by standard operating procedures (SOPs), the *Sample Management Guide* (Ref. 61), the *Environmental Safety and Health Plan* (Ref. 45), the *Environmental Monitoring Plan* (EMP) (Ref. 42), and sampling plans written for specific environmental sampling tasks.

10.2.3 Sample Management Guide

The *Sample Management Guide* (SMG) (Ref. 61) summarizes SOPs and data quality requirements for collecting and analyzing environmental data. The SMG describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. Guidance on developing data quality objectives for specific investigations is also detailed. The SMG details the specific requirements of the EQAPjP.

10.2.4 Environmental Monitoring and Quality Assurance Standard Operating Procedures

SOPs have been developed for routine activities at the WSSRAP. Environmental monitoring SOPs are generally administered by the Environmental Safety and Health (ES&H) Department, and Quality Assurance SOPs are administered by the Project Quality Department. These two departments are responsible for most SOPs used to administer the environmental quality assurance program described in this section. Controlled copies of SOPs are maintained in accordance with the document control requirements of the *Project Management Contractor Quality Assurance Program* (Ref. 22).

10.2.5 Use and Presentation of Data

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in all reporting and calculations for this site environmental report where available. Uncensored data are those data that do not represent a ND (nondetect) and instead report instrument responses that quantitate to values below the reported detection limit. These types of data are designated by parentheses around the data value, for example "(1.17)". If uncensored data were not available, nondetect data were used in calculations of averages at a value of one-half the detection limit (DL/2). The EPA recommends the use of the DL/2 value for statistical manipulation of data when the percentage of nondetects in the data set is small and uncensored data are not available (Ref. 46).

10.2.6 Independent Assessments and Appraisals

The environmental programs are assessed by the Project Quality Department. They evaluate compliance by performing surveillances and independent assessments of the environmental programs and generate assessment reports to track deficiencies and corrective actions. The WSSRAP is also appraised routinely by external organizations including U.S. Department of Energy (DOE) Headquarters and the DOE Oak Ridge Operations Office. The external audits assess compliance with applicable regulations, DOE Orders, and site plans and procedures. All assessment and appraisal reports, deficiencies, and corrective actions are tracked using the Site Wide Assessment Tracking System (SWATS).

10.2.7 Subcontracted Off-Site Laboratories Programs

Subcontracted off-site laboratories that performed analyses used for the preparation of this report use Contract Laboratory Program (CLP) methodologies when applicable. For certain analyses (such as radiochemical and wet chemistry) the laboratories are using EPA 600 (drinking water), EPA 900 (radiochemical analysis of drinking water), or methods that are reviewed and approved by the Project Management Contractor (PMC) prior to analysis of each sample. Each of the subcontracted off-site laboratories has submitted a site-specific *Quality Assurance Project Plan* (QAPjP) to the WSSRAP and controlled copies of their standard operating procedures. The QAPjPs and SOPs are reviewed and approved by the PMC before any samples are shipped to the laboratory. Changes to the standard analytical protocols or methodology are documented in the controlled SOPs. All of the laboratories currently being used by the WSSRAP have had a preliminary assessment of their facilities to make sure that they have the capability to perform work according to the specifications of their contracts. Quality assurance assessments are performed routinely to inspect the laboratory facilities and operations, to ensure that the laboratories are performing analyses as specified in their contracts, and to check that WSSRAP data documentation and records are being properly maintained.

10.3 Applicable Standards

Applicable standards for environmental quality assurance include: (1) use of the appropriate analytical and field measurement methodologies; (2) collection and evaluation of quality control samples; (3) accuracy, precision, and completeness evaluations; and (4) preservation and security of all applicable documents and records pertinent to the environmental monitoring programs.

10.3.1 Analytical and Field Measurement Methodologies

Analytical and field measurement methodologies used at the WSSRAP comply with applicable standards required by the DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring follow the EPA CLP requirements (metal and organic methodologies) and the EPA drinking water and radiochemical methodologies or methods that are reviewed and approved by the PMC prior to analysis of each sample. Field measurement methodologies typically follow the American Public

Health Association *Standard Methodologies for the Examination of Water and Wastewater* (Ref. 47).

10.3.2 Quality Control Samples

Quality control samples for environmental monitoring are collected in accordance with WSSRAP SOPs that specify the frequencies of quality control sample collection. Quality control samples are taken in accordance with guidelines in the EPA CLP (Ref. 29).

Descriptions of the QC samples collected at the WSSRAP are detailed in Table 10-1.

TABLE 10-1 QC Sample Description

TYPE OF QC SAMPLE	DESCRIPTION
Water Blank (WB)	Monitors the purity of distilled water used for field blanks and decontamination of sampling equipment. Water blanks are collected directly from the distilled water reservoir in the WSSRAP laboratory.
Field Blank (FB)	Monitors potential contaminants, such as dust or volatile compounds, that may be introduced at the site of sample collection. Field blanks are collected in the field at the same time of sample collection activities.
Equipment Blank (EB)	Monitors the effectiveness of decontamination procedures used on non-dedicated sampling equipment. Equipment blanks include rinsate and filter blanks.
Trip Blank (TB)	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory. Trip blanks shall be collected in the WSSRAP laboratory with prepurged distilled water.
Field Replicate (FR)	Monitors field conditions that may affect the reproducibility of samples collected from a given location. Field replicates are collected in the field at the sample location.
Blind Duplicate	A duplicate that provides an unbiased measure of laboratory precision. Blind duplicates are additional aliquots of the routine sample taken in the field and given an altered identification code to conceal the samples identity from the laboratory.

TABLE 10-1 QC Sample Description (Continued)

TYPE OF QC SAMPLE	DESCRIPTION
Matrix Spike* (MS)	Assesses matrix and accuracy of laboratory measurements for a given matrix type. The results of this analysis and the routine sample are used to compute the percent recovery for each parameter.
Matrix Duplicate* (DU)	Assesses matrix and precision of laboratory measurements for inorganic parameters in a given matrix type. The results of the matrix duplicate and the routine sample are used to compute the relative percent difference for each parameter.
Matrix Spike Duplicate* (MD)	Assesses matrix and precision of laboratory measurements for organic compounds. The matrix spike duplicate is spiked in the same manner as the matrix spike sample. The results of the matrix spike and matrix spike duplicate are used to determine the relative percent difference for organic parameters.
Secondary Duplicate (SD)	A duplicate that compares the primary laboratory with a secondary laboratory, providing an additional check on the performance of the primary laboratory. The secondary duplicate is an additional aliquot of the routine sample that is sent to a secondary laboratory.

* A laboratory sample is split from large volume samples.

10.3.3 Accuracy, Precision, and Completeness

At a minimum, the WSSRAP Data Validation Group determines the analytical accuracy, precision, and completeness of 10% of the environmental data collected. Data validation is required under DOE Order 5400.1.

10.3.4 Preservation and Security of Documents and Records

Requirements for preservation and security of documents and records are specified in DOE Order 5700.6C. All documents pertinent to environmental monitoring are preserved and secured by the departments that produce them.

10.4 Quality Assurance Sample Results

The quality assurance program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

10.4.1 Duplicate Analyses Results

Two kinds of duplicate analyses were performed in 1996, matrix duplicates and secondary duplicates. The matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring site. A secondary duplicate is an additional aliquot of the original sample split by the WSSRAP and placed into a separate container and sent to a secondary laboratory. Matrix duplicates were used to assess the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interferences of sample matrixes.

Generally, matrix duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one for every 20 samples. Secondary duplicate samples were collected in accordance with Procedure ES&H 4.1.4, which states that secondary duplicates shall be collected on a monthly basis. Typically, duplicate samples were analyzed for more common parameters e.g., uranium, inorganic anions, and metals.

When matrix and secondary duplicate samples were available, the average relative percent difference was calculated. This difference represents an estimate of precision. The equation used (as specified in the *USEPA Contract Laboratory Program, Inorganic Scope of Work*, [Ref. 29]) was:

$$RPD = (S-D)/((S+D)/2) \times 100$$

where S = the normal sample
D = the duplicate analysis

The relative percent difference was calculated only for samples whose analytical results exceeded five times the detection limit.

Table 10-2 summarizes the data of calculated relative percent differences for groundwater (including springs) and surface water (including National Pollutant Discharge Elimination System [NPDES]) samples. Both the matrix duplicates and the secondary duplicates are summarized together. Parameters that were not commonly analyzed for and/or were not contaminants of concern were not evaluated.

The results in Table 10-2 demonstrate that all average relative percent differences calculated were within the 20% criterion as recommended in the CLP (Ref. 29 and 46). As a result duplicate sample analyses in 1996 were of acceptable quality.

TABLE 10-2 Summary of Calculated Relative Percent Differences

PARAMETER	N(a)	AVG. RPD	MIN. RPD	MAX. RPD
Alkalinity	1	0.5	0.5	0.5
Arsenic	3	2.0	0.0	3.0
Barium	12	3.6	0.2	16.1
Calcium	1	1.1	1.1	1.1
Chloride	9	2.1	0.0	4.0
Fluoride	4	4.0	0.0	12.5
Magnesium	1	0.8	0.8	0.8
Manganese	1	1.0	1.0	1.0
Mercury	1	3.7	3.7	3.7
Nitrate-N	13	4.9	0.2	15.4
Strontium	1	0.8	0.8	0.8
Sulfate	16	2.2	0.0	12.1
Total Suspended Solids	4	4.7	1.7	12.2
Gross Alpha	7	11.1	0.9	33.7
Uranium, Total	17	3.5	0.3	16.4

(a) Data population size.

10.4.2 Blank Sample Results Evaluation

Various types of blanks are collected by the WSSRAP to assess the conditions and/or contaminants that may be present during sample collection and transportation. These conditions and contaminants are monitored by collecting samples to ensure routine samples are not being contaminated. Blank samples evaluate the:

- Environmental conditions under which the samples (i.e., volatile analyses) were shipped (trip blanks).
- Ambient conditions in the field that may affect a sample during collection (field/trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).
- Quality of water used to decontaminate sampling equipment and/or assess the ambient conditions (distilled water blanks).
- Presence or absence of contamination potentially introduced through sample preservation and/or sample containers.

Sections 10.3.2.1 through 10.3.2.4 discuss the sample blank analyses and the summary of analytical results that were above the analytical detection limits. Field blank samples for groundwater, surface water, spring and seep water, and NPDES water were evaluated together as a set.

10.4.2.1 Trip Blank Evaluation. Trip blanks are collected to assess the impact of sample collection and shipment on groundwater and surface water samples analyzed for volatile organic compounds. Trip blanks are sent to the laboratory with each shipment of volatile organic samples.

In 1996, 35 trip blanks were analyzed for volatile organic compounds. Low concentrations of acetone and methylene chloride were detected in three blanks. All detections found in these samples were just above the detection limits and did not exceed CLP criterion.

10.4.2.2 Field Blank Evaluation. Field blank samples are collected at monitoring sites just prior to, or immediately after, actual samples are collected. The field blanks are collected to assess the ambient air conditions at the sample locations. They are analyzed for the parameters being sampled which, therefore, are generally the parameters of concern, such as uranium, anions, metals, and nitroaromatics.

In 1996, six field blanks were collected. Table 10-3 presents the ratio of detects to total number of samples collected for each parameter having results above the detection limits.

TABLE 10-3 Summary of Field Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF ANALYSES	EVALUATION AND SUMMARY OF DETECTS
Nitroaromatics	0 out of 6 (0%)	N/A
Chloride	1 out of 4 (25%)	1 of 1 (100%) >5xDL
Fluoride	0 out of 4 (0%)	N/A
Sulfate	0 out of 6 (0%)	N/A
Nitrate-N	2 out of 4 (50%)	1 of 1 (100%) <2xDL 1 of 1 (100%) <3xDL
Uranium, Total	1 out of 6 (17%)	1 of 1 (100%) >5xDL
Arsenic	0 out of 4 (0%)	N/A
Barium	2 out of 4 (50%)	2 of 2 (100%) <3xDL
Beryllium	0 out of 2 (0%)	N/A
Cadmium	1 out of 4 (25%)	1 of 1 (100%) <2xDL
Chromium	0 out of 4 (0%)	N/A
Lead	1 out of 4 (25%)	1 of 1 (100%) <3xDL
Lithium	1 out of 2 (50%)	1 of 1 (100%) <2xDL

TABLE 10-3 Summary of Field Blank Parameter Results (Continued)

PARAMETER	NUMBER OF DETECTS/NUMBER OF ANALYSES	EVALUATION AND SUMMARY OF DETECTS
Mercury	0 out of 4 (0%)	N/A
Selenium	0 out of 4 (0%)	N/A
Strontium	1 out of 2 (50%)	1 of 1 (100%) <5xDL
Thallium	0 out of 2 (0%)	N/A

DL Detection limit; <2x = Less than two times; >5 x = Greater than five times
N/A Not applicable

10.4.2.3 Equipment and Bailer Blank Evaluation. Equipment and bailer blanks are collected by rinsing decontaminated equipment and bailers with distilled water, and collecting the rinse water. This procedure is used to determine the effectiveness of the decontamination process. At the WSSRAP, most of the groundwater samples are collected from dedicated equipment, and surface water is collected by placing the sample directly into a sample container; therefore, no further discussion is presented.

10.4.2.4 Distilled Water Blank Evaluation. Water blank samples are collected to evaluate the quality of the distilled water used to decontaminate sampling equipment and to assess whether contaminants are present in the water used for field and trip blanks. Water blank samples also serve as laboratory blanks. Generally, the water blanks were analyzed for contaminants of concern and were collected at the same time as field blanks.

