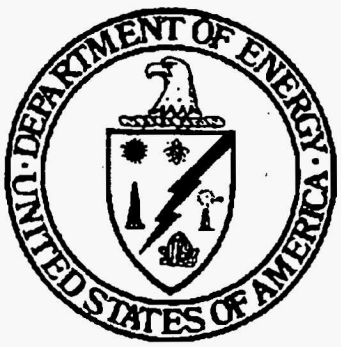
DOE/OR/21548-512
CONTRACT NO. DE-AC05-86OR21548

# WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1994

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

**MAY 1995** **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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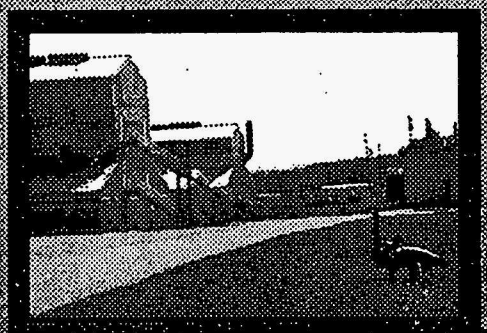

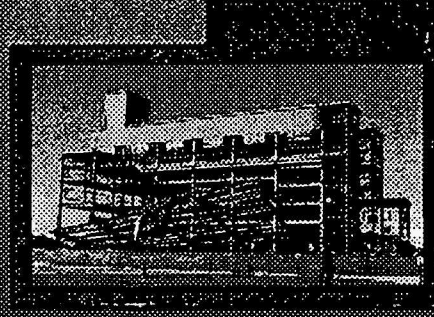

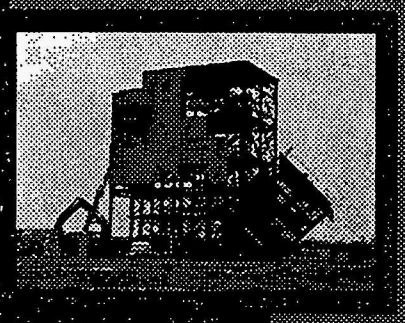

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

May 1995
Rev. 0

Printed in the United States of America. Available from the National Technical Information Service, NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

NTIS Price Codes - Printed copy: A22
Microfiche: A01

40 CFR Part 61 - Subpart H - The National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities

This *Weldon Spring Site Environmental Report for Calendar Year 1994* fulfills the requirement for an annual report as specified in 40 CFR 61.94. This statement applies only to the NESHAPs portion of the Site Environmental Report (Section 6). This clause states:

"Each report shall be signed and dated by a corporate officer or public official in charge of the facility and contain the following declaration immediately above the signature line: 'I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001.'"

Stephen H. McCracken, Project Manager
Weldon Spring Site Remedial Action Project

| MK-FERGUSON A MORRISON KNUDSEN COMPANY | |
|---|---|
| Weldon Spring Site Remedial Action Project<br>Contract No. DE-AC05-86OR21548 | Rev. No. 0 |
| PLAN TITLE: Weldon Spring Site Environmental Report for Calendar Year 1994 | |

## APPROVALS

Department Manager — Date: 5/11/95

Quality Assurance Manager — Date: 05/12/95

Project Director (or Deputy Project Director) — Date: 5/12/95

DOE/OR/21548-512

Weldon Spring Site Remedial Action Project

# EXECUTIVE SUMMARY

Environmental Report for Calendar Year 1994

Revision 0

May 1995

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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# EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 1994* has been prepared to provide information about the public safety and environmental protection programs conducted by the Weldon Spring Site Remedial Action Project (WSSRAP). The Weldon Spring site is located in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry. The chemical plant, raffinate pits, and quarry are located on Missouri State Route 94, southwest of U.S. Route 40/61.

The objectives of the *Site Environmental Report* are to present a summary of data from the environmental monitoring program, to characterize trends and environmental conditions at the site, and to confirm compliance with environmental and health protection standards and requirements. The report also presents the status of remedial activities and the results of monitoring these activities to assess their impacts on the public and environment.

This report includes monitoring data from routine radiological and nonradiological sampling activities. These data include estimates of dose to the public from the Weldon Spring site, estimates of effluent releases, and trends in groundwater contaminant levels. Additionally, applicable compliance requirements, quality assurance programs, and special studies conducted in 1994 to support environmental protection programs are discussed.

Dose estimates presented in this report are based on hypothetical exposure scenarios of public use of areas near the site. In addition, release estimates have been calculated on the basis of 1994 National Pollutant Discharge Elimination System (NPDES) and air monitoring data. Effluent discharges from the site under routine NPDES and National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring were below permitted levels.

## MONITORING OVERVIEW

WSSRAP environmental management programs are designed to ensure that releases from the site are at levels demonstrably and consistently "as low as reasonably achievable" (ALARA). The ALARA principle drives the work activities related to site remediation and contaminant cleanup programs under U.S. Environmental Protection Agency (EPA) enforcement of the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA).

Effluent and environmental monitoring programs provide early detection of contaminants, assessment of potential impacts to the environment, and data needed to implement the ALARA strategy. Routine monitoring also demonstrates compliance with applicable State and Federal permits and regulations.

## REGULATORY COMPLIANCE

The Weldon Spring site is listed on the National Priorities List (NPL) and is governed by the CERCLA. Under the CERCLA, the WSSRAP is subject to meeting or exceeding applicable or relevant and appropriate requirements of Federal, State, and local laws. Primary regulations include the *Resource Conservation Recovery Act* (RCRA), *Clean Water Act* (CWA), *Clean Air Act* (CAA), *Toxic Substances Control Act* (TSCA), and, because the U.S. Department of Energy (DOE) is the lead agency for the site, the requirements of the *National Environmental Policy Act* (NEPA).

Accomplishments under the CERCLA in 1994 were the finalization of the *Quarry Residuals Work Plan* (Ref. 10) and *Quarry Residuals Sampling Plan* (Ref. 11) in January 1994. A *Draft Work Plan* and *Sampling Plan for the Groundwater Operable Unit* were also submitted to DOE-HQ during 1994.

Notable compliance activities included treatment and discharge of water from the quarry and site water treatment plants, development of the *Draft Site Treatment Plan* required by the *Federal Facility Compliance Act*, and a clay cap was placed over the pond and south dump area of Ash Pond to reduce the spread of contamination.

## MONITORING SUMMARY

Environmental monitoring data showed that dose estimates were below the U. S. Department of Energy guideline of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. NESHAPs air monitoring results for radioactive air particulates were all well below the NESHAPs standard of 10 mrem per year. The 1994 air particulate release estimate was 0.00037 Ci (1.4E7 Bq) and was assumed to be natural uranium. This corresponds to a mass release of 0.54 kg.

Release estimates (which include storm water and water from the treatment plants) decreased from the 1993 release estimate of 0.177 Ci (6.5E9 Bq) to 0.071 Ci (2.6E9 Bq) in 1994. Effluent releases were below permitted compliance units. Data from groundwater and surface water monitoring indicated no measurable impact on drinking water sources from Weldon Spring site contaminants.

Dose Estimates

In 1994, the maximum committed effective dose equivalent to a hypothetical individual who frequented the Busch Memorial Conservation Area was 0.018 mrem (0.00018 mSv). This hypothetical individual also consumes fish, sediment, and water from lakes and other bodies of water in the area. The maximum committed effective dose equivalent to a hypothetical individual at the boundary of the quarry was 0.731 mrem (0.00731 mSv). This scenario assumed an individual walking along the southeastern perimeter of the quarry 5 hours/year. The committed effective dose equivalent to the maximally exposed individual at the vicinity property from consumption of fish tissue and inhalation of radioactive air particulates was 0.010 mrem (0.00010 mSv). This scenario assumed an individual fishing at the slough and eating 6.5 g/day of fish. This estimate is below the U.S. Department of Energy (DOE) guideline of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. By comparison, the annual effective dose equivalent in the United States due to naturally occurring sources of radioactivity is approximately 300 mrem (3 mSv).

The collective population dose equivalent for populations assumed to frequent the Katy Trail and the Busch Memorial Conservation Area was 0.072 person-rem (0.00072 person-Sv). The Katy Trail estimate was based on an affected population of 72,000 individuals and the Busch Conservation Area was based on an affected population of 165,895 persons assumed to have potential for exposure through ingestion of fish, water, and sediments.

Air Monitoring

During 1994, airborne releases from the Weldon Spring Chemical Plant (WSCP) area included only radioactive particulates as measured by low volume gross alpha samplers. Airborne releases from the Weldon Spring Quarry included both radioactive air particulates measured by low volume samplers and integrated radon gas. Statistical analysis of air particulate data indicates that the concentrations at five WSCP perimeter monitoring locations, five quarry

locations, and two off-site locations were greater than those recorded at the designated background location. Among the monitoring stations that exceeded background levels, 10 showed 1994 annual concentrations greater than the comparative 1992 and 1993 annual concentrations. This was anticipated due to the progress of building dismantlement at the WSCP area and quarry bulk waste removal activities.

The average integrated radon gas concentration at the quarry perimeter was 0.7 pCi/l above the measured background concentration. The estimated Rn-222 release was 32 Ci (1.2E12 Bq) and the estimated Rn-220 release was 84 Ci (3.1E12 Bq). Statistical analysis of integrated radon data indicates that the concentrations at five stations at the raffinate pits and two stations at the quarry were greater than background levels. Among the monitoring stations that were statistically greater than background measurements, six indicated 1994 annual concentrations greater than the comparative 1992 and 1993 annual concentrations. This was anticipated due to remediation activities that were underway during the year.

The results of NESHAPs monitoring for radioactive particulates indicated that all doses to the public at critical receptor locations were less than 1.0 mrem (0.01 mSv) per year. This dose is below the NESHAPs standard of 10 mrem (0.1 mSv) per year. Critical receptor locations upon which this dose was estimated included the Missouri Highway Maintenance Facility, Francis Howell High School, the WSSRAP administration building, the nearest quarry residence, and the Department of the Army Weldon Spring Training Area (Figures 5-1 through 5-3). Statistical analysis of NESHAPs monitoring results indicated that the only station that had above background results was the Missouri Highway Maintenance Facility station.

During periods of asbestos abatement work, airborne asbestos was monitored as a part of the nonradiological air monitoring program. Only 156 of the 363 samples indicated results above the detection limits. Concentrations indicated that asbestos fibers were effectively contained during abatement operations.

NPDES Monitoring

In 1994, intermittent surface runoff at the Weldon Spring Chemical Plant transported uranium from the site through seven major discharge routes as identified in Section 7 of this report. Radionuclide release estimates were calculated on the basis of the activity of uranium.

The estimate of uranium released to water was 0.035 Ci (1.26E9 Bq) (50 Kg) for U-234, 0.002 Ci (7.4E7 Bq) (2.9 Kg) for U-235, and 0.034 Ci (1.3E9 Bq) (51.5 Kg) for U-238.