In 1996, 12 water blanks were collected. Table 10-4 presents the ratio of detects to the total number of samples collected for each parameter that had results above the detection limit.

TABLE 10-4 Summary of Distilled Water Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF ANALYSES	EVALUATION AND SUMMARY OF DETECTS
Nitroaromatics	0 out of 11 (0%)	N/A
PCB's	0 out of 4 (0%)	N/A
Chloride	0 out of 7 (0%)	N/A
Fluoride	0 out of 7 (0%)	N/A
Nitrate-N	3 out of 7 (43%)	3 of 3 (100%) >5xDL
Sulfate	0 out of 10 (0%)	N/A
Uranium, Total	2 out of 11 (18%)	1 of 1 (100%) <2xDL 1 of 1 (100%) <4xDL
Arsenic	0 out of 10 (0%)	N/A
Barium	1 out of 10 (10%)	1 of 1 (100%) <5xDL
Beryllium	0 out of 5 (0%)	N/A
Cadmium	0 out of 8 (0%)	N/A
Chromium	0 out of 8 (100%)	N/A
Lead	1 out of 8 (13%)	1 of 1 (100%) <2xDL
Lithium	0 out of 4 (0%)	N/A
Mercury	0 out of 8 (0%)	N/A
PAH's	0 out of 4 (0%)	N/A
Selenium	0 out of 8 (0%)	N/A
Strontium	1 out of 3 (33%)	1 of 1 (100%) <4xDL
Thallium	0 out of 5 (0%)	N/A
Volatiles	0 out of 3 (0%)	N/A

DL Detection limit; <2x = Less than two times; >5x = Greater than five times.
N/A Not applicable.

10.5 1996 Data Validation Program Summary

Data validation programs at the WSSRAP involve reviewing and qualifying at least 10% of the data collected during a calendar year. The data points represent the number of parameters analyzed (e.g., toluene), not the number of physical analyses performed (e.g., volatile organics analyses).

Table 10-5 identifies the number of quarterly and total data points that were selected for data validation, and indicates the percentage of those selected that were complete. Data points presented in this table include all sample types.

Table 10-6 identifies validation qualifiers assigned to the selected data points as a result of data validation. The WSSRAP validation technical review was performed in accordance with the *U.S. EPA Contract Laboratory Program Data Statement of Work for Inorganics Analysis* (Ref. 62), the *U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis* (Ref. 63), and the *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analysis* (Ref. 64). To date, 100.0% of data validation has been completed. Data points presented in this table include groundwater, surface water, spring and seep water, and NPDES samples only.

Table 10-7 identifies the average accuracy and precision for all sample types including environmental and waste management samples for anion, metals, nitroaromatic, radiochemical, and miscellaneous parameters. The accuracy values are based on the percent recoveries of the laboratory control samples, and the precision values are based on the relative percent difference between duplicates. The data population size associated with each accuracy and precision value is listed as "N." Data points presented in this table include groundwater, surface water, spring and seep, and NPDES samples only.

TABLE 10-5 WSSRAP Validation Summary for Calendar Year 1996

CALENDAR QUARTER	NO. OF DATA POINTS COLLECTED	NO. OF DATA POINTS SELECTED FOR VALIDATION	PERCENT SELECTED	NO. OF DATA POINTS VALIDATED	PERCENT VALIDATED
Quarter 1	8288	879	10.6%	879	100.0%
Quarter 2	12615	1710	13.6%	1710	100.0%
Quarter 3	24098	2484	10.3%	2484	100.0%
Quarter 4	23504	2439	10.4%	2439	100.0%
1996 Total	68505	7512	11.0%	7512	100.0%

TABLE 10-6 Annual Data Validation Qualifier Summary for Calendar Year 1996

NO. OF DATA POINTS								
	ANIONS	METALS	MISCELLANEOUS	NITROAROMATICS	RADIOCHEMICAL	SEMI-VOA	VOA	TOTAL
Accepted	50	301	14	10	75	48	248	746
Rejected	2	3	4	1	1	0	8	19
On Hold	0	0	0	0	0	0	0	0
Not Validatable	0	0	0	0	0	0	0	0
Pending	0	0	0	0	0	0	0	0
Total	52	304	18	11	76	48	256	765
PERCENTAGES								
Accepted	96.2%	99.0%	77.8%	90.9%	98.7%	100.0%	96.9%	97.5%
Rejected	3.8%	1.0%	22.2%	9.1%	1.3%	0.0%	3.1%	2.5%
On Hold	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Not Validatable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pending	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1996

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
IONS							
Bromide	2	99.0	99.0	99.0	2.8	2.8	2.8
Chloride	8	101.7	97.0	107.0	4.1	0.0	7.9
Fluoride	6	92.0	79.1	101.9	1.7	0.0	3.1
Nitrate-N	17	102.1	98.0	105.6	5.9	0.0	12.6
Sulfate	19	95.8	86.0	102.2	7.4	0.0	16.0
METALS							
Aluminum (Al)	11	108.0	102.4	119.8	1.7	0.0	6.8
Antimony (Sb)	13	100.2	91.2	106.3	1.6	0.3	3.6
Arsenic (As)	13	101.4	88.9	112.1	1.0	0.1	2.5
Barium (Ba)	12	100.5	95.7	103.6	1.0	0.5	1.6
Beryllium (Be)	9	106.5	98.6	113.5	1.7	0.1	2.7
Cadmium (Cd)	11	103.6	96.2	107.3	1.1	0.1	2.9
Calcium (Ca)	7	103.1	95.5	110.1	1.6	1.3	2.4
Chromium (Cr)	21	103.0	97.2	107.8	0.8	0.1	1.9
Cobalt (Co)	9	99.8	93.6	103.2	1.3	0.3	1.8
Copper (Cu)	16	102.3	96.5	106.2	1.6	0.2	2.6
Iron (Fe)	15	100.7	85.0	108.4	4.2	0.5	8.9
Lead (Pb)	15	101.6	93.5	109.9	1.7	0.0	12.9
Lithium (Li)	10	103.8	97.6	110.4	0.5	0.2	1.2
Magnesium (Mg)	7	105.1	94.2	117.6	0.9	0.3	1.2
Manganese (Mn)	19	98.8	94.2	103.8	1.5	0.2	3.5
Mercury (Hg)	11	98.9	91.9	103.7	2.5	0.0	10.6
Molybdenum (Mo)	12	97.7	88.6	102.0	1.0	0.2	2.1
Nickel (Ni)	9	102.6	95.4	105.2	1.2	0.5	2.4
Potassium (K)	7	104.6	98.3	108.7	1.3	0.4	2.6
METALS (Continued)							

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1996 (Continued)

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
Selenium (Se)	13	104.5	97.1	120.3	2.9	0.6	8.6
Silver (Ag)	13	96.7	74.9	108.7	3.9	0.2	14.1
Sodium (Na)	7	102.6	99.4	108.1	0.9	0.3	1.8
Strontium (Sr)	2	99.2	99.2	99.2	1.2	1.2	1.2
Thallium (Tl)	16	99.7	93.2	115.8	3.7	0.1	14.2
Vanadium (V)	9	98.5	92.0	102.5	1.1	0.7	1.7
Zinc (Zn)	17	101.8	91.2	109.1	1.9	1.2	5.7
MISC.							
Alkalinity	2	92.0	92.0	92.0	0.0	0.0	0.0
COD	2	80.0	80.0	80.0	0.0	0.0	0.0
Phosphorus, Total	2	89.0	89.0	89.0	1.0	1.0	1.0
Silica, Dissolved	2	106.0	106.0	106.0	1.0	1.0	1.0
Total Dissolved Solids (TDS)	2	94.0	94.0	94.0	0.0	0.0	0.0
Total Organic Carbon (TOC)	2	102.0	102.0	102.0	1.0	1.0	1.0
Total Suspended Solids (TSS)	6	97.4	92.0	100.1	0.0	0.0	0.0
NITROAROMATICS							
1,3,5-Trinitrobenzene	3	107.3	92.0	119.0	0.9	0.0	2.7
2,4,6-TNT	2	91.5	91.0	92.0	0.0	0.0	0.0
2,6-DNT	1	104.0	104.0	104.0	0.0	0.0	0.0
2-Amino-4,6-DNT	3	99.3	98.0	102.0	0.0	0.0	0.0
4-Amino-2,6-DNT	2	71.0	71.0	71.0	0.0	0.0	0.0

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1996 (Continued)

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
RADIOCHEMICAL							
Gross Alpha	8	100.1	70.0	104.4	2.2	1.8	2.3
Gross Beta	1	96.3	96.3	96.3	1.2	1.2	1.2
Radium-226	11	116.4	94.9	118.5	15.2	14.2	24.8
Radium-228	12	92.5	90.1	96.8	1.2	0.7	5.6
Radon-222	1	93.8	93.8	93.8	3.4	3.4	3.4
Thorium-228	1	110.0	110.0	110.0	3.9	3.9	3.9
Thorium-230	11	105.1	104.0	105.2	15.4	12.7	15.7
Thorium-232	1	109.0	109.0	109.0	0.7	0.7	0.7
Uranium, Total	30	97.9	92.0	104.1	2.1	0.0	13.9
SEMI-VOLATILES							
Acenaphthene	3	70.0	70.0	70.0	NC	NC	NC
Acenaphthylene	3	77.0	77.0	77.0	NC	NC	NC
Anthracene	3	95.0	95.0	95.0	NC	NC	NC
Benzo(a)anthracene	3	96.0	96.0	96.0	NC	NC	NC
Benzo(a)pyrene	3	85.0	85.0	85.0	NC	NC	NC
Benzo(b)fluoranthene	3	91.0	91.0	91.0	NC	NC	NC
Benzo(g,h,i)perylene	3	39.0	39.0	39.0	NC	NC	NC
Benzo(k)fluoranthene	3	79.0	79.0	79.0	NC	NC	NC
Chrysene	3	95.0	95.0	95.0	NC	NC	NC
Dibenzo(a,h)anthracene	3	34.0	34.0	34.0	NC	NC	NC
Fluoranthene	3	96.0	96.0	96.0	NC	NC	NC
Fluorene	3	79.0	79.0	79.0	NC	NC	NC
Indeno(1,2,3-cd)pyrene	3	60.0	60.0	60.0	NC	NC	NC
Naphthalene	3	69.0	69.0	69.0	NC	NC	NC

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1996 (Continued)

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
SEMI-VOLATILES (Continued)							
Phenanthrene	3	87.0	87.0	87.0	NC	NC	NC
Pyrene	3	96.0	96.0	96.0	NC	NC	NC
VOLATILES							
1,1,1-Trichloroethane	8	83.0	83.0	83.0	NC	NC	NC
1,1,2-Trichloroethane	8	89.0	89.0	89.0	NC	NC	NC
1,1-Dichloroethane	8	82.0	82.0	82.0	NC	NC	NC
1,1-Dichloroethene	8	83.0	83.0	83.0	NC	NC	NC
1,2-Dichloroethane	8	87.0	87.0	87.0	NC	NC	NC
1,2-Dichloroethene (total)	8	66.0	66.0	66.0	NC	NC	NC
1,2-Dichloropropane	8	87.0	87.0	87.0	NC	NC	NC
2-Butanone	8	92.0	92.0	92.0	NC	NC	NC
2-Hexanone	8	89.0	89.0	89.0	NC	NC	NC
4-Methyl-2-Pentanone	8	98.0	98.0	98.0	NC	NC	NC
Acetone	8	95.0	95.0	95.0	NC	NC	NC
Benzene	8	88.0	88.0	88.0	NC	NC	NC
Bromodichloromethane	8	79.0	79.0	79.0	NC	NC	NC
Bromoform	8	73.0	73.0	73.0	NC	NC	NC
Bromomethane	8	88.0	88.0	88.0	NC	NC	NC
Carbon Disulfide	8	69.0	69.0	69.0	NC	NC	NC
Carbon Tetrachloride	8	78.0	78.0	78.0	NC	NC	NC
Chlorobenzene	8	89.0	89.0	89.0	NC	NC	NC
Chloroethane	8	74.0	74.0	74.0	NC	NC	NC
Chloroform	8	75.0	75.0	75.0	NC	NC	NC
Chloromethane	8	86.0	86.0	86.0	NC	NC	NC

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1996 (Continued)

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
VOLATILES (Continued)							
cis-1,3-Dichloropropene	8	82.0	82.0	82.0	NC	NC	NC
Dibromochloromethane	8	79.0	79.0	79.0	NC	NC	NC
Ethyl Benzene	8	80.0	80.0	80.0	NC	NC	NC
Methylene Chloride	8	87.0	87.0	87.0	NC	NC	NC
Styrene	8	86.0	86.0	86.0	NC	NC	NC
Tetrachloroethene	8	86.0	86.0	86.0	NC	NC	NC
Toluene	8	91.0	91.0	91.0	NC	NC	NC
trans-1,3-Dichloropropene	8	79.0	79.0	79.0	NC	NC	NC
Trichloroethane	8	83.0	83.0	83.0	NC	NC	NC
Vinyl Chloride	8	79.0	79.0	79.0	NC	NC	NC
Xylenes, Total	8	91.0	91.0	91.0	NC	NC	NC

NC No calculation

10.6 Interlaboratory Comparison Program Results

This section summarizes the interlaboratory comparison program data received from the subcontracted laboratories. Data presented in this section are from three programs: (1) the DOE quality assessment program, (2) the EPA intercomparison radionuclide control program and (3) the EPA organic and inorganic performance evaluation studies.

The interlaboratory comparison programs are intended to allow participating laboratories to analyze spiked control samples to verify and evaluate how their standard operating procedures (SOPs) and quality assurance and quality control (QA/QC) programs are performing. Interlaboratory comparison program results presented in this section do not impact any of the analytical data used to prepare this report, but are discussed here to provide information about laboratories' capabilities to perform accurate analyses of spiked control samples.

Results of the DOE environmental measurement laboratory quality assessment program are presented in Table 10-8. This table provides information on the parameter, matrix type, laboratory name, DOE value, reported value, percent recovery, and performance criteria evaluation.

TABLE 10-8 Summary of DOE Interlaboratory Comparison Program

PARAMETER (matrix)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION [a]
Gross alpha (air)	Barringer	1.620	1.970	122%	A
Gross beta (air)	Barringer	1.770	1.700	96%	A
Uranium, 234 (air)	Barringer	0.052	0.074	143%	W
Uranium, 238 (air)	Barringer	0.053	0.073	137%	A
Uranium, total (air)	Barringer	4.310	6.080	141%	W
Uranium, 234 (soil)	Barringer	34.200	48.500	142%	N
Uranium, 238 (soil)	Barringer	35.900	47.300	132%	W
Uranium, total (soil)	Barringer	2.900	3.970	137%	W
Gross alpha (water)	Barringer	1850.000	1810.000	98%	A
Gross beta (water)	Barringer	744.000	530.000	71%	N
Uranium, 234 (water)	Barringer	0.274	0.290	106%	A
Uranium, 238 (water)	Barringer	0.276	0.276	100%	A
Uranium, total (water)	Barringer	0.022	0.023	104%	A
Gross alpha (air)	ESE	1.620	1.660	103%	A
Gross beta (air)	ESE	1.770	1.260	71%	N
Uranium, 234 (air)	ESE	0.052	0.061	118%	A
Uranium, 238 (air)	ESE	0.053	0.062	116%	A
Uranium, total (air)	ESE	4.310	4.990	116%	A
Uranium, 234 (soil)	ESE	34.200	31.300	92%	A
Uranium, 238 (soil)	ESE	35.900	31.700	88%	A
Uranium, total (soil)	ESE	2.900	3.040	105%	A
Uranium, 234 (water)	ESE	0.274	0.286	104%	A

TABLE 10-8 Summary of DOE Interlaboratory Comparison Program (Continued)

PARAMETER (matrix)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION [a]
Uranium, 238 (water)	ESE	0.275	0.290	105%	A
Uranium, total (water)	ESE	0.022	0.023	105%	A
Gross alpha (air)	General	1.620	1.750	108%	A
Gross beta (air)	General	1.770	1.640	93%	A
Uranium, 234 (air)	General	0.052	0.067	130%	A
Uranium, 238 (air)	General	0.053	0.055	103%	A
Uranium, total (air)	General	4.310	4.360	101%	A
Uranium, 234 (soil)	General	34.200	35.200	103%	A
Uranium, 238 (soil)	General	35.900	33.200	93%	A
Uranium, total (soil)	General	2.900	2.650	91%	A
Gross alpha (water)	General	1850.000	1700.000	92%	A
Gross beta (water)	General	744.000	733.000	99%	A
Uranium, 234 (water)	General	0.274	0.335	122%	W
Uranium, 238 (water)	General	0.275	0.316	115%	W
Uranium, 234 (air)	IEA	0.052	0.056	108%	A
Uranium, 238 (air)	IEA	0.053	0.054	101%	A
Uranium, total (air)	IEA	4.310	4.400	102%	A
Uranium, 234 (soil)	IEA	34.200	35.200	103%	A
Uranium, 238 (soil)	IEA	35.900	34.800	97%	A
Uranium, total (soil)	IEA	2.900	2.820	97%	A
Gross alpha (water)	IEA	1850.000	1970.000	107%	A
Gross beta (water)	IEA	744.000	541.000	73%	N
Uranium, 234 (water)	IEA	0.274	0.292	107%	A
Uranium, 238 (water)	IEA	0.275	0.277	101%	A
Gross alpha (air)	Lockheed	1.620	1.990	123%	A
Gross beta (air)	Lockheed	1.770	1.740	98%	A
Uranium, 234 (air)	Lockheed	0.052	0.095	184%	W

TABLE 10-8 Summary of DOE Interlaboratory Comparison Program (Continued)

PARAMETER (matrix)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION [a]
Uranium, 238 (air)	Lockheed	0.053	0.086	161%	W
Uranium, 234 (soil)	Lockheed	34.200	33.800	99%	A
Uranium, 238 (soil)	Lockheed	35.900	32.000	89%	A
Gross alpha (water)	Lockheed	1850.000	1980.000	107%	A
Gross beta (water)	Lockheed	744.000	539.000	72%	N
Uranium, 234 (water)	Lockheed	0.274	0.320	117%	A
Uranium, 238 (water)	Lockheed	0.275	0.290	105%	A
Gross alpha (air)	Quanterra	1.620	2.490	154%	W
Gross beta (air)	Quanterra	1.770	1.580	89%	A
Uranium, 234 (soil)	Quanterra	34.200	33.100	97%	A
Uranium, 238 (soil)	Quanterra	35.900	38.700	108%	A
Uranium, total (soil)	Quanterra	2.900	3.140	108%	A
Gross alpha (water)	Quanterra	1850.000	1800.000	97%	A
Gross beta (water)	Quanterra	744.000	466.000	63%	N
Gross alpha (air)	TMA/Eberline	1.620	2.090	129%	A
Gross beta (air)	TMA/Eberline	1.770	1.560	88%	W
Uranium, 234 (air)	TMA/Eberline	0.052	0.049	95%	A
Uranium, 238 (air)	TMA/Eberline	0.053	0.048	91%	A
Uranium, total (air)	TMA/Eberline	4.310	3.980	92%	A
Uranium, 234 (soil)	TMA/Eberline	34.200	38.700	113%	W
Uranium, 238 (soil)	TMA/Eberline	35.900	38.300	107%	A
Uranium, total (soil)	TMA/Eberline	2.900	3.160	109%	A
Gross alpha (water)	TMA/Eberline	1850.000	1870.000	101%	A
Gross beta (water)	TMA/Eberline	744.000	903.000	121%	A
Uranium, 234 (water)	TMA/Eberline	0.274	0.257	94%	A
Uranium, 238 (water)	TMA/Eberline	0.275	0.262	95%	A

TABLE 10-8 Summary of DOE Interlaboratory Comparison Program (Continued)

PARAMETER (matrix)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION [a]
Uranium, total (water)	TMA/Eberline	0.022	0.021	95%	A

Units for matrices: Air = Bq/filter, Soil = Bq/kg, Water = Bq/l
(a) A = Acceptable, W = Acceptable with warning, N = Not acceptable

Results of the EPA intercomparison radionuclide control program and the EPA organic/inorganic performance evaluation program are not presented in this section. However, this information is evaluated during routine assessments of each laboratory.

11 SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project that support and assist in the implementation of environmental protection policies. In addition, short term environmental studies are described that support regulatory requirements not specifically covered by U.S. Department of Energy (DOE) Order 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 42).

11.1 Off-Site Migration of Uranium in Storm Water

In an effort to determine whether site activities have caused an increase in the off-site migration of uranium in storm water at the three major National Pollutant Discharge Elimination System (NPDES) outfalls (NP-0002, NP-0003, NP-0005), the data for the years 1987 through 1994 were reviewed and corrected for several factors, as required to normalize the data. The corrections were for precipitation, watershed areas, and runoff coefficients and are outlined in the *Weldon Spring Site Environmental Report for Calendar Year 1994* (Ref. 66).

These data have been updated with the inclusion of 1995 and 1996 data. The 1995 and 1996 data did not require correction. The annual mass, annual precipitation, and mass per inch of precipitation are tabulated in Table 11-1. The annual precipitation and total annual mass discharged off site through 1996 are plotted in Figure 11-1, Figure 11-2 and Figure 11-3. The mass per year versus annual precipitation is plotted for all three outfalls shown in Figure 11-4.

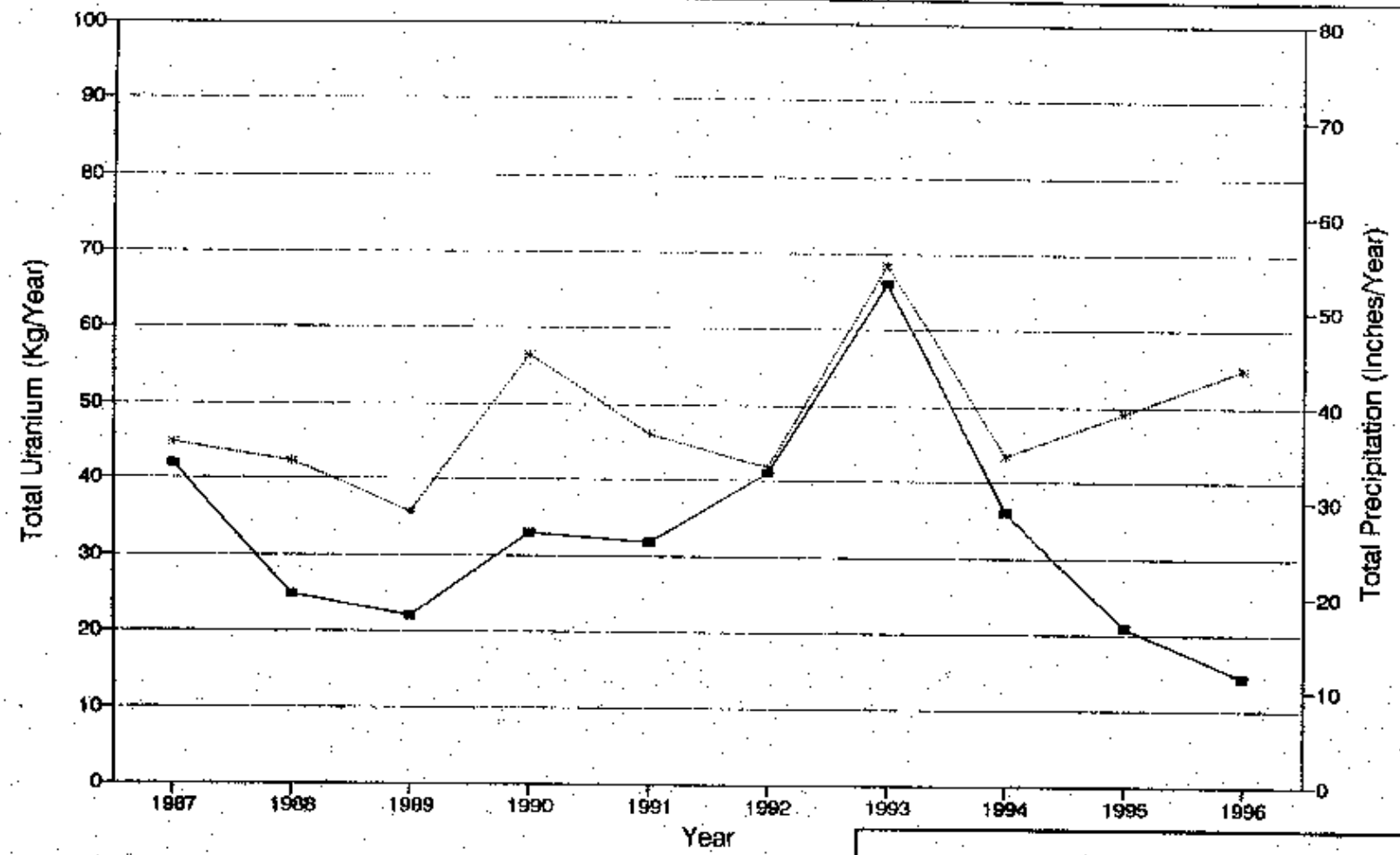
Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of Frog Pond and receives runoff from the eastern section of the chemical plant. Figure 11-1 indicates that uranium migrating off site initially decreased or increased in relative proportion to annual precipitation before remediation started. Building dismantlement occurred in 1992, which appears to have increased the mass of uranium migrating off site, although precipitation was less than the previous year. With the completion of building dismantlement, the positive correlation of uranium versus precipitation resumed until 1995 when precipitation increased and uranium decreased. This trend continued into 1996.