Annual average uranium concentrations increased at an abandoned process sewer outfall (NP-0001) and at Outfall NP-0005. The increase at Outfall NP-0001 is attributed to inflow from a storm water source upstream of NP-0005. Levels at Outfall NP-0005 may be attributable to the diversion of water from Outfall NP-0001 to NP-0005. The annual averages decreased at Frog Pond (NP-0002) and at Ash Pond (NP-0003). The reduction at Outfall NP-0002 is attributed to diverting source water containing elevated levels of uranium to the site water treatment plant. Outfall NP-0003 reductions were due to the return of normal precipitation rates during 1994.

The Missouri River was monitored during 1994 in support of quarry and site water treatment plant operations. Both the site and quarry water treatment plants operated during 1994. Surface water and sediment samples were taken from the river and analyzed for uranium. The river receives discharges from both water treatment plants. The sample results indicate that treatment plant discharges caused no increase in radiological contaminant concentrations in river water or sediments.

Surface Water

Surface water monitoring in 1994 indicated that contaminant concentrations were within historic ranges with the exception of uranium concentrations at sampling locations SW-2002 and SW-2016. These locations are the inlet to Busch Lake 36 and downstream in Dardenne Creek. Samples collected at these locations were the first indication that uranium concentrations had increased in the watershed. Sampling conducted upstream of the outfall indicated that the sources of the higher uranium concentrations were most likely related to dust control and storm water runoff associated with building demolition. This water was diverted for treatment until subsequent sampling showed that uranium concentrations had returned to historic levels in both the source water and the water at the outfall.

Groundwater

The groundwater monitoring program included extensive monitoring for radiological and chemical compounds. Radiological results for the St. Charles County well field remained within

background levels. No detectable concentrations of the six nitroaromatic compounds of concern were found in groundwater monitoring wells south of the Femme Osage Slough, including the well field, which is near the quarry.

Environmental monitoring indicates that contamination is still present in the bedrock of the quarry rim and in the alluvial materials and bedrock north of the Femme Osage Slough.

The St. Charles County Well Field was inundated by the Missouri River during the spring; therefore, nine monitoring wells were not sampled during the second quarter of 1994. Subsequent sampling indicated that the St. Charles County production wells were not impacted by contaminants migrating from the bulk wastes in the quarry during the flooding.

At the chemical plant, uranium, sulfate, nitrate, and nitroaromatic compounds in groundwater and springs remained near historic ranges. High concentrations of uranium typically occur in groundwater wells near Raffinate Pit 4 and at the southeast corner of the chemical plant. Contaminant transport continued to be primarily confined to the upper weathered zone of the bedrock aquifer at the plant.

Biological

The results of biological monitoring of fish from Busch Lakes 34, 35, and 36 showed uranium concentrations ranging from 0.0005 pCi/g ($1.85 \times 10^{-5}$ Bq/g) to 0.05 pCi/g (0.002 Bq/g) in edible portions. The calculated dose from ingestion of fish was found to be less than 1 mrem/yr (0.01 mSv/yr) and therefore does not pose a threat to human health.

A 3-year aquatic study was also completed during 1994. A comprehensive report is due out in 1995 summarizing the 3-year study.

DOE/OR/21548-512

Weldon Spring Site Remedial Action Project

# Weldon Spring Site Environmental Report for Calendar Year 1994

Revision 0

May 1995

Prepared by

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U.S. DEPARTMENT OF ENERGY
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## ABSTRACT

This *Site Environmental Report for Calendar Year 1994* 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 from environmental monitoring program.

In 1994, the maximum effective dose equivalent to a hypothetical individual who frequented the Busch Memorial Conservation Area was 0.018 mrem (0.00018 mSv). This scenario assumes an individual consumes fish, sediment, and water from lakes and other water bodies in the area. The maximum effective dose equivalent to a hypothetical individual at the boundary of the Weldon Spring Quarry was 0.731 mrem (0.00731 mSv). These estimates are below the U.S. Department of Energy requirement of 100 mrem (1 mSv) annual committed effective dose equivalent for all exposure pathways.

The collective population dose equivalent for populations assumed to frequent the Busch Memorial Conservation Area (165,895 individuals) and the Missouri Department of Natural Resources' Katy Trail (72,000 individuals) was 0.072 person-rem (0.00072 person-Sv). Results from radiological air monitoring for the National Emission Standards for Hazardous Air Pollutants (NESHAPs) program indicated that all estimated effective dose equivalents were less than 1 mrem (0.01 mSv), which is below the U.S. Environmental Protection Agency (EPA) standard of 10 mrem per year.

Comprehensive monitoring indicated that emissions of radiological compounds in airborne and surface water discharges from the Weldon Spring site consisted primarily of natural uranium and were estimated to be 116 Ci (4.3E12 Bq) and 0.071 Ci (2.69E9 Bq), respectively, for a total of 103,500 grams (103.5 kg). There was no measurable impact to any drinking water source.

Various State and Federal permit levels are monitored under these National Pollutant Discharge Elimination System (NPDES) permits. Permit levels were maintained during 1994 except for one occasion when the administration building sewage treatment plant exceeded the biochemical oxygen demand in April.

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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 1994* is a summary of the environmental monitoring results obtained in 1994 and the status of Federal and State compliance activities.

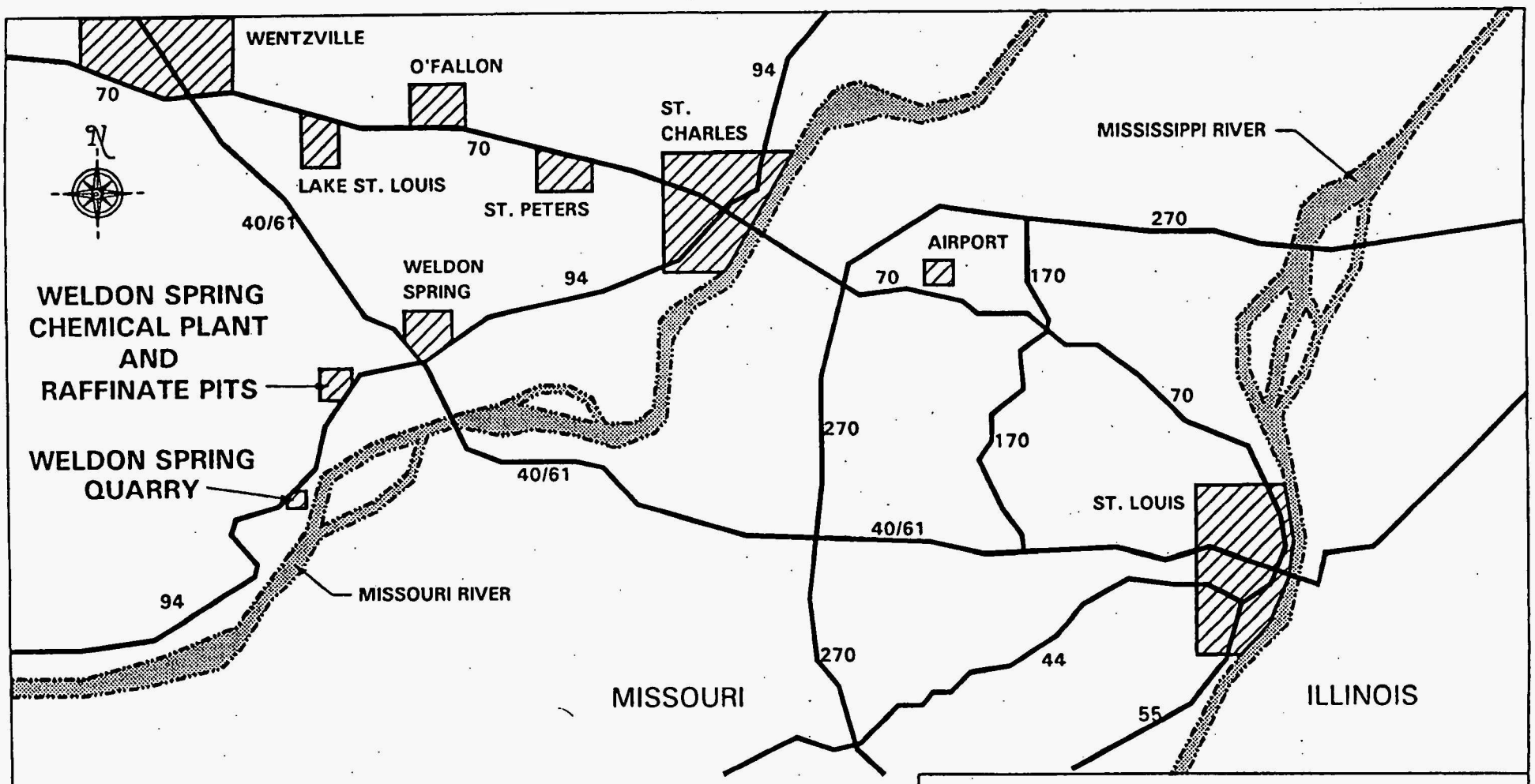
DOE requirements for environmental monitoring and protection of the public, as well as the mandate for this document, are designated in DOE Order 5400.1, *General Environmental Protection Program*, DOE Order 5400.5, *Radiation Protection*, and its implementing guide: *Environmental Regulatory Guide for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

In 1994, 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 ensure public safety and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Site Environmental Report for Calendar Year 1994* include providing general information on the WSSRAP and the current status of remedial activities; presenting summary data and interpretations for the 1994 environmental monitoring program; providing information on mitigative actions for remedial action; documenting continuing compliance with Federal, State, and local requirements and DOE standards; providing dose estimates for radiological compounds as appropriate for the WSSRAP; and 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




# LOCATION OF THE WELDON SPRING SITE

## FIGURE 1-1

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/VP/077/1193 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 11/30/94 |

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 24 hour on-site security.

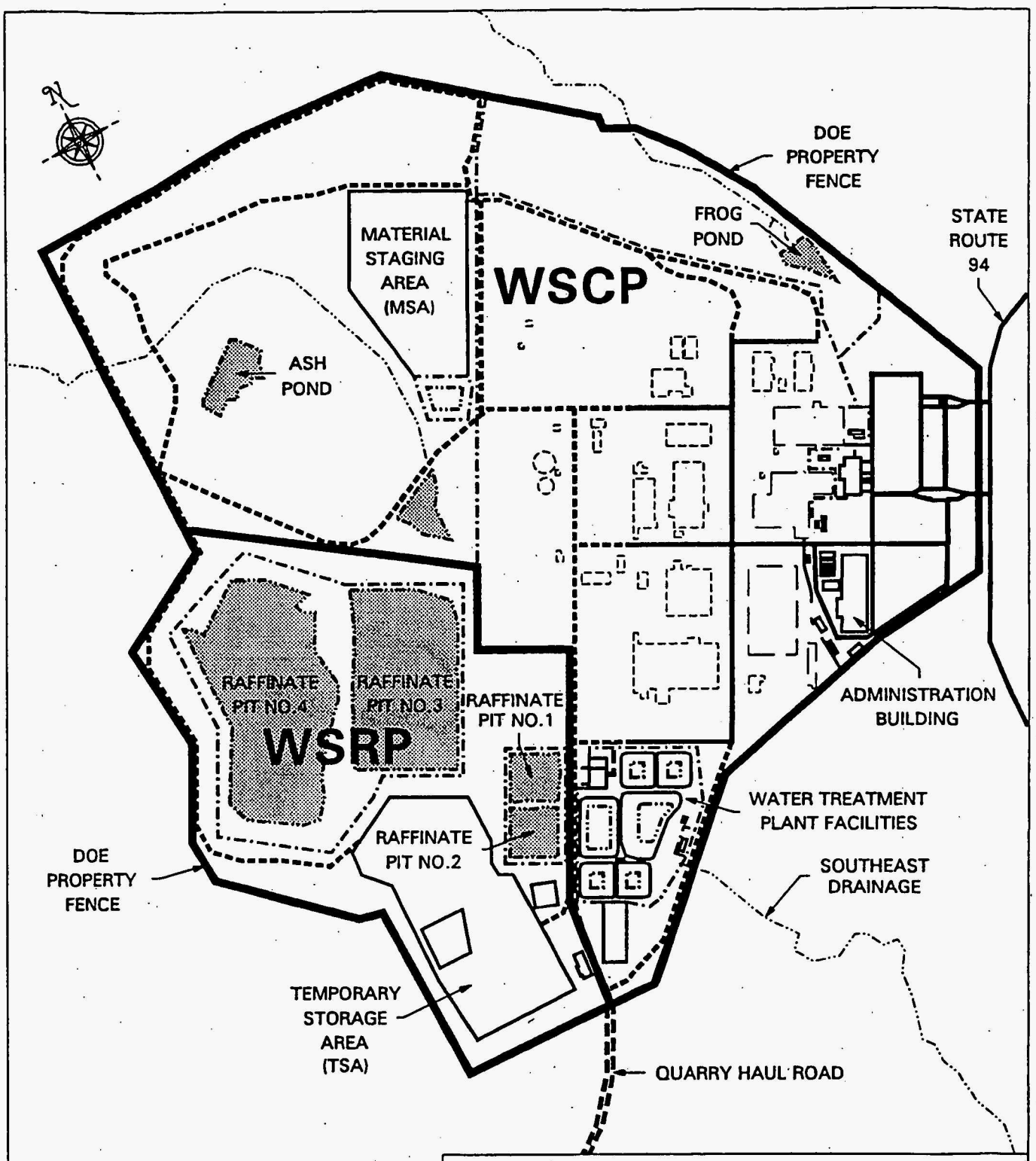
The Weldon Spring Chemical Plant is a 67.2 ha (166 acres) area which operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, and small quantities of uranium and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls, 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 include 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, polychlorinated biphenyls (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 operations. The quarry bulk wastes contain radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatiles, nitroaromatics, and asbestos.

## 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.

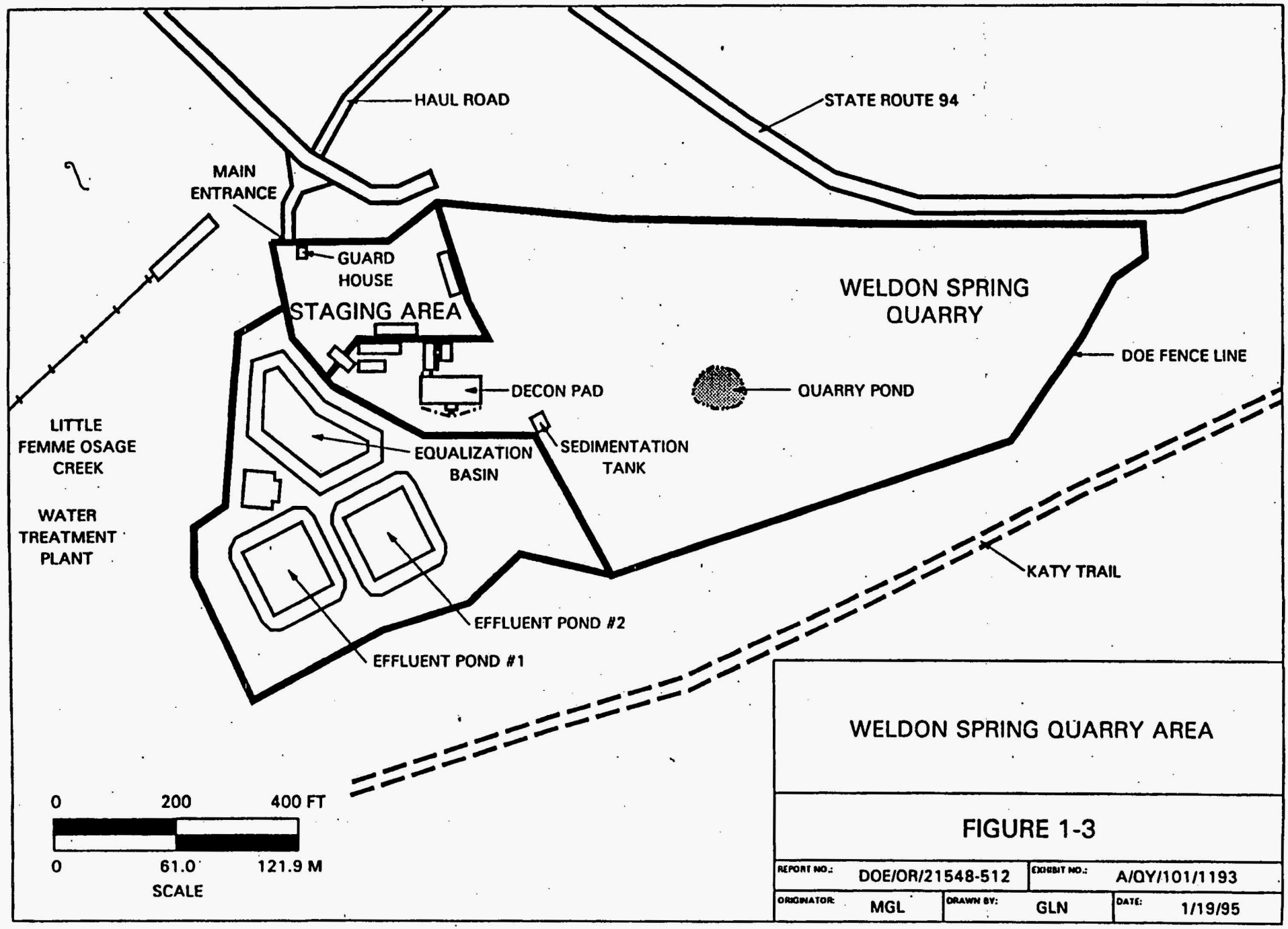
Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former




# WELDON SPRING CHEMICAL PLANT AND RAFFINATE PIT AREAS

## FIGURE 1-2

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/CP/124/1193 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 4/17/95 |




# WELDON SPRING QUARRY AREA

## FIGURE 1-3

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/QY/101/1193 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 1/19/95 |

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 Saint 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

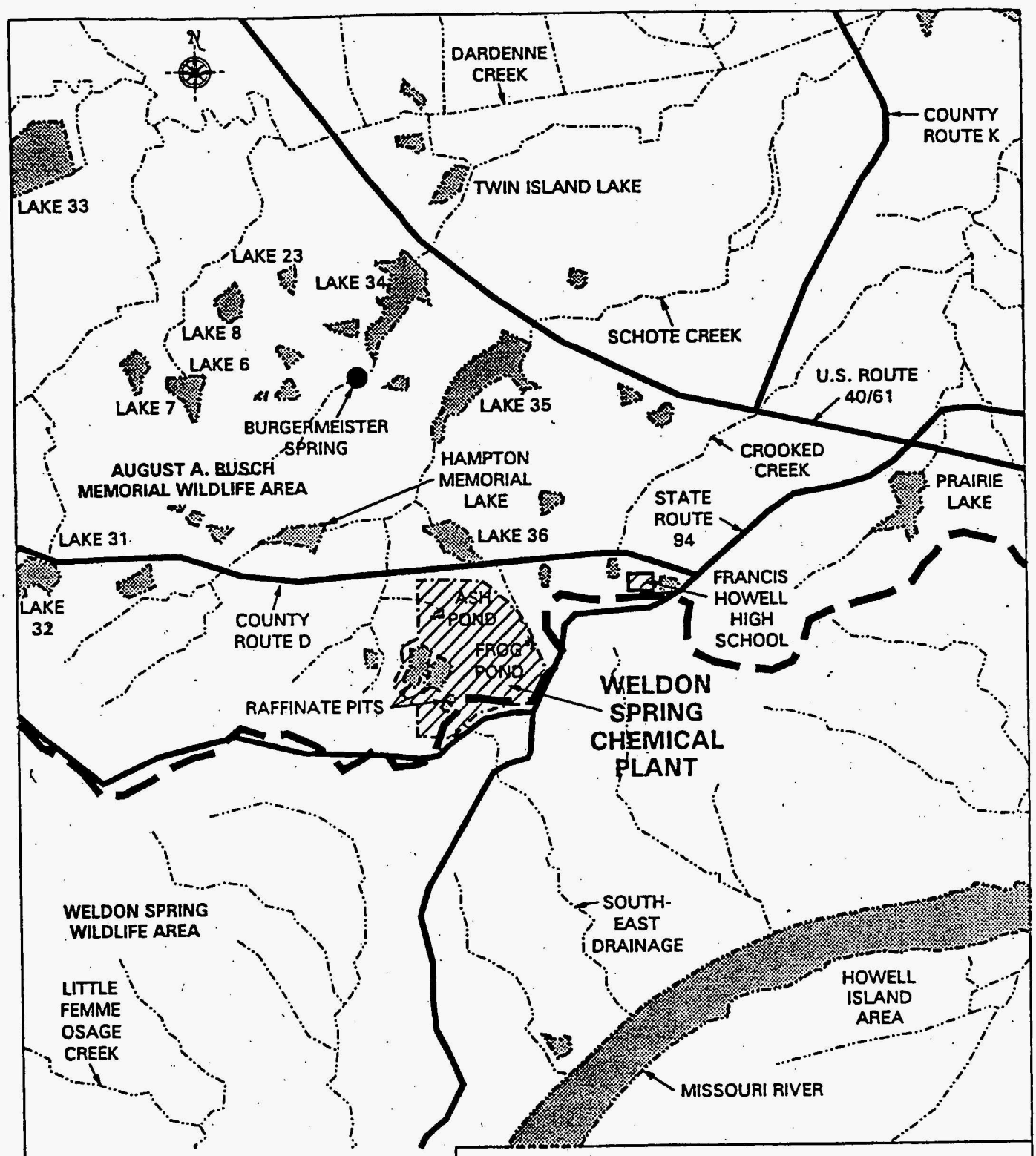
The Weldon Spring site is situated near the boundary between the Central Lowland and the Ozark Plateau physiographic provinces. This boundary nearly coincides with the southern edge of Pleistocene glaciation that covered the northern half of Missouri over 10,000 years ago (Ref. 4).