TABLE 11-1 Mass of Uranium Discharged from NPDES Storm Water Outfalls

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
(PPT) (inches)	35.8	33.9	28.5	45.1	38.9	33.4	54.7	34.7	39.3	43.9
NP-0002 (kg)	42	25	22	33	32	41	66	36	20.6	14.3
Mass/Inch of PPT (kg/in)	1.17	0.74	0.77	0.73	0.87	1.23	1.21	1.03	0.52	0.33
NP-0003 (kg)	362	176	35	17.7	73	75	163	48	12.6	19.1
Mass/Inch of PPT (kg/in)	10.11	5.19	1.23	0.39	1.98	2.25	2.98	1.41	0.32	0.44
NP-0005 (kg)	38	26	15	25	27	16	31	12	5.0	4.0
Mass/Inch of PPT (kg/in)	1.06	0.77	0.53	0.55	0.73	0.48	0.57	0.34	0.13	0.09
Total Mass Kg[a]	442	227	72	75.7	132	132	260	97	38.2	37.4

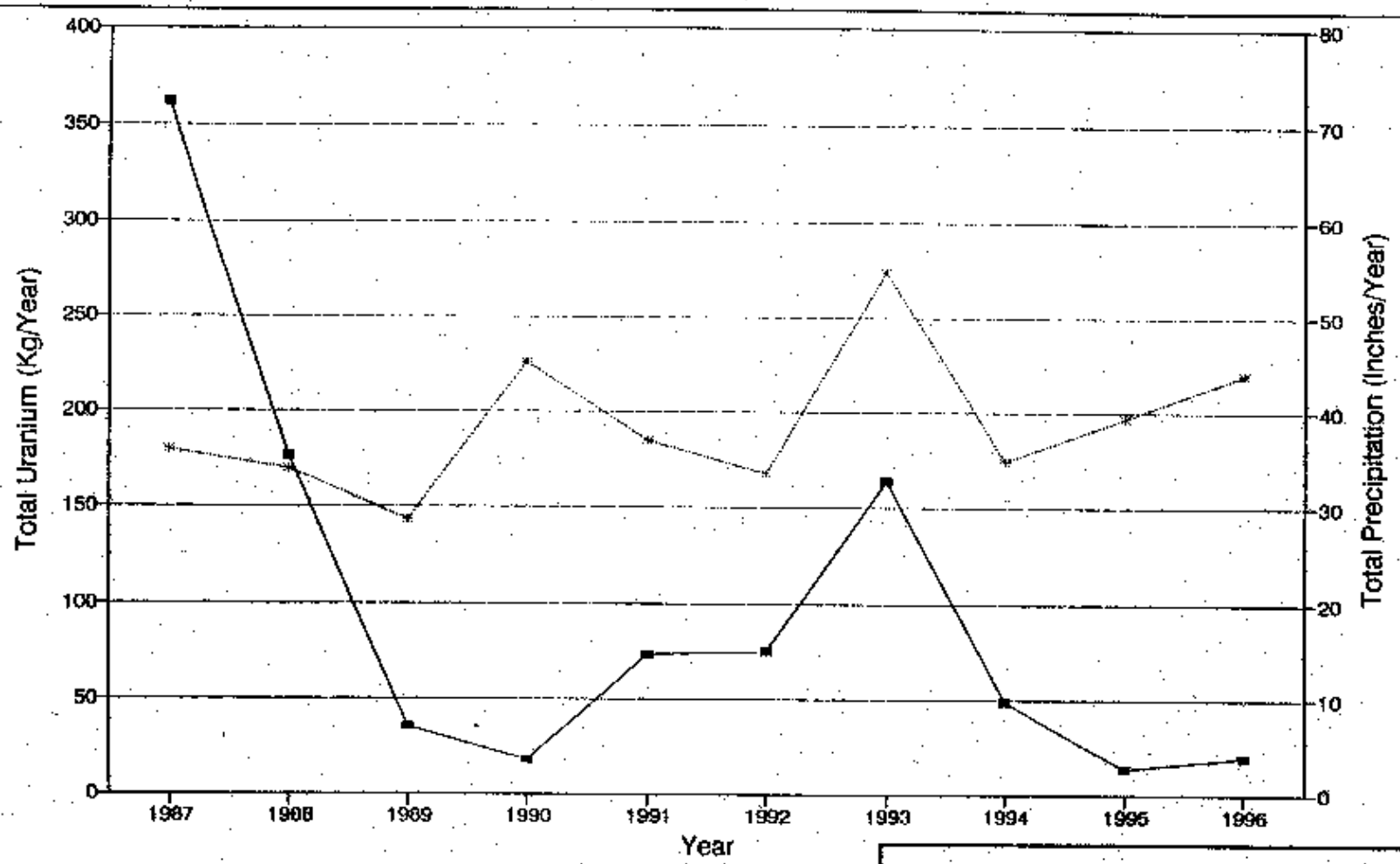
PPT Precipitation
(a) Includes Outfalls NP-0002, NP-0003 and NP-0005. Other outfalls are negligible.



TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0002

FIGURE 11-1

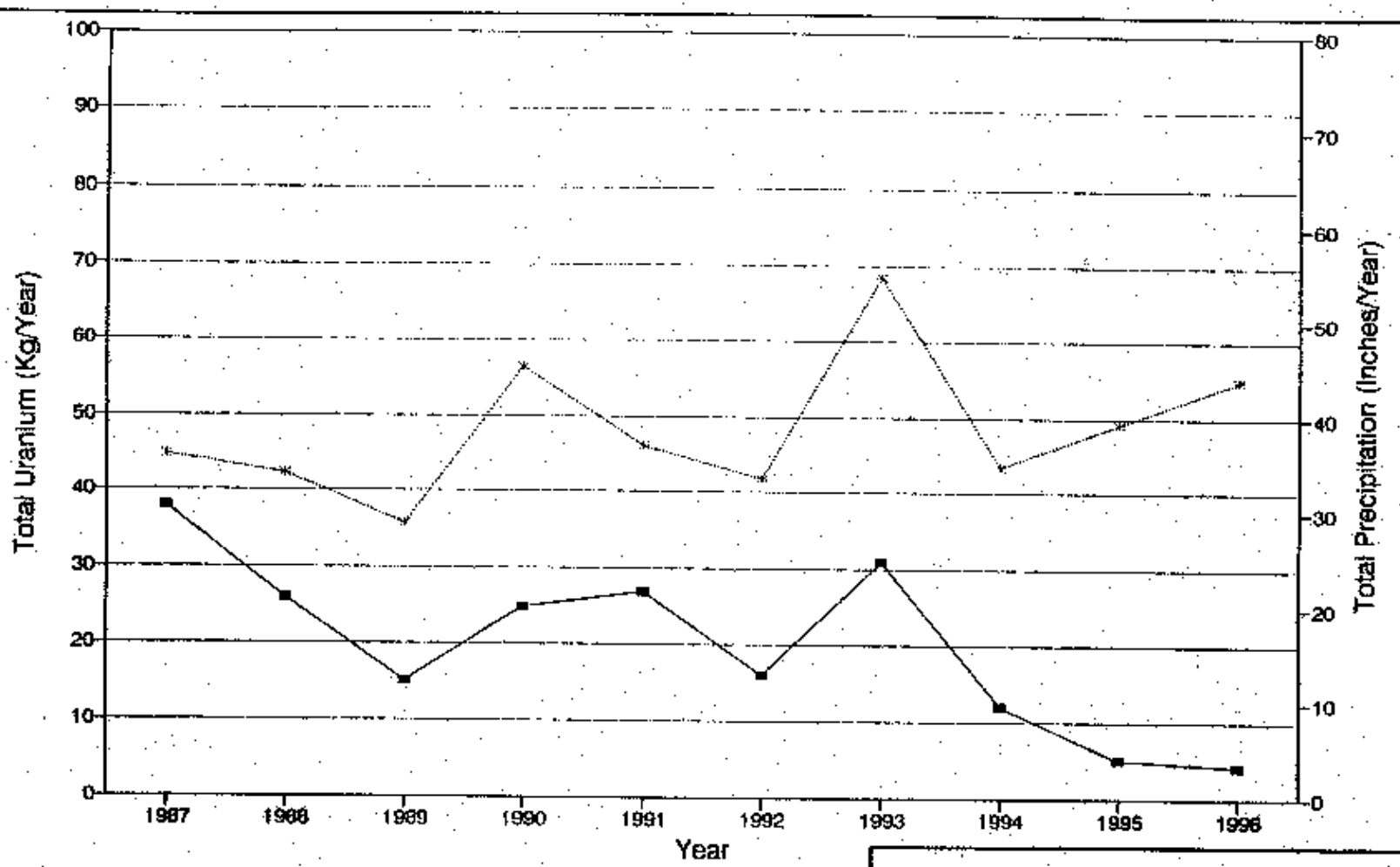
REPORT NO.:	DOE/OR/21548-876	EXHIBIT NO.:	A/PI/016/0497		
ORIGINATOR:	ED	DRAWN BY:	GLN	DATE:	4/17/97



TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0003

FIGURE 11-2

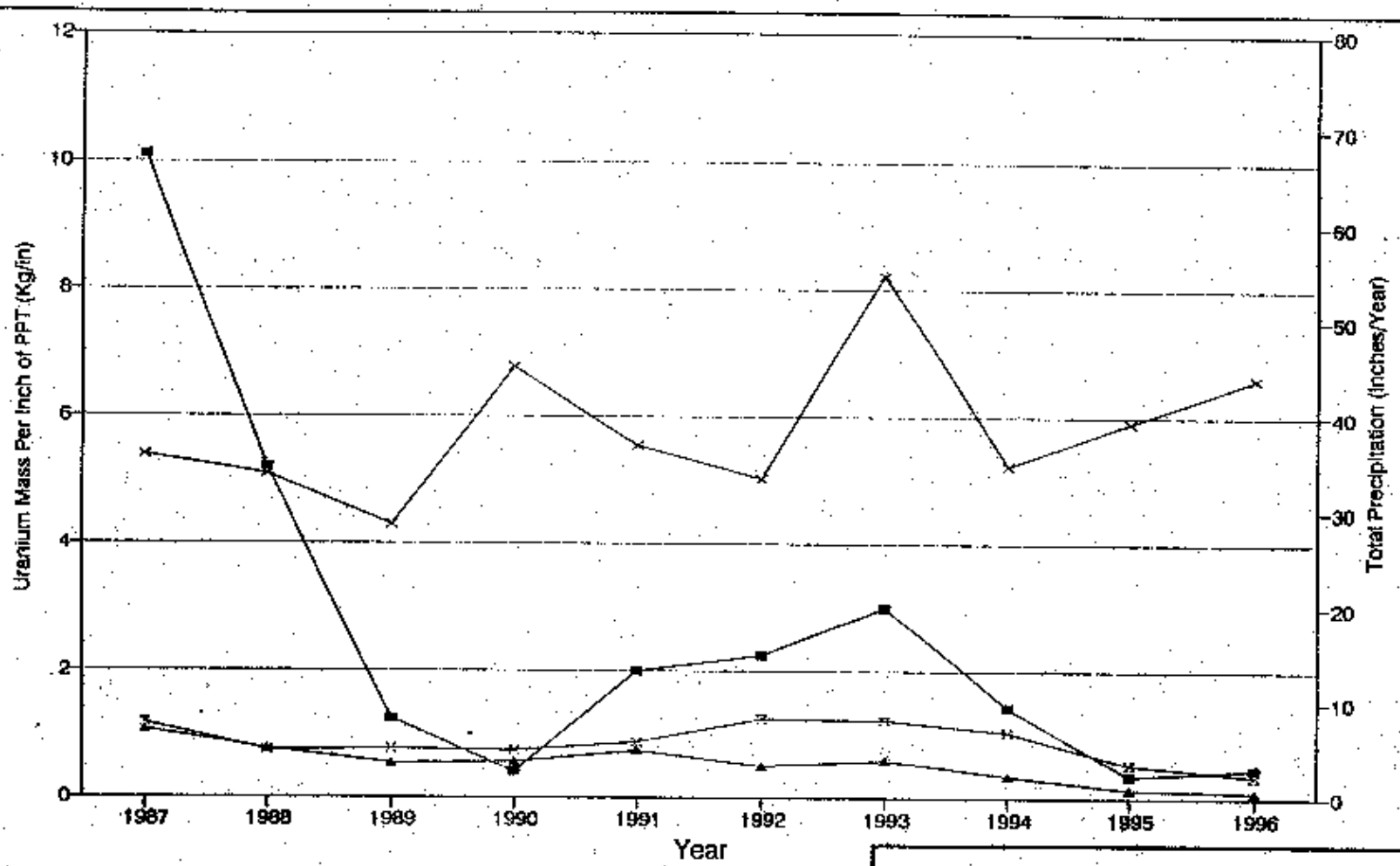
REPORT NO.: DOE/OR/21548-876		EXHIBIT NO.: A/PI/017/0497	
ORIGINATOR: ED	DRAWN BY: GLN	DATE: 4/17/97	



TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0005

FIGURE 11-3

REPORT NO.: DOE/OR/21548-676		EXHIBIT NO.: A/P1/018/0497	
ORIGINATOR: ED	DRAWN BY: GLN	DATE: 4/17/97	



KILOGRAMS OF URANIUM DISCHARGED PER INCH OF PRECIPITATION

FIGURE 11-4

REPORT NO.: DOE/OR/21548-676		DOBBY NO.: A/PI/019/0497	
ORIGINATOR: ED	DRAWN BY: GLN	DATE: 4/17/97	

Mass reduction in 1995 was presumed to be due to precipitation patterns, since the reductions were similar at all three outfalls, although activities in the three watersheds differed. The reduction in 1996 is believed to be due to the settling of contaminated soil from the discharged water at the sedimentation basin and the removal of contaminated soil and building foundations. The downward trend is expected to continue.

Storm Water Outfall NP-0003

Figure 11-2 indicates that uranium migrating off site sharply decreased from 1987 to 1989 at Outfall NP-0003. The reduction for 1988 is assumed to be due to precipitation patterns since there was no other activity in the watershed. The reduction in 1989 was due to construction of the Ash Pond diversion channel, which began in November of 1988 and was completed in April of 1989, along with lower precipitation in 1989. Prior to construction of the diversion channel, most of the water in the watershed flowed through Ash Pond, which is a highly contaminated area. Following construction of the diversion channel, the only water that flowed from Ash Pond was precipitation that fell directly on the pond area.

Construction of the diversion channel made the annual uranium mass at Outfall NP-0003 highly dependent on the flow from Ash Pond. During the summer, and other dry periods, there may be little or no flow from the pond. As a result, the diversion channel flow (from much less contaminated area of the site) made up the bulk of the flow. This caused lower uranium levels at the outfall.

During winter, when the Ash Pond soils have become saturated and precipitation amounts generally have been higher, flow from Ash Pond increased and concentrations at the outfall trended higher. The mass in 1990 was again reduced over the previous year, although precipitation was much higher. This may have been a result of precipitation patterns and/or the times the samples were taken (i.e., no flow from Ash Pond). During 1991 and 1992, precipitation was less than in 1990, but uranium mass was higher. Again, this presumably was due to precipitation patterns and the time of sample collection.