The Weldon Spring Quarry is located in low limestone hills near the western bank of the Missouri River. The mid-Ordovician bedrock of the quarry area is 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).

There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian Limestones and the middle aquifer consists of the Kimmswick Limestone. The deep aquifer consists of formations from the top of the St. Peter Sandstone to the base of the Potosi Dolomite. Alluvial aquifers are present near the Missouri and Mississippi Rivers.

## 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 six surface water bodies at the chemical plant area: four raffinate pits, Ash Pond, and Frog 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




# NATURAL RESOURCES IN THE WELDON SPRING SITE AREA

## FIGURE 1-4

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/VP/078/1193 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 11/30/94 |

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 in 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 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 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. These drainages, Burgermeister Spring, and Lakes 34, 35, and 36 are contaminated as a result of previous plant operations.

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 (Figure 1-3). 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. Recent dewatering activities in the quarry suggest that the sump interacts directly and rapidly with the local groundwater. The sump is contaminated with radiological and chemical compounds. 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.

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 (Figure 7-2). 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 which 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 (Appendix A).

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 northwest portion of the chemical plant area (22 ha [54 acres]) is relatively natural and contains forest habitat typically found in the upland areas of eastern Missouri.

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).

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. On the average, there are 49 days a year when maximum temperatures are above 32.2° C (90° F). Minimum daily temperatures below 0° C (32° F) occur about 111 days of the year. Temperatures below -18° C (0° F) are infrequent, only about 5 days per year. Mean annual precipitation in the area is approximately 92.7 cm (36.5 in.). The monthly meteorological monitoring results for 1994 are presented in Table 1-1.

Wind data recorded at St. Louis for the period 1941 to 1970 indicate that prevailing winds are from the south during summer and fall, and from the northwest and west-northwest during winter and early spring. The average annual wind speed is about 15.3 kph (9.5 mph) from the south.

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. The station provides data on wind speed, wind direction, ambient air temperature, 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.

The meteorological station was nonoperational from August 1993 through August 1994. Normal operation of the station resumed in the latter part of August 1994, and the first full month of site data was collected in September 1994. Meteorological monitoring results presented in Table 1-1 include data from Lambert-St. Louis International Airport for January through August, and WSSRAP meteorological station data for September through December.

TABLE 1-1 Monthly Meteorological Monitoring Results for 1994

| Month | Total Precip (in.) | Average Temp (degrees C) | Average Barometric Pressure (millibars) | Average Wind Speed (m/sec) | Predominant Wind Direction |
|---|---|---|---|---|---|
| January | 2.09 | -2.9 | 1002 | 4.83 | W |
| February | 1.51 | 1.7 | 1001 | 4.96 | W |
| March | 1.27 | 8.8 | 996 | 4.92 | WNW |
| April | 10.32 | 14.3 | 995 | 5.14 | SSW |
| May | 1.72 | 18.3 | 997 | 3.44 | SSE |
| June | 2.16 | 26.1 | 993 | 3.67 | SW |
| July | 1.42 | 26.4 | 995 | 3.62 | SW |
| August | 3.76 | 24.8 | 997 | 3.80 | S |
| September | 1.59 | 19.3 | 993 | 2.26 | SSW |
| October | 3.37 | 14.7 | 993 | 2.37 | S |
| November | 6.25 | 10.1 | 993 | 3.31 | S |
| December | 2.35 | 3.9 | 997 | 3.72 | NNW |
| Annual Average | 3.15 | 13.8 | 996 | 3.84 | --- |

## 1.7 Land Use and Demography

The population of St. Charles County in 1990 was 212,907; 20% of the population lives in the city of St. Charles, approximately 22.4 km (14 mi) northeast of the Weldon Spring site. The population in St. Charles increased by 48% from 1980 to 1990. 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 1990 was 1,131 (see Appendix A). No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses.

Francis Howell High School and the Missouri Highway and Transportation Department are both within 1 km (0.6 mi) of the site (Figure 1-4). Francis Howell High School is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs

approximately 150 faculty and staff, and about 2,175 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 Transportation Department, located adjacent to the north side of the chemical plant, employs 10 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 employees supplemented by two to 10 workers 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 buildings and 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 Environmental Priorities List (NPL). The DOE is also responsible for complying with the various Federal compliance acts including the *National Environmental Policy Act* (NEPA) of 1969. 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.

## 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 which 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 effluent monitoring and environmental surveillance activities that are performed.

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 at the facility boundary, in migration contaminant 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 on the general public and the environment.

The WSSRAP environmental monitoring program samples various media for radiological elements, primarily U-234, U-238, Ra-226, Ra-228, Th-228, Th-230, and Th-232. These radionuclides are the primary contaminants of concern at the Weldon Spring site. Radiological

monitoring is conducted routinely at the perimeters 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 unplanned releases have occurred. The nonradiological compounds included in the routine 1994 monitoring program are metals, inorganic ions (nitrate and sulfate), and nitroaromatic compounds. Other chemical 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 certain groundwater locations. The geochemical data are used in characterization and contaminant flow transport studies.

## 2.4 Project Accomplishments in 1994

Several activities were completed in 1994 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

A significant event for 1994 was the completion of the final building dismantlement work package. This was a major project milestone. Design work for foundations removal has begun; however, due to funding limitations, removal operations are not scheduled to begin until 1996.

**2.4.1.1 Site Water Treatment Plant.** Ongoing discharges of treated water into the Missouri River have consistently been well below the effluent standards set forth in the conditions of the chemical plant's NPDES permit. During 1994, 114 million liters (30 million gallons) of contaminated water was treated and discharged. The site water treatment plant Train 2 construction contract was awarded in 1994 and a Notice to Proceed was issued in August. Construction is scheduled for completion in the second quarter of calendar year 1995. Train 2 is designed to treat nitrate contaminated water in the raffinate pits.

**2.4.1.2 Building Dismantlement.** The building dismantlement work for Work Packages WP-255 and WP-257 was completed in 1994. The third work package (WP-257) was completed in first quarter 1995.

**2.4.1.3 RCRA/TSCA Storage.** The *Resource Conservation and Recovery Act* (RCRA) and *Toxic Substance Control Act* (TSCA) storage facility, Building 434, is currently being upgraded to support waste storage and operation needs. Improvements will include reroofing, upgrading the fire extinguishing system, adding an emergency shower, and adding a covered area outside the building for expanded storage. Completion of the upgrade is currently scheduled for second quarter of 1995.

**2.4.1.4 Disposal Cell/Cell Support.** The borrow area work package has been negotiating real estate issues for the proposed borrow soil with the Missouri Department of Conservation. Approximately, 1.5 million cubic meters (2 million cubic yards) of soil will be removed in support of the disposal cell construction. A proposal to realign the highway adjacent to the site in support of a haul road underpass has been sent to the Missouri Highway and Transportation Department. Also, a presentation was made to the EPA and the Missouri Department of Natural Resources on the first deliverable for the 30% disposal cell design.

**2.4.1.5 CSS Pilot Plant.** Work Package 354, for construction of a Chemical Stabilization/Solidification (CSS) pilot plant, was awarded and completed in 1994.

**2.4.1.6 Raffinate Pit Berms.** A contract was awarded in October 1994 for repair of the WSSRAP raffinate pit berms. The berms were assessed and stabilization efforts are underway to maintain the berms throughout the remainder of their eight to 12 year life expectancy.

**2.4.1.7 South Dump/Ash Pond Capping.** In October and November of 1994, the Ash Pond and South Dump areas were capped with clay to reduce the spread of contamination via surface water runoff.

### 2.4.2 Weldon Spring Quarry Bulk Wastes Operable Unit

**2.4.2.1 Quarry Water Treatment Plant.** Due to lack of water in the quarry pond, the quarry water treatment plant (QWTP) shuts down periodically. During 1994, the QWTP has treated and discharged approximately 42 million liters (11 million gallons) of contaminated water. All discharges have been within the effluent standards set forth in the conditions of the NPDES Permit for the Weldon Spring Quarry.

**2.4.2.2 Bulk Wastes Removal.** Due to continued problems with the haul vehicles, a direct hauling method was proposed and approved by the DOE during 1994. The new method allows for direct hauling of waste. Over 4,000 loads of bulk waste have been transported from the quarry to the TSA without incident.

Phase II overburden activities were completed in 1994. The materials removed included the overburden, which consisted of soil, rock, brush, and trees. Phase III sump materials are currently being removed and transported to the TSA.

### 2.4.3 Weldon Spring Quarry Residuals Operable Unit

The *Quarry Residuals Work Plan* (Ref. 10) and *Quarry Residuals Sampling Plan* (Ref. 11) were finalized in January 1994. The characterization investigation includes sampling groundwater, surface water, soils, and sediment to determine the effect quarry bulk waste is having on the surrounding areas. Later phases of sampling will concentrate on the quarry proper after the bulk waste has been removed.

The sampling, originally scheduled for October 1993, began in January 1994, and proceeded throughout the year. Due to the floods of 1993, further schedule contingencies were developed in the event that flooding recurs and access to the study areas is again closed. The next phase of sampling is scheduled to begin in November 1995.

### 2.4.4 Groundwater Operable Unit

A draft work plan and sampling plan for the Groundwater Operable Unit were submitted to DOE-HQ during 1994. The WSSRAP and the Department of the Army are working together to jointly address the groundwater issues for the Weldon Spring Ordnance Works and the Weldon Spring Chemical Plant.

## 2.5 Incident Reporting - Environmental Occurrences in 1994

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 report this information in the annual *Site Environmental Report*.

In 1994, six off-normal occurrences and one unusual occurrence were categorized under DOE Order 5000.3B, *Occurrence Reporting and Processing of Operations Information*. Table 2-1 lists these environmental occurrences for 1994.

Occurrence 1994-0004 was a severe hydraulic leak from a subcontractor trackhoe that developed while sizing and placing debris from Building 108. Approximately 57 liters (15 gal) of hydraulic fluid was spilled on the concrete pad. The spill was immediately contained and cleaned up without incident. The root cause analysis determined that a defective or failed part was responsible for the spill. Prior to operations, the trackhoe was thoroughly inspected and approved by the Project Management Contractor (PMC) in accordance with WSSRAP policy. The subcontractor also performed routine inspections and found no indications of potential line failure. The lessons learned were that hydraulic lines and fittings are susceptible to failure, and conducting routine inspections minimizes the potential for line and/or fitting failure.

After analyzing annual data, it was found that an annual average derived concentration guide (DCG) for uranium was exceeded at Outfall NP-0001 in CY1993. This occurrence (Occurrence 1994-0010) resulted in monthly rather than quarterly monitoring at the outfall to help determine measures for decreasing the concentration of uranium. DCGs are not release limits, but are screening values for considering best available technology (BAT) solutions. A root cause analysis was performed and it was found that weather and/or ambient conditions were responsible for the occurrence. Upstream sampling was conducted by the ES&H staff in an

TABLE 2-1 Environmental Occurrences CY1994

| Occurrence Report Number | Occurrence Date | Subject of Occurrence |
|---|---|---|
| 1994-0004(a) | 01/25/94 | Hydraulic fluid spill. |
| 1994-0005(a)(c) | 01/27/94 | Oil release in Raffinate Pit 4 (see Section 3.2.2.1). |
| 1994-0010(a) | 02/14/94 | Annual average derived concentration guide for uranium exceeded at Outfall NP-0001 in 1993. |
| 1994-0017(a) | 04/12/94 | Settleable solids sample results exceeds NPDES permit limits for Outfall NP-0039. |
| 1994-0024(a) | 05/27/94 | Water sample from a QWTP manhole sump showed an elevated uranium concentration. |
| 1994-0025(b)(c) | 05/31/94 | Release of PCB oil by accidental puncture of an intact barrel at the quarry sump zone. |
| 1994-0041(a) | 09/29/94 | Equalization basin liner at the SWTP was damaged during pump replacement. |

(a) Off-normal occurrence.
(b) Unusual occurrence.
(c) See Section 3.2.2.1 for details.

attempt to identify high uranium sources; however, the sampling data were inconclusive as to whether the exceedance was from remediation activities or excessive rainfall. The outfall has since been eliminated and the ditch and upstream storm water inlets were sealed to prevent any potential contamination from leaving the site.

Occurrence 1994-0017 involved a settleable solids reading in excess of the NPDES permit reporting levels for Outfall NP-0039. Outfall NP-0039 is located in the site water treatment plant effluent pipeline construction area. A root cause analysis was performed and it was found that weather and/or ambient conditions were responsible for the occurrence. The steep grade of a hill combined with several 15-cm (6-7 in.) rainfalls in a short period of time caused the erosion and subsequently caused the high settleable solids level. Since the occurrence exceeded the NPDES reporting level, a letter of notification was sent to the Missouri Department of Natural Resources (MDNR) within 5 days, as required. In addition, diversion dikes were installed to slow the flow down the hill. Construction of the pipeline has since been completed and the disturbed areas have been stabilized.

Occurrence 1994-0024 involved an elevated uranium contamination level detected during the sampling of water from a QWTP manhole sump. The sump contains groundwater that is diverted from a French drain prior to being pumped into the QWTP equalization basin for treatment. All pumping of water from the quarry pond sump to the equalization basin was restricted. Nearby groundwater wells were sampled and the sump hose was shortened above the equalization basin overflow spillway. Potential pathways were investigated to determine the cause for the increase in uranium concentration found in the manhole sump. The root cause of the occurrence was found to be a violation of requirements in a procedure by personnel. Personnel were instructed not to deviate from procedures. The DOE was notified. The usual level of water in the equalization basin is between 30 in. (76 cm) to 40 in. (102 cm); however, in this case it was allowed to fill to a level over 70 in. (178 cm). When the water filled above the normal level, the hose was submerged, allowing a back-syphoning to the groundwater sump.

Occurrence 1994-0041 involved damage to the SWTP equalization basin during pump replacement. When workers were replacing a pump at the basin, the pump was dropped from a height of about 0.9 m (3 ft) through standing water onto the bottom of the basin. The pump struck the liner causing three punctures. In accordance with the *Leachate Production Action Response Plan* (Ref. 12), the DOE was notified that Action Level III had been exceeded. The DOE provided written notification to the MDNR and the EPA within five working days. The equalization basin was pumped down in order to complete repairs on the liner. Groundwater samples collected from monitoring wells around the basin were analyzed for uranium, chlorides, fluorides, and nitrates. The analysis indicated no detection of chloride, which was used as the indicating parameter. The root cause was determined to be an inadequate work environment. There were no anti-fall devices in place to prevent damage/falls. A shore- mounted pump was installed to allow easier access to the pump for maintenance. Workers discussed the occurrence at the weekly safety meetings to prevent recurrence.

Releases reported to other agencies (i.e., the EPA, the 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 *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, including the radiological control program, self assessments under DOE Order 5482.1B, and the surface water management program in place at the WSSRAP to support the environmental protection program.

### 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 fundamental methods such as groundwater sampling, water level monitoring, slug tests, tracer tests, and geologic logging.

### 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, barometric pressure, 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.

A meteorological system upgrade was completed in August 1994. The upgrade consisted of replacing the old tower and instrumentation with heavy-duty units and computerized enhancements designed to improve data retrieval and archival. In addition, an off-site meteorologist now 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. An ALARA evaluation is being conducted during 1995.

This plan identifies existing and potential water sources, water quality categories, and also 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 in the plan. The key elements of the plan are source identification, characterization, monitoring, engineering controls, and management methods. During 1994, 378 controlled releases of water have been managed through this program.

### 2.6.4 Radiation Protection Program

The *U.S. Department of Energy Radiological Control Manual* (RADCON) (Ref. 15), specifies how the DOE expects all facilities and contractors to conduct and manage their radiation protection programs. RADCON requirements extend beyond the requirements of 10 CFR 835 (*Occupational Radiation Protection*), which was issued in December 1993 in the Federal Register and sets the minimum acceptable radiological control standards for DOE facilities. The manual contains requirements for all aspects of radiation protection, including protective measures for contamination control, ALARA practices, internal and external dosimetry, protective clothing and equipment, instrumentation and calibration, worker training, warnings and sign postings, survey procedures, waste management, environmental surveillance, and shipping and receiving. The DOE's objective in preparing this manual was to ensure that worker training and radiation protection programs are consistent among DOE facilities.

The WSSRAP is in compliance with approximately 91 % of the provisions in the manual and has an aggressive implementation plan and schedule for complying with the remaining provisions.

### 2.6.5 Waste Management Program

The waste management program involves characterization of hazardous chemicals and wastes found on site and proper storage of the waste. This program also encompasses the packaging and shipping of hazardous waste samples. Hazardous and mixed wastes are stored in the on-site RCRA and TSCA storage facility, Building 434, and at the asbestos storage area and temporary storage area until a final treatment or disposal option is available. No RCRA waste has been shipped off site; therefore, the WSSRAP has not been required to comply with RCRA manifest or biennial report requirements.

Waste minimization and pollution prevention activities at the Weldon Spring site have been combined and are described in the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 16). The key elements of this program are chemical control, training and awareness, work activity review, and a recycling program.

### 2.6.6 Self-Assessment Program

The WSSRAP has attempted to comply with the guidelines and requirements presented in DOE Order 5482.1B and the Secretary of Energy Notice dated July 29, 1990, for the development and implementation of a self-assessment program. The WSSRAP has developed and implemented a *Self-Assessment Program Implementation Plan* (Ref. 17), associated procedures, auditor and root cause analysis training, and a number of self-assessments have been performed by various Project Management Contractor (PMC) department managers.

In spite of these accomplishments, the PMC has not fully implemented this program as noted during the performance of the 1993 and the 1994 Functional Appraisals. In response to findings noted during these appraisals, the PMC has initiated the following corrective measures:

- The program will be evaluated to determine its feasibility and to simplify the self-assessment process.

- WSSRAP Procedures SQP-24a, *Administration and Conduct of Self-Assessments*, and MGT-6a, *Surveillances and Walkthroughs* will be combined into one procedure i.e.,

MGT-9a, *Guidance for Conducting Self-Assessments, Surveillances, and Walkthroughs*.

- Training will be conducted to fully implement MGT-9a.
- The *Self-Assessment Program Implementation Plan* (Ref. 17) will be revised.

Three self-assessments were conducted at the WSSRAP during 1994, addressing shipping document files, Service Contract Act compliance, and wastewater treatment operations.

### 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 1994

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 *Toxic Substance Control Act* (TSCA), the *National Historic Preservation Act* (NHPA), the *Safe Drinking Water Act* (SDWA), and Missouri regulations. Because the DOE is the lead agency for the site, the procedural and documentation requirements of the *National Environmental Policy Act* (NEPA) must also be met, as well as the requirements of U.S. Department of Energy (DOE) Orders. Section 3.1.1 is a summary of WSSRAP compliance with applicable Federal regulations, and Section 3.1.2 is a summary of the WSSRAP compliance with major DOE Orders.

### 3.1.1 Regulatory Compliance Status

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. For example, *Engineering Evaluation/Cost Analyses* (EE/CAs) and *Remedial Investigation/Feasibility Study* (RI/FS) documents including (RI/FS) work plans, which are CERCLA documents, contain the required NEPA information for *Environmental Assessments* (EAs) and *Environmental Impact Statements* (EISs).

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.

National Environmental Policy Act

On June 13, 1994, a memorandum from Hazel R. O'Leary, Secretary of Energy, was sent to all DOE secretarial officers and heads of field elements. The subject of the memorandum was the NEPA Policy Statement, which has been included in Appendix A. Specifically, the DOE will rely on the CERCLA documentation process for review of actions to be taken under CERCLA and will address NEPA values and public involvement procedures within the CERCLA documents.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site are managed as required by the RCRA (as substantive applicable or relevant and appropriate requirements [ARARs]). 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 FFCA waives sovereign immunity for fines and penalties for RCRA violations at Federal facilities. However, a provision postpones that waiver for 3 years for mixed waste Land Disposal Restriction storage prohibition violations at DOE sites, and requires the DOE to prepare plans for developing the required treatment capacity and treatment technologies for mixed wastes. Each plan must be approved by the State or the U.S. Environmental Protection Agency (EPA), after consultation with other affected States and

consideration of public comment, and an order issued, by the regulator, requiring compliance with the plan.

The Weldon Spring site submitted its *Conceptual Site Treatment Plan* to the Missouri Department of Natural Resources and the Environmental Protection Agency in October 1993. The *Draft Site Treatment Plan* was submitted in August 1994. The *Proposed Site Treatment Plan* will be submitted by March 1995.

Currently, two underground storage tanks containing gasoline and diesel fuel remain on site. The tanks are scheduled to be closed during removal of the building foundations.

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

Toxic Substances Control Act

Polychlorinated biphenyls (PCBs) that have been removed from service are stored on site. Regulation 40 CFR 761.65 requires that any PCB article or container be removed from storage and disposed of within 1 year from the date it was first placed in storage; however, the WSSRAP is currently storing PCB articles and containers longer than 1 year as waived in accordance with the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 24). PCB wastes will be stored in an adequate PCB facility (meeting the requirements of 40 CFR 761.65[b]) until final disposition of the PCB wastes can be accomplished.

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 1994 indicate the highest receptor location 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 oxide ($NO_x$) 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 5 and 6, along with the 1994 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 liter (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 and budgets 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 ozone-containing equipment (i.e., refrigerators, heating, ventilating, and air conditioning [HVAC] units, abandoned refrigeration units, etc.) or any WSSRAP vehicle cooling system.