Uranium mass increased greatly in 1993 because precipitation increased dramatically and Ash Pond was discharged throughout the year. Mass decreased in 1994 with the decrease in precipitation and a soil cover placed over the South Dump area during the middle of the year.

Mass was again reduced in 1995 with an increase in precipitation. This was likely the result of precipitation patterns (because reductions were similar at all three outfalls) and the construction during 1995 of a sedimentation basin immediately upstream of Outfall NP-0003. Mass increased slightly in 1996 due to increased precipitation and the storage of contaminated soil and debris in Ash Pond. With the storage of soil and debris in Ash Pond, the water is managed and is not discharged to the sedimentation basin unless it is less than the 600 pCi/l (22.2 Bq/l) Derived Concentration Guideline (DCG). With the storage of contaminated materials in Ash Pond, the mass of uranium at Outfall NP-0003 is expected to be highly dependant on precipitation and water discharged from Ash Pond.

Storm Water Outfall NP-0005

Figure 11-3 indicates that the mass of uranium migrating off site has been generally proportional with annual precipitation. The construction of the site water treatment plant beginning in 1992, with much earth disturbance for construction of the effluent and equalization basins, appears to have had little if any effect on the outfall. A siltation basin was constructed to settle sediments from the water flowing off the treatment plant area. The storm water from the site water treatment plant sedimentation basin is generally less than 10 pCi/l (0.07 Bq/l) for uranium. The other major source for the outfall (until it was remediated in 1996) was a watershed that drained the highly contaminated Building 301 area. This area was partially capped during 1994 to decrease the concentration of uranium in storm water leaving the area.

The concentration of uranium in storm water from individual sampling events was highly dependent on precipitation rates, periods between precipitation, and the ratio of flow from the sedimentation basin and the Building 301 area. The mass of uranium migrating off site was reduced in 1995 and again in 1996. The reduction in 1995 is likely the result of precipitation patterns, because all three outfalls had similar reductions. The watershed for NP-0005 was remediated during 1996. This resulted in another reduction in uranium mass leaving the site in 1996. Uranium mass is expected to continue to decline and then stabilize at close to background levels.

Mass of Uranium Per Inch of Precipitation

Figure 11-4 and Table 11-1 indicate that mass of uranium migrating from the site per inch of precipitation has relatively flat trend lines for the three major outfalls. This indicates that, all other factors remaining constant, the mass of uranium migrating off site is dependent upon annual precipitation and the contamination level in the watershed. Outfalls NP-0002 and NP-0005 show similar levels, with NP-0003 showing relatively higher levels. This is to be expected because the Outfall NP-0003 watershed contains Ash Pond, which is a highly contaminated area. Variations may be due to precipitation patterns, soil disturbance, or remediation. The mass per inch of precipitation is expected to trend downward with the completion of remediation in the watersheds of the major outfalls.

Annual Migration of Uranium Mass from the WSSRAP

The mass of uranium that migrated off site in 1987, before any remedial actions were taken, was 442 kg (972 lb). During 1996, 37.4 kg of uranium migrated off site, a 91.5% reduction from the 1987 mass. Table 11-1 shows the mass of uranium that migrated off site during the intervening years. Mass has fluctuated from year to year with precipitation levels, remedial actions, land disturbance, and finally, foundation and contaminated soil removal. The masses during 1995 and 1996 were at similar levels of 38.2 kg (84 lb) and 37.4 kg (82 lb). Because contaminated soil removal has been completed for major sections of the site, levels for 1997 are expected to be similar to or lower than 1995 and 1996 levels, regardless of precipitation. Outfall NP-0003 mass may not follow this trend because the contaminated soil removed from other areas of the site is stored in Ash Pond, which is in the NP-0003 watershed. Ash Pond is managed to prevent water greater than 600 pCi/l (22.2 Bq/l) from discharging from Ash Pond; therefore, effluent at Outfall NP-0003 will not exceed 600 pCi/l (22.2 Bq/l). Additional efforts will be made to keep uranium migrating from Outfall NP-0003 as low as reasonably achievable.

11.2 Baseline Monitoring at NPDES Outfalls NP-0002, NP-0003, and NP-0005

The NPDES storm water Outfalls NP-0002, NP-0003, and NP-0005 were sampled once a month for Ra-226, Ra-228, Th-228, Th-230, Th-232, 2,4-DNT, 2,4,6-TNT, hazardous substance list (HSL) metals, polychlorinated biphenyls (PCBs), and polycyclic (or polynuclear)

aromatic hydrocarbons (PAHs) starting in September 1994 and continuing through February 1995. These parameters were analyzed to establish baseline concentrations before removal of contaminated building foundations. The averages for the 6 months of baseline monitoring are shown in Tables 11-2 and 11-3. Radium and thorium were detected either at very low activities or were not detected. The chemical parameters were also present at low levels. The baseline concentrations were calculated by using the averages in Tables 11-2 and 11-3 and adding two standard deviations. The baseline concentrations will be used for comparison to results from future sampling.

TABLE 11-2 Average Radiological Concentrations (pCi/l) for Storm Water Outfalls NP-0002, NP-0003, NP-0005 Baseline Monitoring for September 1994 to February 1995

LOCATION	Ra-226	Ra-228	Th-228	Th-230	Th-232
NP-0002	0.45	0.88	0.53	0.34	0.35
NP-0003	0.40	0.63	0.37	0.39	0.35
NP-0005	0.48	0.94	0.31	0.29	0.26

Note: 1 pCi/l = 0.037 Bq/l

TABLE 11-3 Average Chemical Concentrations (μg/l) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995

LOCATION PARAMETER	NP-0002	NP-0003	NP-0005
2,4-DNT	<0.20[a]	<0.20[a]	<0.20[a]
2,4,6-TNT	<0.26[a]	<0.26[b]	<0.26[a]
Al	1,840*	1,302*	3,892*
Sb	<11.67[a]	<11.67[a]	<11.67[a]
As	3.07	3.75	2.37
Ba	80.97	82.13	90.85
Be	0.48	0.37	0.37
Cd	1.42	1.42	1.42

TABLE 11-3 Average Chemical Concentrations (μg/l) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995 (Continued)

LOCATION PARAMETER	NP-0002	NP-0003	NP-0005
Ca	61.100*	78.433*	67.600*
Cr	5.16	5.01	6.77
Co	3.40	3.40	3.93
Cu	7.20	5.92	7.03
Fe	1.603*	1.152*	2.888*
Pb	7.65	3.33	4.33
Li	14.23	4.95	4.33
Mg	12.215*	14.467*	12.352*
Mn	185.85	41.28	73.67
Hg	0.24	0.08	0.08
Mo	6.13	7.15	5.70
Ni	10.23	10.83	12.40
K	5.21*	5.03*	3.71*
Se	2.38	3.23	1.94
Ag	1.93	1.93	1.67
Tl	2.81	1.98	1.85
V	4.47	4.68	8.45
Zn	55.40	31.28	48.75
PCBs	(c)	1.0[d]	1.0[d]
PAHs	<20[e]	<20[e]	<20[e]

* mg/l.
(a) All nondetect.
(b) All nondetect with one detect of 0.0491 μg/l.
(c) N.D. at <1.0 except 1 detect at 0.18μg/l and one Aroclor-1221 N.D. at D.L. of 2.0 μg/l.
(d) Except one Aroclor-1221 N.D. at D.L. of 2.0 μg/l.
(e) All N.D. with the maximum D.L. being 20 μg/l.

11.3 Temporary Storage Area Radon Flux Monitoring

11.3.1 Description

The *Record of Decision for the Management of the Bulk Waste at the Weldon Spring Quarry* (Ref. 57) states that at completion, the temporary storage area (TSA) will have to meet the Rn-222 flux standards specified in 40 CFR 192.02(b)(1). This standard requires reasonable assurance that Rn-222 from residual radioactive material will not exceed an average release rate of 20 pCi/m^2-sec (0.62 Bq/yd^2-sec) or increase the annual average concentration of Rn-222 in the air at or above any location outside the site perimeter by more than 0.5 pCi/l (0.02 Bq/l).

The materials disposed of in the quarry and subsequently excavated and placed on the TSA consist of waste from the chemical plant as well as wastes brought in from other areas. These wastes include (1) uranium, radium, and thorium-contaminated rubble and building materials, (2) materials associated with the processing of uranium and thorium concentrates, and (3) drummed thorium residues.

The wastes on the TSA have been segregated primarily by earthen materials (i.e., soil and rock) and metals, as shown on Figure 11-5. Two separate piles contain the earthen materials. The northern pile (i.e., fine grained soils) consists of nitroaromatic contaminated soils, drummed materials, rock, rubble, and fine grained soils, and the southern pile consists of nitroaromatic contaminated soil and rubble. Waste soils and materials approximately 15 cm (6 in.) in diameter or less are considered fine grained soils. The northern fine grained soils pile covers an area of approximately 1.6 ha (4 acres) and contains approximately 95,600 cu m (125,000 cu yd) of waste, which includes the rock and rubble used at the base of the side slopes. The southern pile covers an area of approximately 4,047 sq m (1 acre) and contains approximately 9,900 cu m (13,000 cu yd) of waste.

To comply with the Rn-222 flux standard specified in 40 CFR 192, radon flux measurements were collected quarterly from the second quarter of 1996 through the first quarter of 1997 on the quarry fine grained soils located on the TSA. The sampling methods and results are described below.

11.3.2 Method of Sampling

The method described in 40 CFR 61, Appendix B, Method 115, and used by the WSSRAP to make radon flux measurements, involves adsorption of radon on activated charcoal in a large area collector. The large-area activated charcoal collector (LAACC) is fabricated from a 25.4 cm (10 in.) diameter polyvinyl chloride (PVC) piping end cap.

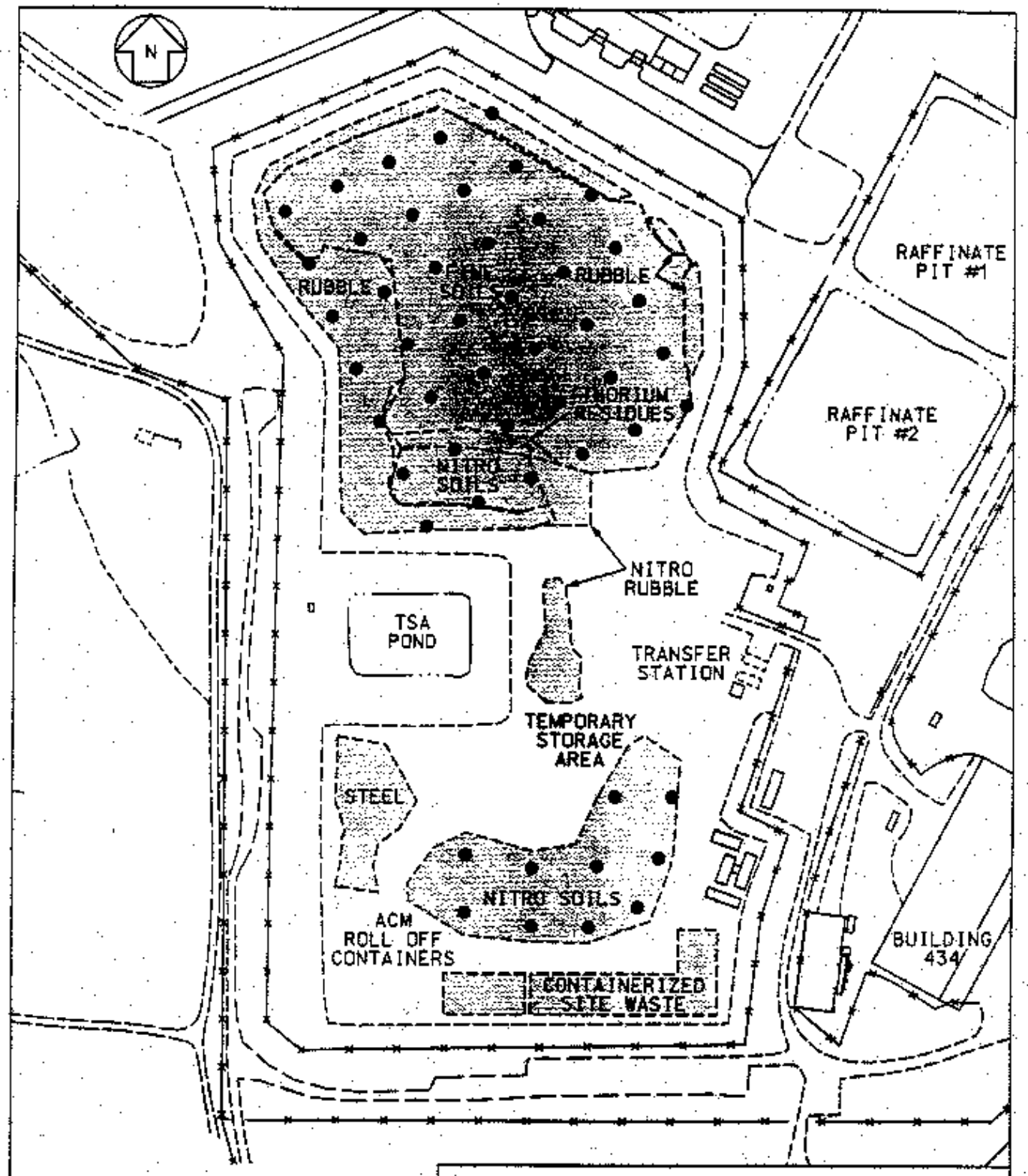
Sampling was conducted per Procedure ES&H 4.6.5, *Radon Flux Measurements Using the Large Area Activated Charcoal Collector Method* and the *Temporary Storage Area Radon Flux Monitoring Plan* (Ref. 76). Preparation of the LAACC involves purging the radon and water from the activated charcoal by heating the charcoal at a minimum of 110°C (230°F) for approximately 4 hours. The activated charcoal is then placed in the LAACC, and the cover pad and retaining ring are secured. The LAACC is placed on the measurement surface and approximately 2.5 cm to 5 cm (1 in. to 2 in.) of soil is packed around the detector and the measurement surface interface. The sample ID number, date, time, and location are recorded. The collection period is 24±2 hours. After retrieval, the charcoal was removed from each LAACC, placed in a separate analysis can, sealed, labeled, and shipped to the vendor for analysis via gamma spectroscopy.

Measurements were not collected within 24 hours of a rainfall. A minimum of 0.1 cm (0.05 in.) of water constitutes a rainfall. If a rainfall occurs within the 24-hour measurement period, the measurement was considered invalid if the soil used to seal the measurement surface/collector interface has washed away or if the collector was surrounded by standing water.

Measurements were not performed when the ambient temperature was below 1.7°C (35°F) or when the measurement surface was frozen.

The surface areas of the northern and southern earthen waste piles each consist of only one region, with no water covered or water-saturated areas and the piles are approximately 1.6 ha (4 acres) and 0.4 ha (1 acre), respectively. Approximately 50 measurements per quarter were collected, 40 on the northern fine grain soils pile and 10 on the southern fine grain soils pile.

The flux measurements were made at regularly spaced locations over both the northern and southern piles. These locations were used for the four quarterly sampling events. The



0 150 300

SCALE FEET

FENCING

BERM & MATERIALS LIMITS

SAMPLE LOCATION

APPROXIMATE RADON FLUX MEASUREMENT LOCATIONS

FIGURE 11-5

REPORT NO.: DOE/OR/21548-676		PROJECT NO.: A/DC/046/1196	
ORIGINATOR: MAP	DRAWN BY: GLN	DATE: 12/4/96	

approximate sample locations are shown on Figure 11-5. Sample locations included the side slopes and rock and rubble used at the toe of the side slopes for stability. If an established sampling location was too rough for a measurement, the measurement was made at the closest suitable location.

11.3.3 Radon Flux Results

For each quarterly sampling event, the mean radon flux for the TSA fine grain soils piles was calculated by summing all the individual measurements and dividing by the total number of measurements. The quarterly averages are listed in Table 11-4. The average radon flux is approximately 1.8 pCi/m^2-sec (0.06 Bq/yd^2-sec), which is far below the criteria of 20 pCi/m^2-sec (0.62 Bq/yd^2-sec).

TABLE 11-4 TSA Radon Flux Results

	2ND QUARTER 1996		3RD QUARTER 1996		4TH QUARTER 1996		1ST QUARTER 1997	
SAMPLE LOCATION	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA
TSA-1	0.3	0.05	5.3	0.2	0.3	0.06	1.2	0.05
TSA-2	1	0.09	2.8	0.2	0.9	0.08	3.4	0.09
TSA-3	3.9	0.2	7.3	0.3	5	0.2	3.1	0.08
TSA-4	0.8	0.08	3.2	0.2	11	0.3	11.2	0.4
TSA-5	0.2	0.05	0.4	0.09	0.09	0.04	0.3	0.03
TSA-7	3.2	2.9	-	-	0.2	0.05	0.7	0.04
TSA-8	4.8	3.3	0.9	0.1	0.1	0.05	0.3	0.03
TSA-9	2.2	3.2	1.4	0.1	0.5	0.07	0.2	0.02
TSA-10	0.3	0.06	0.5	0.09	0.3	0.06	0.6	0.04
TSA-11	2.2	0.1	0.9	0.1	0.3	0.06	1	0.04
TSA-12	0.4	0.07	0.2	0.09	0.2	0.08	0.2	0.03
TSA-13	0.9	0.1	1.3	0.1	0.4	0.07	1.2	0.05

TABLE 11-4 TSA Radon Flux Results (Continued)

	2ND QUARTER 1996		3RD QUARTER 1996		4TH QUARTER 1996		1ST QUARTER 1997	
SAMPLE LOCATION	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA
TSA-14	4.4	0.2	2.5	0.2	4.3	0.2	1.8	0.06
TSA-15	0.9	0.1	0.3	0.1	0.2	0.06	0.7	0.04
TSA-16	0.5	0.08	0.4	0.1	0.5	0.07	0.3	0.02
TSA-17	3	0.2	8.2	0.3	0.5	0.08	1.2	0.04
TSA-18	0.5	0.08	0.8	0.1	0.05	0.06	0.3	0.03
TSA-19	1.5	0.1	7	0.3	0.3	0.07	2.6	0.07
TSA-20	0.4	0.07	1.7	0.2	0.1	0.06	0.6	0.04
TSA-21	0.2	0.06	0.5	0.2	1.2	0.1	0.2	0.03
TSA-22	0.2	0.06	0.4	0.1	<0.1	-	0.2	0.03
TSA-23	1.8	0.1	4.2	2.1	0.3	0.07	0.9	0.05
TSA-24	0.5	0.08	-	-	0.2	0.05	0.2	0.03
TSA-25	0.5	0.08	7.2	0.3	1.6	0.2	0.3	0.03
TSA-26	1.9	0.1	3.5	0.2	1.3	0.1	0.8	0.04
TSA-27	<0.3	-	0.3	0	0.8	0.07	0.9	0.05
TSA-28	1.8	0.1	0.5	0.1	0.3	0.06	0.4	0.03
TSA-29	1.7	0.1	2.5	0.2	0.3	0.06	0.3	0.02
TSA-30	6.7	0.3	11	0.4	0.6	0.09	1	0.04
TSA-31	1.1	0.1	1.9	0.2	0.6	0.09	0.4	0.03
TSA-32	<0.1	-	2.4	0	0.2	0.07	0.5	0.03
TSA-33	1.6	0.1	5.2	0.3	0.6	0.08	0.8	0.04
TSA-34	0.6	0.1	4.2	0.2	0.2	0.06	0.3	0.02
TSA-35	23.1	0.5	2.1	0.2	0.2	0.04	30.4	0.4
TSA-36	1.5	0.1	0.7	0.1	0.9	0.1	1.8	0.08
TSA-37	3.2	0.2	1.8	0.2	1.3	0.2	1.2	0.06

TABLE 11-4 TSA Radon Flux Results (Continued)

	2ND QUARTER 1996		3RD QUARTER 1996		4TH QUARTER 1996		1ST QUARTER 1997	
SAMPLE LOCATION	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA	RADON FLUX	TOTAL UNCERT. 1-SIGMA
TSA-38	1.8	0.1	6.5	0.3	0.2	0.06	2.4	0.09
TSA-39	0.5	0.08	2.2	0.2	0.1	0.05	0.1	0.01
TSA-40	1.3	0.1	2.4	0.2	1.2	0.2	1.7	0.07
TSA-41	0.8	0.1	1.9	0.2	0.4	0.07	0.2	0.01
TSA-42	1.2	0.1	0.9	0.1	0.4	0.09	0.4	0.2
TSA-43	0.6	0.1	0.8	0.1	1.5	0.2	0.4	0.2
TSA-44	0.6	0.1	2.2	0.2	0.5	0.08	2.2	0.02
TSA-45	0.5	0.08	1.8	0.2	-	-	0.3	0.02
TSA-46	-	-	-	-	0.3	0.07	0.6	0.03
TSA-47	1.1	0.1	2	0.2	0.1	0.04	0.6	0.04
TSA-48	0.4	0.09	1.6	0.2	0.6	0.09	0.7	0.03
TSA-49	0.3	0.08	2.4	0.2	0.7	0.09	0.7	0.04
TSA-50	1.7	0.2	3.8	0.2	0.3	0.07	0.2	0.03
TSA-51	1.2	0.1	3.7	0.2	2	0.2	1.6	0.06
TSA-52	1.5	0.2	2.2	0.2	-	-	0.3	0.01
AVERAGE	1.9	5.5	2.7	2.5	0.9	0.8	1.6	0.7

"-" indicates measurement not collected.

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ASME NQA-1, *American Society of Mechanical Engineers, Nuclear Quality Assurance*

DOE ORDERS

5000.3B, *Occurrence Reporting and Processing of Information*
5400.1, *General Environmental Protection Program*
5400.3, *Hazardous and Mixed Waste Program*
5400.5, *Radiation Protection of the Public and the Environment*
5480.1B, *Environment, Safety and Health Program for Department of Energy Operations*
5480.4, *Environmental Protection, Safety, and Health Protection Standards*
5482.1B, *Safety Analysis and Review System*
5700.6C, *Quality Assurance*
5820.2A, *Radioactive Waste Management*

REGULATIONS

10 CFR 830.120, *Quality Assurance*
10 CFR 1022, *Department of Energy, Compliance With Floodplain/Wetlands Environmental Review Requirements*
36 CFR Part 800.5, *Protection of Historic and Cultural Properties*
40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*
40 CFR Part 141, *National Primary Drinking Water Regulations*
40 CFR 264, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*
40 CFR 761, *Polychlorinated Biphenyls, Manufacturing, Processing, Distribution in Commerce, and Use in Prohibitions*

40 CFR 761.125, *Requirements for PCB Spill Cleanup*

10 CSR 20-7.031, *Water Quality Standards*

10 CSR 25-7, *Hazardous Waste Management Commission - Rules Applicable to Owners/Operators of Hazardous Waste Facilities*

PROCEDURES

ES&H 3.1.7, *Noise Monitoring*

ES&H 4.1.4, *Quality Control Samples for Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection Procedures*

ES&H 4.2.1, *Erosion Control Survey*

ES&H 4.2.3, *Embankment Survey*

ES&H 4.6.5, *Radon Flux Measurements Using the Large Area Activated Charcoal Collector Method*

ES&H 4.9.3, *Data Review Procedures for Surface Water, Groundwater, and Soils*

MGT-6, *Surveillances and Walkthroughs*

13 GLOSSARY, ACRONYMS, AND ABBREVIATIONS

13.1 Technical Terms

ABSORBED DOSE: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray).

ACTIVITY: The rate at which the atoms of a radioactive material decay (transform). Activity is expressed in units of curie (or becquerel).

ALARA: An acronym for "As Low as Reasonably Achievable." This refers to the U.S. Department of Energy goal of keeping releases of radioactive substances to the environment and exposures of humans to radiation as far below regulatory limits as "reasonably achievable."

ALLUVIAL AQUIFER: A subsurface zone, formed by the deposition of sediments by running water, capable of yielding usable quantities of groundwater to wells.

ALPHA PARTICLE: A positively charged particle emitted from the nucleus during the radioactive decay of certain radionuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.

BACKGROUND RADIATION: Radiation due to cosmic rays and radiation from the naturally radioactive elements in the surface of earth.

BEDROCK: A rock formation usually underlying one or more unconsolidated formations.

BECQUEREL: The SI unit for activity. 1 becquerel (Bq) = 1 disintegration/second = 2.703×10^{-11} curies.

BETA PARTICLE: A charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

CHAIN-OF-CUSTODY FORM: A standardized form used in tracing the possession and handling of individual samples from the time of field collection through laboratory analysis.

COLLECTIVE POPULATION DOSE EQUIVALENT: The average total effective dose equivalent (TEDE) received by members of the public from exposure to radioactive material released by a DOE facility or operation, multiplied by the number of individuals in the population. Collective population dose equivalent is expressed in units of person-rem (or person-Sv).

COMMITTED DOSE EQUIVALENT: The predicted total dose equivalent to a tissue or organ over a 50-year period following a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert).

COMMITTED EFFECTIVE DOSE EQUIVALENT: The sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighing factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

CONTAMINATION: A foreign substance in or on the surfaces of soils, structures, areas, objects, or personnel.

COUNTING STATISTICS: Statistical analysis required to process the results of nuclear counting experiments and to make predictions about the expected precision of quantities derived from these measurements.

CURIE: A measure of the rate of radioactive decay. One curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dps), which is equal to the decay rate of one gram of Ra-226.

DECAY PRODUCTS: Isotopes that are formed by the radioactive decay of some other isotope. In the case of Ra-226, for example, there are 10 successive decay products, ending in the stable isotope Pb-206.

DERIVED CONCENTRATION GUIDE: The concentration of a radionuclide in air or water that, when an individual is continuously exposed by one exposure mode (ingestion of water, submersion in air, or inhalation), results in an effective dose equivalent of 100 mrem (1 mSv).

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well or spring) at a given instant in terms of volume per unit of time.

DOSE EQUIVALENT: The product of the average absorbed dose in a tissue or organ, measured in rad (or gray), and a radiation weighing factor (formerly known as quality factor). Radiation weighing factors ranging from 1-20 are assigned to all types of radiation (e.g., alpha, beta, gamma) depending on their ability to damage tissue. Dose equivalent is expressed in units of rem (or sievert).

DOSIMETER: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

EFFECTIVE DOSE EQUIVALENT: The summation of the products of the dose equivalents received by specified tissues of the body and tissue-specific weighing factors. It is used to estimate the risk of health effects of the exposed individual to ionizing radiation. Tissue specific weighing factors represent the fraction of the total health risk resulting from uniform whole-body irradiation contributed by a particular tissue. The effective dose equivalent includes contributions from internal deposition of radionuclides (committed effective dose equivalent) and the effective dose equivalent due to external exposure (gamma and/or X-rays). Effective dose equivalent is expressed in units of rem (or sievert).