Clean Water Act

Effluents discharged to waters of the United States are regulated under the 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 includes meeting parameter limits set in five National Pollutant Discharge Elimination System (NPDES) permits. Both effluent and erosion-control monitoring are performed. Section 7 includes additional details on the NPDES permits.

During 1994, 41.8 million liters (11 million gallons) of water was treated through the quarry water treatment plant and discharged through the QWTP NPDES outfall. In the same period, 114 million liters (30 million gallons) of water was treated through the site water treatment plant and discharged through the SWTP NPDES outfall.

Rivers and Harbors Act

On February 1, 1994, the WSSRAP made applications to the U.S. Army Corps of Engineers (COE) under Nationwide permit (NWP) 26, Section 404 of the *Clean Water Act* for the elimination of 0.9 ha (2.2 acre) of wetlands in the borrow area. The acreage would be mitigated by the creation of 2 ha (5 acres) of wetland as part of a 21 ha (52 acre) waterfowl habitat prospect on Missouri Department of Conservation (MDC) lands. On March 11, 1995, the Kansas City COE authorized the requested activities, contingent upon a signed mitigation agreement between the DOE and the MDC and the special conditions outlined in Nationwide Permit 26.

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 1994. The site currently has one person certified as an applicator and is in the process of training and certifying another individual.

Department of Transportation

Pursuant to HM-181, the WSSRAP conducted on-site training on the *Hazardous Material Transportation Act*. The training targeted personnel with responsibilities for hazardous materials transportation. The training covered classification of hazardous materials by new shipping names, new performance based packaging requirements, new requirements for marking, labeling and placarding, and proper segregation and modes of transportation. The appropriate personnel are current on the training requirements and retraining is required on a biannual basis.

Safe Drinking Water Act

Currently, the SDWA is not an ARAR 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 *Emergency Planning and Community Right-to-Know Act (EPCRA) Tier II* report was completed and provided to the local emergency planning committee (LEPC) and to the Missouri State Emergency Response Commission (MERC).

In June of 1994, the WSSRAPs first Toxic Release Inventory (TRI) report was submitted, which included nine chemicals, to the EPA under the DOE voluntary early response program. The process to complete the report identified numerous refinements that will be required in order to complete future reports.

The WSSRAP continued to identify the full EPCRA requirements and developed a plan of action to assist in preparing EPCRA reports for chemical storage and use. The plan included purchasing an off-the-shelf software program to replace the site's current system. The new system is capable of providing complete requirements under SARA Title III and also generates Tier II and TRI reports.

National Historic Preservation Act

The *Mitigation Action Plan for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 18) area specifies that any sites eligible for nomination to the National Register will be preserved through data recovery or avoidance if impacted by the borrow area or haul road development. This work is ongoing and will extend into 1995.

The Phase II archeological study for the proposed borrow area development was completed April 1994, and no sites were identified that meet the eligibility requirements for preservation, data recordation, and recovery (Phase III). The State Historic Preservation Officer concurred with conclusions of the Phase II survey. The site has not yet received the official reports for the Phase II study.

The construction material staging area will require the DOE fenceline to be moved within a 30. 5 m (100 ft) easement to allow for proper sloping of the area. A Phase I archeological survey concluded that there was no effect to cultural resources in the potentially affected area.

Endangered Species Act

There were no work projects established in 1994 that required consultation with the U.S. Fish and Wildlife Agency.

Executive Order 11990 Protection of Wetlands

The Mitigation Agreement (Appendix A) for the mitigation of borrow area wetlands between the Missouri Department of Conservation (MDC) and the U.S. Department of Energy-Weldon Spring (DOE-WS) was approved in November 1994. This agreement provides partial funding of a wetland creations project on MDOC property in exchange for the creation credits and is a condition of the Nationwide Permit Number 26 received by the site. This permit allows for the temporary loss of the 0.9 ha (2.2 acres) of wetlands in the borrow area development.

A wetlands survey for the construction material staging area was conducted by ANL on December 16, 1994. One jurisdictional wetland was noted and is being addressed in the

wetlands Mitigation Agreement with MDC. One other wetland area was identified outside the proposed fenceline expansion, but no action is anticipated.

### 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 nine 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 1994. The appropriate dose evaluation techniques were used to assess 1994 environmental monitoring and surveillance data in compliance with this requirement.

Storm water runoff exceeded the derived concentration guideline (DCG) of an annual average of 600 pCi/l for uranium at Outfall NP-0001 with an annual average concentration of 1,226 pCi/l. Outfall NP-0001 was eliminated by removing the outfall pipe during May 1994 and is further discussed in Section 7.5.1.

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 1994 are being maintained in accordance with the requirement of this order. All reports and records generated at the WSSRAP in 1994, 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 III (low-level waste), 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 IV were not present at the site.

**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 an alternate method 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.** On January 27, 1994, approximately 57 liters (15 gal) (4,000-5,000 parts per million PCBs) of polychlorinated biphenyl (PCB) contaminated oil was released having leaked from materials that were abandoned in Raffinate Pit 4 approximately 30 years ago (Occurrence 1994-0005). The materials included discarded equipment and corroded storage barrels. The release was contained and efforts to absorb the oil were initiated. These efforts included the placing of an absorbent boom on the water surface and the draining of barrels near the edge of the water. A root cause analysis was performed and it was found that the former management of the site did not provide an environment conducive to the proper storage of the drums (i.e., the drums were placed in an environment that led to their degradation). The DOE and the EPA (Region VII) were notified. Corrective actions included: the containment and control of contaminated oils in Raffinate Pit 4, as stated above; debris and barrels near the water's edge were moved to higher ground where practical; barrels that contained oil were pumped and moved to appropriate storage where practical; and the condition of Raffinate Pit 4 was monitored daily during the work week.

On April 27, 1994, approximately 1.4 kg to 1.8 kg (3 lbs to 4 lbs) of ethylene glycol was released onto the Building 401 concrete pad. This release exceeded the reportable quantity (RQ) for ethylene glycol under the CERCLA, which is 0.45 kg (1 lb). The release was reported to the National Response Center (NRC) on April 27, 1994, as a release of a reportable quantity.

On July 6, 1994, approximately 2.3 kg to 2.7 kg (5 lbs to 6 lbs) of ethylene glycol was released when a piece of paving equipment broke a radiator hose. This release exceeded the RQ for ethylene glycol under the CERCLA, which is 0.45 kg (1 lb). The release was reported to the NRC as a release of a reportable quantity. Some of the spilled material fell into a catch pan and boiled off, and the remaining material spilled onto the asphalt and was covered by additional asphalt; therefore, no cleanup was possible.

On May 25, 1994, PCB contaminated oil was released at the quarry sump zone due to an accidental puncture of an intact drum (Occurence 1994-0025). During a PMC inspection of

the drum pile at the quarry sump zone, one of the drums was found to be leaking. This occurred when the subcontractor was moving debris away from the drum pile using an excavator with a grappler attachment. Approximately 2.3 kg (5 lbs) of liquid leaked from the container. Using qualitative methods it was found that PCBs were present; and the PCB concentration was assumed to be 500 ppm based on 40 CFR 761.123. Samples were taken and sent to an off site laboratory for analysis. The sampling results showed positive results for chlorine greater than 50 parts per million (ppm) and PCB concentration of 120,000 ppm. The PCB volume released exceeded the reportable quantity of 0.45 kg (1 lb); therefore, the required notifications were made to the DOE, the EPA, and the National Response Center (NRC) on May 31, 1995.

The release was not reported until May 31, 1994, because the PCB concentration was assumed to be 500 ppm at the time of the release. As stated previously samples were also taken and submitted for off-site analysis which indicated a much higher PCB concentration than 500 ppm originally assumed. Although there was a delay in reporting, due to the inaccurate concentration estimate, immediate actions were taken to clean up the spill. The spill was cleaned up and wastes placed in a 321 liter (85-gallon) overpack. Root cause analysis determined that an inadequate work environment was the reason for the occurrence. The material being removed had been resting in one place for approximately 33 years, causing the drums to deteriorate. Once the material was moved to decommission the quarry sump zone, the deteriorated drums released their contents to the environment. The leaking drum and the surrounding soil were overpacked by subcontractor personnel. The PMC has instructed the subcontractor to proceed with caution as the remedial action continues.

On October 26, 1994, approximately 7.3 kg (16 lbs) of ethylene glycol was released from a radiator hose on a truck used to transport rolloff containers. This release exceeded the RQ for ethylene glycol, which is 0.45 kg (1 lb). The release was reported to the NRC as a release of a reportable quantity under the CERCLA. The spill was immediately cleaned up.

Occurrences noted under the DOE Order 5000.3B are not discussed in this section. Refer to Section 2.5, Incident Reporting - Environmental Occurrences in 1994, for discussion of those types of occurrences. The WSSRAP did not have any EPCRA reportable releases.

**3.2.2.2 Functional Appraisal - Environment, Safety and Health, and Quality Assurance.** A functional appraisal of selected environmental, safety, health, and quality

TABLE 3-1 Results of Oak Ridge Functional Appraisal

| | New Findings Cited | Previous Findings Open | Previous Findings Closed |
|---|---|---|---|
| Water Pollution Control | 6 | 2 | 10 |
| Environmental Quality Assurance | 4 | 0 | 2 |
| Groundwater Programs | 3 | 0 | 3 |
| Asbestos Management | 3 | 2 | 1 |
| Radiological Monitoring | 7 | 0 | 9 |
| Toxic and Hazardous Substance Control | 6 | 1 | 3 |
| Quality Assurance | 6 | 3 | 7 |
| Health Physics | 2 | 0 | 3 |
| Industrial Hygiene | 2 | 2 | 2 |
| Industrial and Construction Safety | 0 | 2 | 9 |
| Transportation Safety | 0 | 0 | 1 |
| Fire Protection | 4 | 5 | 0 |
| Facility Safety (Safety Analysis Process) | 3 | 0 | 0 |
| Total | 46 | 17 | 50 |

assurance programs was conducted by the DOE Oak Ridge Operations Office from July 12 to July 21, 1994 at the WSSRAP. The appraisal was performed to assist the WSSRAP site office in their management assessment.

Table 3-2 summarizes the number of deficiencies resulting from the functional appraisal of selected environmental safety, health, and quality assurance programs.

**3.2.2.3 Compliance with the Price-Anderson Act.** The PMC has revised the *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 22), by applying the quality assurance criteria specified in paragraph (c) Quality Assurance Criteria, of 10 CFR 830.120. The PMC QAP includes discussion of how the criteria in paragraph (c) will be satisfied.