ERG: Unit of Energy 1 ERG = 10^{-7} Joules.

EXPOSURE PATHWAY: The route by which a contaminant or health hazard may enter and impact the environment or an individual.

EXTERNAL EXPOSURE: The fraction of dose equivalent contributed by penetrating radiation from sources external to the body (e.g., gamma and/or X-rays). Measured in rem (or sievert).

GAMMA RADIATION: Penetrating high energy, short wave-length, electromagnetic radiation (similar to X-rays) emitted during radioactive decay. Gamma rays are very penetrating and can be attenuated only by dense materials such as lead.

GROSS ALPHA: Measurement of all alpha-emitting radionuclides in a sample.

GROSS BETA: Measurement of all beta-emitting radionuclides in a sample.

HALF-LIFE: The time it takes for half the atoms of a quantity of a particular radioactive element to decay to progeny. Half-lives of different isotopes vary from small fractions of a second to billions of years.

HECTARE: A unit of area in the metric system equal to 10,000 square meters. It is approximately 2.5 acres.

HYDROLOGIC: Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

ISOTOPE: Nuclides having the same atomic number but different numbers of neutrons (mass numbers).

LLD: Lower limit of detection.

MDA: Minimum detectable activity.

NATURAL URANIUM: A naturally occurring radioactive element that consists of 99.2830% U-238, 0.7110% U-235, and 0.0054% U-234 by mass. On an activity basis, it consists of 48.6% U-238, 2.3% U-235, and 49.1% U-234.

NUCLIDE: A general term referring to isotopes of the chemical elements, both stable and unstable.

PERCHED LENS: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

PROGENY: An element that results immediately from the disintegration of a radioactive element.

RAD: A unit of absorbed dose; acronym for radiation absorbed dose.

RADIATION: A very general term that covers many forms of particles and energy, from sunlight and radio waves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, X-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIONUCLIDE: An unstable nuclide that undergoes radioactive decay.

RAFFINATE: A waste product from a refining process, i.e., that portion of a treated liquid mixture that is not dissolved and not removed by a selective solvent.

REM (Roentgen Equivalent Man): A quantity used in radiation protection to express dose equivalent for all forms of ionizing radiation. A rem is the product of the absorbed dose in rads and factors related to relative biological effectiveness.

SI: International System of Units.

SIEVERT: The SI unit used to quantify dose equivalent for all forms of ionizing radiation; 1 Sv = 100 rem.

STOCHASTIC: "Stochastic" effects are those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose, without a threshold.

WORKING LEVEL: Any combination of Rn-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of Rn-222 (or 8 pCi of Rn-220) in 1 liter of air, where the decay products are in radioactive equilibrium with the parent.

WORKING LEVEL MONTH: The product of WL and duration of exposure, normalized to a 1-month occupational exposure period (170 hours).

X-RAY: Penetrating electromagnetic radiation having a wave length that is much shorter than that of visible light. It is customary to refer to rays originating in the nucleus of an atom as gamma rays and to those originating in the electron field of the atom as X-rays.

13.2 Acronyms and Abbreviations

No abbreviations for common units of measure or chemical elements and compounds are included in this list. Some less common units of measure, such *pCi* and *μCi* are included.

ACM	asbestos-containing materials
AEC	Atomic Energy Commission
AHERA	Asbestos Hazard and Emergency Response Act
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARAR	applicable and/or relevant and appropriate requirements
ASME	American Society of Mechanical Engineers
BA	Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site
BOD	Biochemical Oxygen Demand
Bq	becquerel
CAA	Clean Air Act
CEDE	Committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curie
CLP	Contract Laboratory Program
CM&O	Construction Management and Operations
COD	chemical oxygen demand
CONOPS	Conduct of Operations
CWA	Clean Water Act
CX	categorical exclusion
DCG	Derived Concentration Guideline

DL	detection limit
DL/2	one-half detection limit
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	data quality objective
EA	Environmental Assessment
EDAP	Environmental Data Administration Plan
EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Plan
EPA	Environmental Protection Agency
EPA	U.S. Environmental Protection Agency
EPPIP	Environmental Protection Program Implementation Plan
EQA	Environmental Quality Assurance
EQAPjP	Environmental Quality Assurance Project Plan
ES&H	Environmental Safety and Health
FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FHHS	Francis Howell High School
FP	Fire Protection
FS	Feasibility Study for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site
HAP	hazardous air pollutants
HMWM	Hazardous Materials Waste Management
HP	Health Physics
HPO	Missouri Department of Natural Resources Historical Preservation Officer
HQ	Headquarters
HSL	Hazardous Substance List
HVAC	heating, ventilating, and air conditioning
IH	Industrial Hygiene
IS	Industrial Safety
LDR	Land Disposal Restrictions

LLD	lower limit of detection
MACT	Maximum Available Control Technology
MCL	maximum contaminant level (Safe Drinking Water Act)
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDNR	Missouri Department of Natural Resources
MDOC	Missouri Department of Conservation
MHTC	Missouri Highway Transportation Commission
MSA	material staging area
msl	mean sea level
NAAQS	national ambient air quality standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
PCB	polychlorinated biphenyl
pCi	picocurie
PCM	phase contrast microscopy
PMC	Project Management Contractor
PP	Proposed Plan for Remedial Action and the Chemical Plant Area of the Weldon Spring Site
ppm	parts per million
PTI	Project Training and Improvement
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QA	Quality Assurance
QAMS	Quality Assurance Management Staff
QAPjP	Quality Assurance Project Plan
QWTP	quarry water treatment plant
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation

RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Saturation Indexes
SIC	Standard Industrial Classification
SOP	Standard Operating Procedures
SWATS	Site Wide Audit Tracking System
SWTP	site water treatment plant
TBP	tributyl phosphate
TC	toxicity characteristic
TDS	total dissolved solids
TEM	transmission electron microscopy
TLD	thermoluminescent dosimeter
TNB	trinitrobenzene
DNT	dinitrotoluene
TNT	trinitrotoluene
tpy	tons per year
TSA	temporary storage area
TSCA	Toxic Substances Control Act
TSS	total suspended solid
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
WITS	Waste Inventory Tracking System
WLM	Working Level Monitor
WPC	Water Pollution Control
WSCP	Weldon Spring Chemical Plant
WSQ	Weldon Spring Quarry
WSRP	Weldon Spring raffinate pits
WSSRAP	Weldon Spring Site Remedial Action Project
WSUFMP	Weldon Spring Uranium Feed Materials Plant
l	liter
mg	milligram

mg/l	milligrams per liter
μCi	microcurie
μg/l	micrograms per liter
mSv	millisievert

APPENDIX A
Unpublished Documents

University of Missouri St. Louis

Urban Information Center

Office of Computing and Networking Services

8001 Natural Bridge Road
St. Louis, Missouri 63121-4499
Telephone: 314-516-6000
Fax: 314-516-6007

April 14, 1997

Mr. Eric Danielson
Jacob Engineering
7295 Highway 94 South
St. Charles, MO 633304

Dear Mr. Danielson ,

Following is the data you have requested:

	1990	1991	1992	1993	1994	1995	1996
St. Charles County	212,907	219,429	225,364	233,313	238,944	247,695	255,066
Cities of:							
Cottleville	456	464	474	489	499		
Weldon Spring	1,039	1,050	1,066	1,091	1,107		
Weldon Spring Heights	97	98	98	100	101		

Please call me at 516-6035 if you have any questions.

Sincerely,

Linda C. McDaniel

Linda C. McDaniel
Public Data Information Specialist

an equal opportunity institution

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Shimei Xiao
From: Lisa Dunham

Incoming: ___ Outgoing: X WP#: ___
Date: 3-19-97 Time: 10:08 am

Conversation With:
Claudia Geile
of: Francis Howell High School
and:
of:

Phone:
Phone:

Subject: Number of staff and students for Francis Howell High School

Summary of Conversation:
Claudia stated that the numbers for 1996 staff is approximately 200. Student enrollment for 1996 is 2,820.

Action of Follow-Up/Recommendations:

cc:

By: Lisa Dunham

ENG-6a.5 Rev.2 10/92

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Shimei Xiao
From: Lisa Dunham

Incoming: ___ Outgoing: X WP#: ___
Date: 3-19-97 Time: 10:30 am

Conversation With:
Jerry Jones Phone: (314) 441-8471
of: Mo. State Highway Department-Weldon Spring Location
and: Phone:
of:

Subject: Total number of employees at the Weldon Spring Maintenance Site on Highway 94

Summary of Conversation:
I spoke with Jerry Jones who said that nine (9) employees work out of the Weldon Spring Maintenance site of the Missouri Highway and Transportation Department.

Action of Follow-Up/Recommendations:

cc:

By: Lisa Dunham

ENG-6a.3 Rev.2 10/92

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Shimei Xiao
From: Lisa Dunham

Incoming: ___ Outgoing: X WP#: ___
Date: 3-19-97 Time: 10:15 am

Conversation With:
Mike Schroer
of: Department of Conservation-Busch Wildlife
and:
of:

Phone: (314) 441-4554
Phone:

Subject: Number of Employees at the Busch Conservation Area

Summary of Conversation:

I spoke with Mike Schroer who said that employee count for 1996 was the same: 25 total employees including full and part-time employees, as well as any seasonal help hired throughout the year on a temporary basis.

Action of Follow-Up/Recommendations:

cc:

By: Lisa Dunham

ENG-6L3 Rev.2 10/92

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Shimei Xiao
From: Lisa Dunham

Incoming: ___ Outgoing: X WP#: ___
Date: 3-19-97 Time: 10:05am

Conversation With:
Karl Daubel
of: Weldon Spring Training Area-Dept. of Army
and:
of:

Phone: (314) 441-8681
Phone:

Subject: Number of employees located at the U.S. Department of Army Weldon Spring Training Area

Summary of Conversation:
According to Mr. Daubel, he is the only employee located at the Department of Army's Weldon Spring Training Area. Occasionally the Army site will receive visitors.

Action of Follow-Up/Recommendations:

cc:

By: Lisa Dunham

ENG-6a.3 Rev.2 10/92

APPENDIX B
Assumptions and Scenarios for Dose Calculations

A. Dose from the chemical plant and raffinate pits to a maximally exposed individual.

The following dose assessment is for a maximally exposed individual employed full-time (2,000 hours/year) at the Missouri Highway Maintenance Facility, located just northeast of the chemical plant perimeter. This scenario was developed because both the environmental TLD and Rn-220 detectors near the facility indicated greater than background levels in 1996.

1. Inhalation :

a. Airborne Radioactive Particulates: Not applicable since results for all monitoring stations at the Weldon Spring Chemical Plant were indistinguishable from background levels.

b. Radon and Thoron Gas: Statistical analysis of integrated radon (Rn-220 and Rn-222) alpha track monitoring results indicated that all stations at the chemical plant perimeter were indistinguishable from the annual average background concentration. However, the annual average Rn-220 concentration at station RD-2004 was found to statistically exceed background levels by 0.25 pCi/l (see Section 4.1.4.1). Based on measurements made in 1996 (see Section 4), a daughter equilibrium ratio of 0.005 was applied to this dose scenario.

Thoron concentrations are often expressed in units of working levels (WL), where 1 WL (at 100% equilibrium) is equal to 7.43 pCi/l for Rn-220. Thoron exposure is often expressed in terms of working level months (WLm), corresponding to an exposure of 1 WL during the reference working period of 170 hours (one working month).

Committed effective dose equivalent (CEDE) (inhalation of Rn-220 gas)	=	net thoron concentration x exposure time x daughter equilibrium ratio x working month conversion factor x dose conversion factor
	=	0.25 pCi/l x 2,000 hrs x 0.005 x 1 WL/7.43 pCi/l x 1 working month/170 hrs 0.42 rem/WLm x 1000 mrem/rem

CEDE (Rn-220) = 0.83 mrem (0.0083 mSv)

CEDE (inhalation) = CEDE (Rn-220)

= 0.83 mrem (0.0083 mSv)

2. External Gamma Pathway: Statistical analysis of environmental TLD results indicated that station TD-2004 was greater than background (see Section 4.2). This station measured a gross annual dose equivalent of 71 mrem (0.71 mSv), based on 8,784 hours of continuous exposure. Given the background gamma dose equivalent of 63 mrem (0.63 mSv), the net annual gamma dose equivalent was 8 mrem (0.08 mSv) for the monitoring location. The effective dose equivalent (EDE) due to gamma exposure for a MEI at the Missouri Highway Maintenance Facility is thus:

EDE (external) = (gross TLD result - background TLD result) x exposure time

≈ (71 - 63) mrem/y x 2,000 hr x 1 y/8,784 hr

= 1.82 mrem (0.018 mSv)

3. Ingestion Pathway: Because no bodies of water exist at the Missouri Highway Maintenance Facility, fishing, swimming, and ingestion of contaminated water do not constitute realistic scenarios.

The total effective dose equivalent (TEDE) is calculated as follows:

TEDE = CEDE (inhalation) + EDE (external)

= 0.83 mrem + 1.82 mrem

= 2.7 mrem (0.027 mSv)

B. Dose from the Weldon Spring Quarry to a Maximally Exposed Individual

The exposure scenario for the dose estimate from the Weldon Spring Quarry is based on a hypothetical individual who hikes around the southeastern perimeter of the quarry 5 hours per year.