## TABLE 3-2 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-G679035 | O | 08/31/94 | 10/10/97 | N | 04/10/97 | Operating permit covers hydrostatic testing for newly constructed pipelines at the SWTP Train 2 Facilities and the treatment plant. |
| MO-R100B69 | O | 09/01/94 | 06/11/97 | N | 12/11/96 | Storm water discharges from the borrow area and haul road operations. |
| MO-R101389 | O | 12/07/92 | 12/12/96 | N | Terminated 09/28/94 | Covered land disturbance storm water discharges from the SWTP pipeline excavation. |
| 22-4670 | C | 04/19/94 | 04/18/95 | N | 03/18/95 | SWTP Train 1 nitrate removal system. |
| 22-4711 | C | 06/29/94 | 06/28/95 | N | 05/28/95 | SWTP Train 2 appurtenances. |
| 22-4750 | C | 09/28/94 | 09/27/95 | N | 08/27/95 | Construction of the SWTP Train 2. |

(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

On November 3, 1994, the PMC submitted to the U.S. Department of Energy (DOE) a current PMC QAP and the *Project Management Contractor Quality Assurance Program Implementation Plan* (QAPIP) (Ref. 23).

The PMC submitted the draft *Radiation Protection Program Implementation Program Plan* (RPP/IP) to the DOE December 27, 1994. This program is currently under review by the DOE and will be completed during the second quarter 1995.

## 3.3 Summary of Permits for 1994

Various permits were maintained by the WSSRAP for remedial activities including NPDES, excavation, and floodplain permits. Table 3-2 provides a summary of all NPDES and Construction 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 site water treatment plant pipeline excavation (MO-R101389). Two additional operating permits (MO-G679035 and MO-R100B69) were issued during 1994, but activities had not progressed to the point where discharges occurred. Three NPDES construction permits (22-4670, 22-4711, and 22-4750) were also issued during 1994.

## 3.4 Site Remedial Mitigation Action Plan

The wetland mitigation program was delayed pending final signatures. The Missouri Department of Conservation (MDC) and the DOE signed the agreement on February 9, 1994, and November 21, 1994, respectively (Ref. 19). The Army Corps of Engineers was advised that the agreement has been completed, that all conditions of Nationwide Permit No. 26 were now met, and that the parties would now proceed with the project as described.

The MDC anticipates construction of the wetland to begin in the spring of 1996, as their 1995 construction schedule was already completed before the agreement was signed.

## 3.5 Compliance Status for the Period January 1 - April 15, 1995

Compliance status remained unchanged under the RCRA, the CAA, the *Endangered Species Act*, the National Historic Preservation Act, Executive Orders 11988 and 11990 and DOE Orders.

Comprehensive Environmental Response, Conservation, and Liability Act

The Weldon Spring site recently requested various State and Federal Agencies to review and provide comments on the applicability of the CERCLA reporting requirements under Section 103 for planned remedial action activities currently underway at the Weldon Spring Quarry. CERCLA contains provisions requiring notification to the government authorities whenever a reportable quantity (RQ) of a hazardous substance is released. To date, the Project's position has been that planned remedial actions conducted in accordance with an approved Record of Decision (ROD) are not reportable. However, based on recent guidance provided by DOE headquarters and Oak Ridge Operations General Council in collaboration with EPA Headquarters General Council, the Project has determined that the planned activities within the Weldon Spring Quarry boundaries should be reported and subsequent notification was made by telephone to the National Response Center (NRC) on January 18, 1995, at approximately 1415 hours. This initial telephone notification was made in accordance with the provisions of 40 CFR 302.8 entitled *Continuous Releases*. Section 103(f)(2) of CERCLA provides relief from the immediate reporting requirements of CERCLA Section 103(a) for release of hazardous substances that are continuous and stable in quantity and rate. A follow-up written notification was submitted within 30 days, as required by 40 CFR 302.8.

Per discussions with EPA Region VII representatives, the PMC received guidance on the definition of "immediate" release reporting. The EPA emphasized that release reporting should not be delayed in order to determine hazardous chemical concentrations in the release. The PMC agrees and will minimize the time spent qualifying chemical concentrations in any future releases.

On January 17, 1995, at approximately 0720 hours, ethylene glycol (~8 pounds) was discovered leaking from a Grove 850 crane. The absorbant gravel and soils were placed in a container. The National Response Center (NRC) was contacted.

On January 26, 1995, at approximately 1400 hours, ethylene glycol (~2 pounds) was discovered leaking from a loose hose clamp on the radiator hose of a catapiller excavator. The NRC was notified of the spill. The free liquid was absorbed and the soils and absorbant pads placed in a container.

On February 8, 1995, at approximately 1020 hours, ethylene glycol (~12 pounds) was discovered overflowing from a heavy equipment truck at the quarry buffer area. The NRC was notified. The spill was cleaned up and the absorbant pads were placed in a container.

On February 13, 1995, at approximately 0822 hours, ethylene glycol (~1 pound) was discovered overflowing from a Terex truck (heavy equipment truck) in the quarry buffer area. The NRC was notified. The free liquid was absorbed into the pads and placed into a container.

On Monday, February 27, 1995, at approximately 0310 hours, a pipe fitting failed during regeneration of the activated alumina at the site water treatment plant (SWTP) and approximately 150 gallons of sodium hydroxide solution (pH-13) spilled. A small portion was diverted by a culvert into an on-site siltation basin, containing approximately 300,000 gallons of water. The spill was neutralized to a pH of about 6. Personnel at the SWTP diverted the flow to the equalization basin and isolated the tank. The SWTP was temporarily shut down. Initially this event was reported to the NRC; however, after additional information was gathered, it was determined that a reportable quantity (RQ) had not been released. An EPA Region VII follow-up report is currently being prepared.

Price Anderson Act

The WSSRAP has received approval of the QAP and QAPIP for compliance with 10 CFR 830.120 from DOE on January 27, 1995.

Resource Conservation and Recovery Act

The PMC submitted the *Proposed Site Treatment Plan* to MDNR on March 31, 1995, as required by FFCA.

# 4 RADIATION DOSE ANALYSIS

Environmental monitoring is performed at the Weldon Spring site to demonstrate that public health and safety and the environment are protected, to document and quantify potential public exposure, and to demonstrate compliance with applicable legal and regulatory requirements. This section evaluates atmospheric monitoring results and surface and groundwater discharges of radiological contaminants. The evaluations presented include potential calculated dose equivalents to the general public and doses to aquatic biota. These calculations are evaluated against U.S. Department of Energy (DOE) guidelines contained in DOE Order 5400.5.

Dose calculations are presented in this section for each of the following: a maximally exposed individual, a collective population, and native aquatic organisms. 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 Emission of Radionuclides Other Than Radon From Department of Energy Facilities)* are presented in Section 6, NESHAPs Program.

## 4.1 Pathway Analysis

In developing specific elements of the Weldon Spring Site Remedial Action Project (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. Required by DOE Order 5400.1, evaluation of each exposure pathway is based on the sources, release mechanisms, types, and locations of contaminants; the probable environmental fates of the 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, then 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 4-1 lists the six complete pathways for exposure from contaminants evaluated by the WSSRAP environmental monitoring program. These pathways are used to determine radiological and nonradiological exposures from the site. Of the six complete pathways, five were applicable in 1994 and were thus incorporated into dose estimates. These are Liquid (B), Liquid (C), Airborne (A), Airborne (B), and External.

TABLE 4-1 Exposure Pathways for the Weldon Spring Site

| Exposure Pathway | Pathway Description | Applicable to 1994 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 |
| Airborne(B) | Inhalation of radon emitted from contaminated soils/wastes. | Y |
| External | Direct gamma radiation from contaminated soils/wastes. | Y |

As shown in Table 4-1, the Liquid (A) pathway is not applicable to the 1994 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/raffinate pits area.

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

- NESHAPs standard of 10 mrem (0.10 mSv) total effective dose equivalent annually for airborne emissions other than radon at critical receptor locations.

- DOE guideline of 100 mrem (1 mSv) total effective dose equivalent for all exposure pathways on an annual basis.

## 4.2 Radiological Release Estimates

Estimates of radiological releases to air and surface water were calculated for radioactive particulates and radon gas. Table 4-2 shows the estimated activity release of radionuclide to the environment, the corresponding mass released, and the half-life for each radionuclide. The dashes in Table 4-2 indicate that the amount of radioactivity released to the environment was not distinguishable from background levels.

Airborne particulate release estimates were calculated based on NESHAPs monitoring results at two critical receptors located at the chemical plant perimeter. Isotopic analysis of these measurements shows that the primary contaminant is natural uranium. The isotopic release estimates for the chemical plant assume a natural uranium isotopic activity ratio (49.1% U-234, 2.3% U-235, and 48.6% U-238). The Clean Air Act Assessment Package - 1988 (CAP-88) model was used to predict the airborne particulate release rate from the chemical plant and the quarry. This model is an EPA approved Gaussian plume model. The assumptions used in estimating airborne releases are shown in Appendix B. Complete NESHAPs results are provided in Section 6 of this report.

Based on alpha-track radon monitoring results, the average integated radon concentration at the quarry area perimeter was 0.7 pCi/l above background. Box models were used to predict the radon release rate from the quarry for the year. In 1994, the estimated Rn-222 release was 32 Ci (1.2E12 Bq). The estimated Rn-220 release was 84 Ci (3.1E12 Bq). Calculations and assumptions are provided in Appendix B.

During 1994, intermittent surface water runoff transported uranium from the site through three major discharge routes. These routes were monitored through monthly sampling of the

## TABLE 4-2 Radionuclide Emissions to the Environment

| Radionuclide | Activity of Radionuclide Released to Air (Ci) | Activity of Radionuclide Released to Water (Ci) | Mass of Radionuclide Released (grams) | Half-Life (Yrs) |
|---|---|---|---|---|
| U-238 | 1.80E-04 | 0.034 | 102,776 | 4.47E09 |
| U-235 | 8.51E-06 | 0.002 | 746 | 7.04E08 |
| U-234 | 1.82E-04 | 0.035 | 5.5 | 2.34E05 |
| Th-232 | -- | N/A | N/A | 1.40E10 |
| Th-230 | -- | N/A | N/A | 7.40E04 |
| Th-228 | -- | N/A | N/A | 1.910 |
| Ra-228 | -- | N/A | N/A | 5.76 |
| Ra-226 | -- | N/A | N/A | 1,600 |
| Rn-222 | 32 | N/A | N/A | 3.82 days |
| Rn-220 | 84 | N/A | N/A | 55.6 seconds |
| Total Activity | 116 | 0.071 | 103,500 grams | N/A |

N/A Not analyzed for this radionuclide
(a) Total uranium value obtained from Table 6-4
-- Not distinguishable from background
Multiply by 3.7E10 to convert Ci to Bq

runoff water, as required under the site National Pollutant Discharge Elimination System (NPDES) permit (see Section 7). Using NPDES natural uranium values in conjunction with the activity ratios listed above, the U-234, U-235, and U-238 releases to water were calculated and are presented in Table 4-2. Other radionuclides were not routinely monitored in surface water during 1994.