1. Inhalation Pathway:

   a. Airborne Radioactive Particulates: Not applicable since gross alpha concentrations measured at the quarry were indistinguishable from the background average for 1996.

   b. Radon and Thoron Gas: Not applicable since there was no reason to suspect that either radon or thoron concentrations measured at the quarry were greater than background levels.

2. External Pathway: Environmental TLD monitoring station TD-1003, located along the quarry perimeter, was found to be statistically greater than background levels. TD-1003 provided a total annual gross measurement of 72 mrem (see Section 4.2). A background gamma radiation dose equivalent of 63 mrem was measured for the year.

   EDE (external) = (gross TLD result - background TLD result) x exposure time

   = (72 - 63) mrem/y x 5 hrs x 1 y/8,784 hrs

   EDE (external) = 0.0051 mrem (5.1E-5 mSv)

3. Ingestion pathway: Because the quarry is controlled by a 2.4 m (8 ft) high fence, fishing, swimming, and drinking water at the quarry do not constitute realistic scenarios.

   TEDE = EDE (external)

   = 0.0051 mrem (5.1E-5 mSv)

   The total estimated effective dose equivalent to a maximally exposed individual at the quarry is therefore 0.0051 mrem (5.1E-5 mSv).

C. Dose from the Vicinity Properties to a Maximally exposed Individual

1. Inhalation Pathway:

The Femme Osage Slough, located adjacent to the Weldon Spring Quarry, is the only portion of the vicinity properties that would likely be frequented by members of the public. It is assumed that the maximally exposed individual visited the slough for the purpose of fishing.

a. Airborne Radioactive Particulates: Not applicable since radioactive air particulate concentrations measured near the slough were indistinguishable from background levels.

b. Radon Gas: Not applicable since radon concentrations measured near the slough were indistinguishable from background levels.

2. External Gamma Pathway: Not applicable since there is no reason to suspect at the 95% confidence level that external gamma radiation results at the slough are greater than background levels.

3. Ingestion Pathway: The Femme Osage Slough contains uranium contaminated sediments and was considered in estimating the committed effective dose equivalent to a hypothetical individual via the fish ingestion pathway. Due to the stagnant conditions at the slough, ingestion of water or sediments was deemed unrealistic.

Assume a 6.5 g/day fresh water fish consumption rate (Ref. 23) from the slough. Assume the average uranium concentration in fish caught in the slough of 0.005 pCi/g (see Table 9-1).

CEDE (ingestion) = fish consumption rate x uranium concentration x dose conversion factor (DCF)

= 6.5 g/day x 366 d/yr x 0.005 pCi/g x 2.69E-4 mrem/pCi

= 0.0032 mrem (0.032 μSv)

TEDE = CEDE (ingestion)

= 0.0032 mrem (0.032 μSv)

The estimated total effective dose equivalent for the maximally exposed individual at the Femme Osage Slough is therefore 0.0032 mrem (0.032 μSv).

D. Collective Population Dose Estimate

Exposure points are locations where members of the public are potentially being exposed to above-background concentrations of (1) airborne radioactive particulates, (2) radon gas concentrations, (3) external gamma radiation, or (4) radionuclides in food or water. All four pathways are addressed for the collective population dose estimate. Exposure to above-background radionuclide concentrations in food or water is applicable only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the site or from materials stored at the site. If there is no reason to suspect that environmental monitoring results are different from the appropriate background monitoring results, then the area surrounding the environmental monitoring station cannot be considered an exposure point. Therefore, the population near the station, as well as the population beyond the station, would not be included in the collective population dose estimate.

A collective population dose assessment is performed at the exposure points on which the above background environmental monitoring results are obtained and a potential for public exposure is suspected. All four pathways are addressed for this estimate.

1. Airborne Radioactive Particulates

Not applicable since results for all monitoring stations at the Weldon Spring site were indistinguishable from background levels.

2. Radon/Thoron Gas Exposures

Statistical analysis of integrated radon (Rn-220 and Rn-222) alpha track monitoring results indicated that all the critical receptor stations at the WSSRAP perimeter were indistinguishable from the annual average background concentration. However, the annual average Rn-220 concentration at station RD-2004 was found to statistically exceed background levels by 0.25 pCi/l. This station is located at the Weldon Spring Chemical Plant perimeter near the Missouri Highway Maintenance Facility. A scenario was developed and a dose assessment was performed for a maximally exposed individual (MEI) in Section A.1.b. The resulting committed effective dose equivalent (CEDE) for the MEI is 0.83 mrem (0.0083 mSv).

Assuming that in 1996 nine full time employees worked at this facility (see Appendix A), the collective population dose is:

CEDE (radon/thoron gas)	=	0.83 mrem x 9 person
	=	7.47 (person-mrem) x 1 rem/ 1,000 mrem
	=	0.007 (person-rem) (7E-5 person-Sv)

3. External Gamma Pathway

Statistical analysis of environmental thermoluminescent dosimeter (TLD) results indicated that the gamma exposure of station TD-2004 was greater than background levels. The effective dose equivalent (EDE) due to gamma exposure for a MEI at the Missouri Highway Maintenance Facility is 1.83 mrem (0.018 mSv).

For nine full time employees, the collective population dose equivalent due to gamma exposure is:

Population Dose equivalent
(gamma exposure) = 1.83 mrem x 9 persons
= 16.47 person-mrem x 1 rem/1000 mrem
= 0.016 person-rem (1.6E-4 person-Sv)

4. Ingestions of food or water

Exposure to above-background radionuclide concentrations in food or water is applicable only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the Weldon Spring site and are used for fishing and boating activities. The Missouri Department of Conservation conducted a year long survey to determine the number of visitors to the area, the types of activities in which users participate, and the amount of time allocated for these activities (Ref. 30).

Fishing at the Busch Conservation Area averaged 2.5 hours per visit for the approximately 160,000 visits to the area for that purpose (assuming a time-spent to fish-caught ratio of 0.4 fish/hour and a 0.50 ratio of fish caught to fish kept for a total of 80,000 fish). Assuming that one person keeps one fish, the population of concern would be 80,000 persons. For the water and sediment ingestion scenarios, boating is the activity assumed to provide the potential for incidental water and sediment ingestion. An estimated 5,985 visits were made for the purpose of boating with an average of 5.7 hours per visit. Assuming that each visit constitutes one individual, the total population would be 5,985 persons. Each of these ingestion scenarios is further addressed in calculations a, b, and c below.

a. Dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area.

- Assuming that each person of the 80,000 population consumes one fish and that the edible portion of a fish has a mass of 200 g, the

average consumption rate specific to the affected population is 0.55 g/person/day.

- Using the maximum total uranium fish content of 0.038 pCi/g obtained from samples collected in Lake 36 and the population specific consumption rate derived from Missouri Department of Conservation data, the estimated population dose equivalent is:

Population Dose Equivalent (fish ingestion)

= consumption rate x total uranium concentration in fish x exposure time x dose conversion factor x persons

= 0.55 g/day x 0.038 pCi/g x 365 day x 2.69E-4 mrem/pCi x 80,000 persons x 1 rem/1,000 mrem

b. Dose estimate due to incidental ingestion of water at the Busch Conservation lakes:

- Assume that each person of the 5,985 population makes one boating visit on an annual basis and 5% of the visit is spent swimming (0.285 hours/visit).

- Using the maximum total uranium surface water content of 56 pCi/l obtained from Lake 36 and an ingestion rate of 0.05 l/hour (Ref. 30) the estimated population dose equivalent is

Population Dose Equivalent (water ingestion)

= ingestion rate x total uranium concentration in surface water x exposure time x dose conversation factor x persons

= 0.05 l/hr x 56 pCi/l x 0.285 hr x 2.69E-4 mrem/pCi x 5,985 persons x 1 rem/1,000 mrem

= 0.0013 person-rem (1.3E-5 person-Sv)

c. Dose estimate due to ingestion of sediments at the Busch lakes:

- Assume that each person of the 5,985 population makes one boating visit on an annual basis and 5% of the visit is spent swimming (0.285 hours/visit).

- Using the maximum total uranium sediment content of 91.1 pCi/g obtained from Lake 34 in 1996 and an ingestion rate of 200 mg/day, the estimated population dose is:

Population Dose Equivalent (sediment ingestion)

= ingestion rate x total uranium concentration in sediment x exposure time x dose conversion factor x persons

= 200 mg/day x 91.1 pCi/g x 0.285 hr/person x 2.69E-4 mrem/pCi x 5,985 persons x 1 g/1,000 mg x 1 day/24 hr x 1 rem/1,000 mrem

= 0.0003 person-rem (3E-6 person-Sv)

Therefore, the collective population dose equivalent obtained from ingestion of food or water at the Busch Memorial Conservation Area is:

Dose (fish ingestion) + Dose (water ingestion) + Dose (sediment ingestion)

= 0.1642 + 0.0013 + 0.0003 person-rem
= 0.1658 person-rem (1.7E-3 person-Sv)

The total collective population dose equivalent in 1996 for all four pathways addressed in this section is:

Dose (airborne particulates) + Dose (radon/thoron gas) + Dose (gamma exposure) + Dose (ingested as food and water)

= 0 + 0.007 + 0.016 + 0.1658
= 0.19 person-rem (1.9E-3 person-Sv)

E. Airborne Radioactive Release Estimates

During 1996, no high volume critical receptor monitors or low volume perimeter monitors indicated radioactive air particulate concentrations statistically greater than background levels. Therefore, it is assumed that the quantity of radioactive air particulates released from both the chemical plant and quarry in 1996 was negligible.

F. Radon-220 and Radon-222 Release Estimates

Standard track etch detectors along the chemical plant and quarry perimeters indicated no locations where integrated radon (Rn-222 and Rn-220) levels were greater than background. Therefore, no annual Rn-222 release rates were calculated. In addition, annual average Rn-220 concentrations along the quarry perimeter were indistinguishable from background, thus eliminating the need to calculate a Rn-220 release rate from the quarry. However, annual Rn-220 results at WSCP modified track etch perimeter stations RD-2004, RD-3001, and RD-3002 indicated average concentrations of 0.3, 1.7, and 0.9 pCi/l above background, respectively (see Table 4-2). A series of three box models was used to calculate the total Rn-220 release rate from the WSCP based on these results, assuming that the major source of Rn-220 emissions at the WSCP is the north end of Raffinate Pit 4 (based on site-wide continuous radon measurements performed during 1996). The box model approach provides conservative results and is used in place of Gaussian dispersion modeling, which is generally inappropriate for estimating ambient pollutant concentrations at receptors close to a source.

Parameters required for inclusion in the box models include: net average Rn-220 concentration; the range of wind directions (measured out from the source) encompassing the area in which a given monitoring station is located, including the average wind speed and directional frequency (percentage of time the wind blew in those directions) for that range; the estimated Rn-220 release height at the fence line; and the box length, which is the distance between two points

along the fence line drawn on either side of a monitoring station. (These two points are the midpoints between a given monitoring location and the next closest station along the site perimeter.) The following table provides a summary of the parameters and assumptions used in the modeling scheme.

BOX MODEL	MONITORING STATION	RANGE OF WIND DIRECTIONS (WIND BLOWING FROM)	AVERAGE WIND SPEED FOR RANGE (m/s)	DIRECTION FREQUENCY	BOX LENGTH (m)	RELEASE HEIGHT (m)	NET Rn-220 CONCENTRATION (pCi/l)
1	RD-2004	247.5° - 292.5° (WSW - WNW)	3.25	21.1%	396	3	0.3
2	RD-3001	112.5° - 202.5° (ESE - SSW)	2.88	39.8%	579	3	1.7
3	RD-3002	22.5° - 112.5° (NNE - ESE)	2.40	17.3%	366	3	0.9

The following calculation is used to estimate the Rn-220 release rate from the chemical plant for each model:

Release Rate (Ci/y) = Box Length (m) x Release Height (m) x Average Wind Speed (m/s) x Net Rn-220 Concentration (pCi/l) x 1E-12 Ci/pCi x 1,000 l/m^3 x 3.1536E7 s/y x Directional Frequency

Box Model 1 (RD-2004):

Release Rate = 396 m x 3 m x 3.25 m/s x 0.3 pCi/l x 1E-12 Ci/pCi x 1,000 l/m^3 x 3.1536E7 s/y x 0.211

Release Rate (RD-2004) = 7.7 Ci/y (2.85E11 Bq/y)

Box Model 2 (RD-3001):

Release Rate = 579 m x 3 m x 2.88 m/s x 1.7 pCi/l x 1E-12 Ci/pCi x 1,000 l/m^3 x 3.1536E7 s/y x 0.398

Release Rate (RD-3001) = 107 Ci/y (3.96E12 Bq/y)

Box Model 3 (RD-3002):

Release Rate = 366 m x 3 m x 2.4 m/s x 0.9 pCi/l x 1E-12 Ci/pCi x 1,000 l/m^3 x 3.1536E7 s/y x 0.173

Release Rate (RD-3002) = 13 Ci/y (4.81E12 Bq/y)

The total estimated Rn-220 release rate from the chemical plant area is the sum of the results of the 3 box models, or approximately 128 Ci/y (4.74E12 Bq/y).

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Weldon Spring Site Remedial Action Project

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Date: 24 Jul 97 **Transmittal No.**: CD-0162-00

Title of Document: Weldon Spring Site Environmental Report for Calendar Year 1996

Doc. Num.: 676 **Rev. No.**: 0 **Date of Document**: July 1997

Purpose of Transmittal: Request for Department of Energy acceptance of contract deliverable.

In compliance with the Project Management Contract, MK-Ferguson Company hereby delivers the attached document to the U.S. Department of Energy, Weldon Spring Site Office. The document has been reviewed and approved by Project Management Contractor management.

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