### 4.3 Exposure Scenarios

Dose calculations were performed for the maximally exposed individual, collective population, and NESHAPs critical receptors for applicable exposure pathways (Table 4-1) 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/raffinate pits area, the quarry, and vicinity properties. A second dose equivalent for a collective population was calculated for users of the Katy Trail and the August A. Busch Memorial Conservation Area. A third set of dose equivalent calculations was performed to meet

NESHAPs requirements (see Section 6). Results of these estimates were then compared to applicable standards in order to evaluate the impact on members of the public and the environment.

Statistical analysis of the annual results indicated that 10 perimeter low volume particulate sampling locations averaged greater than background in 1994, no concentrations greater than background were detected by high volume NESHAPs monitoring devices at critical receptor locations other than the total uranium concentration measured at Station AP-2001 (see Figure 5-1). 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. However, the collective 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 described. Estimates of health risks are based on statistical 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 at the WSSRAP. The scenarios and resulting estimated doses used in the calculations are outlined in Table 4-3. In addition, the percentage of the DOE guideline of 100 mrem (1.0 mSv) 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 the exposure point and the number of persons exposed. Exposure points are locations where members of the public are

## TABLE 4-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates

| Exposure Scenario | Pathway | Activity | Media | Exposure Duration | Exposure/ Inhalation/ Ingestion Rate | Concentration | Estimated Effective Dose Equivalent (mrem) | Percent of DOE Guidance |
|---|---|---|---|---|---|---|---|---|
| WSCP/WSRP Hypothetical Individual | Liquid(B) | Consumption of fish from Busch Lake 36 | Fish | 365 days | 2,500 g/yr | 0.009 pCi/g | 0.0064 | 0.0064% |
| | Liquid(C) | Swimming at Busch Lake 36 | Sediments | 2.85 hours | 200 mg/day | 91.1 pCi/g | 0.0006 | 0.0006% |
| | | | Water | 2.85 hours | 0.05 liters/hour | 67.5 pCi/l | 0.0027 | 0.0027% |
| | Airborne(A) | Visiting Busch Lakes Area | Air | 119.5 hours | 0.96 $m^3$/hour[a] | 5.0E-16 $\mu$Ci/ml | 0.008 | 0.008% |
| | Airborne(B) | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 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 | Air | 5 hours | 4.4 mrem/yr | N/A | 0.0102 | 0.0102% |
| | Airborne(A) | Walking near WSQ perimeter | Air | 5 hours | 1.25 $m^3$/hour[a] | 1.6E-15 $\mu$Ci/ml | 0.0013 | 0.0013% |
| | Airborne(B) | Walking near WSQ perimeter | Air | 5 hours | 1.25 $m^3$/hour[a] | Tn-5.4 pCi/l[b] Rn-0.5 pCi/l | 0.720 | 0.72% |
| 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) | Fishing at slough | Air | 62.5 hours | 0.96 $m^3$/hour[a] | 8.6E-16 $\mu$Ci/ml | 0.007 | 0.007% |
| | Airborne(B) | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

## TABLE 4-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

| Exposure Scenario | Pathway | Activity | Media | Exposure Duration | Exposure/ Inhalation/ Ingestion Rate | Concentration | Collective Population Dose Equivalent (person-rem) | Percent of DOE Guidance |
|---|---|---|---|---|---|---|---|---|
| Collective Population | Liquid(B) | Fishing at Busch Lake 36 (population = 5,985) | Fish | N/A | 200 g/person | 0.009 pCi/g | 0.041 | N/A |
| | Liquid(C) | Swimming at Busch Lake 36 (population = 5,985) | Sediments | 0.285 hr/person | 200 mg/day | 91.1 pCi/g | 0.0004 | N/A |
| | | | Water | 0.285 hr/person | 0.05 liters/hour | 67.5 pCi/l | 0.0016 | N/A |
| | Airborne(A) | Fishing/Boating at Busch (population = 160,000/5,985) | Air | 2.5 hrs/5.7 hrs | 0.96 $m^3$/hour[a] | 5.0E-16 $\mu$Ci/ml | 0.028 | N/A |
| | | Hiking at Katy Trail (population = 72,000) | Air | 5 minutes/year | 1.25 $m^3$/hour[a] | 8.6E-16 $\mu$Ci/ml | 0.0008 | N/A |
| | Airborne(B) | N/A | N/A | N/A | N/A | N/A | N/A | 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
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 0.96 $m^3$/hour is used for an individual engaged in light activity, while 1.25 $m^3$/hour is for an individual engaged in strenuous activity (Ref. 25).
(b) = Rn Radon-222
= Tn Radon-220

potentially exposed to airborne radioactive particulate concentrations, radon gas concentrations, external gamma radiation, or radionuclide concentrations in water or food at above-background levels. The effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, food, and external gamma pathways 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 and the amount of external gamma radiation received by the potentially exposed population.

All ingestion and inhalation (internal radiation exposure routes) 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).

## 4.4 Dose Equivalent Estimates

Dose equivalent estimates for the exposure scenarios are presented in Table 4-3 and were calculated using 1994 monitoring data. Calculations for dose scenarios are provided in Appendix B. Dose equivalent estimates are far below the standards set by the DOE for annual public exposure and EPA NESHAPs limits.

The total effective dose equivalents (TEDEs) for a hypothetical maximally exposed individual near the chemical plant/raffinate pits, quarry, and vicinity properties are 0.018 mrem (0.00018 mSv), 0.731 mrem (0.00731 mSv), and 0.010 mrem (0.00010 mSv), respectively. These values represent less than 1% 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 area of the site results in a TEDE of approximately 300 mrem (3 mSv). The collective population dose equivalent is 0.072 person-rem (0.00072 person-Sv) for recreational users of the Busch Memorial Conservation Area and the Katy Trail.

### 4.4.1 Radiation Dose Equivalent From the Chemical Plant/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/raffinate pits and receive a radiation dose by the three 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%. Recreational use of the Busch Memorial Conservation Area is considered in the assessment of the exposure to a maximally exposed individual from chemical plant/raffinate pits area effluents, since some of the lakes in the area receive effluent from the site. None of these lakes are used as sources of drinking water, but recreational use of the conservation area includes fishing and boating. Thus, the Liquid (B) pathway (fish ingestion) and the Liquid (C) pathway (incidental water and sediment ingestion) are potential pathways for exposure. The low volume and high volume radioactive airborne particulate samplers at the Busch Memorial Conservation Area indicated no above background concentrations of radionuclides.

Although the low and high volume samplers at the Busch Memorial Conservation Area indicated no above-background concentrations of radionuclides from the WSSRAP, a dose estimate was calculated based on the average net concentration above background levels, as measured by the low volume sampler at Station AP-2002. The dose estimate performed assumes the primary contaminant is uranium, which is the only above background radionuclide detected by the NESHAPs program from stations located at the WSSRAP perimeter.

The exposure scenario assumptions are as follows:

- Inhalation dose occurs to maximally exposed individual during fishing and boating trips for a total of 119.5 hours.
- Net airborne particulate concentrations of 5.0E-16 $\mu$Ci/ml (1.85E-11 Bq/ml) measured at AP-2002 at the northern boundary of the chemical plant.
- The average fresh-water fish consumption rate was 2,500 g/day and assumed 25 trips, averaging 2.5 hours/trip.

- The average uranium concentration in fish was 0.009 pCi/g (0.0003 Bq/g), collected from Busch Lake 36, where the concentration was the highest of the three lakes receiving runoff from the site (see Section 9.3.1.1).

- An individual made 10 boating trips per year to the Busch Memorial Conservation Area.

- The individual spent 5.7 hours boating per visit (Ref. 30).

- While boating, the individual spent 5% of the time swimming.

- While swimming the individual ingested 0.05 liters/hour of water (Ref. 29 and 30).

- The concentration of uranium in surface water was 67.5 pCi/l (2,500 Bq/$m^3$) from Busch Lake 36 (see Section 9), which had the highest average surface water concentration of the three lakes receiving runoff.

- The average uranium concentration of surface sediments was 91.1 pCi/g (3.37 Bq/g) from Busch Lake 36, which had the highest sediment concentration of lakes receiving runoff from the site.

Based on the exposure scenario and assumptions described above, a maximally exposed individual who frequented the Busch Memorial Conservation Area and other properties adjacent to the chemical plant received a total effective dose equivalent of 0.018 mrem (0.00018 mSv) from inhalation of airborne particulates, ingestion of water and sediment, and ingestion of fish from contaminated waters.

### 4.4.2 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 1994 monitoring results indicated no above background exposure pathways. Therefore, all calculations of dose equivalent due to the

applicable pathways of airborne radioactive particulate inhalation (Airborne A), radon progeny inhalation (Airborne B), and direct external gamma exposure assume a realistic residence time of 5 hours/year, based on a hypothetical individual who hikes along the southeastern boundary of the quarry. This exposure scenario is less conservative than the 50 hours/year exposure time used in previous years, and results from a reevaluation of the scenario in response to a 1994 DOE functional appraisal. 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 pathways Liquid(B) or Liquid(C) in Table 4-1 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.

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

- The net gamma radiation exposure (measured at TD-1003) was 17.8 mrem/year (0.178 mSv/year).

- The highest measured annual average concentration of radon gas was 0.5 pCi/l (18.5 $Bq/m^3$) above the normal background concentration of 0.2 pCi/l (7.4 $Bq/m^3$) at station RD-1002 along the quarry perimeter (see Section 5). The highest estimated annual average concentration of thoron gas, at RD-1002, was 5.4 pCi/l (200 $Bq/m^3$) above the normal background concentration of 0.1 pCi/l (3.7 $Bq/m^3$).

- The equilibrium ratio between radon gas (both Rn-220 and Rn-222) and its progeny was 10%.

- The effective dose equivalent conversion factor was 1.0 rem/working level month (WLM) (10 mSv/WLM) (Ref. 31) for Rn-222 and 0.33 rem/WLM (3.3 mSv/WLM) for Rn-220.

The effective dose equivalent to the hypothetical maximally exposed individual at the quarry was 0.731 mrem (0.00731 mSv) from inhalation of radon progeny, inhalation of airborne particulates, and direct gamma exposure.

### 4.4.3 Radiation Dose From Vicinity Properties to a Hypothetical Maximally Exposed Individual

This section discusses the estimated 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 residence time of 62.5 hours/year. This scenario uses the applicable exposure pathways listed in Table 4-1 and is based on a hypothetical individual who fished at the Femme Osage Slough.

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

- An annual average radioactive air particulate concentration of 8.6E-16 $\mu$Ci/ml (3.2E-11 Bq/ml) above background, measured by the low volume sampler at station AP-1010 (see Figure 5-2), was used in the dose estimate.

- 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 fish samples taken from the Femme Osage Slough was 0.005 pCi/g (1.85E-4 Bq/g) (see Section 9.3.1.1).

- The fresh water 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.

The committed effective dose equivalent to the maximally exposed individual at the vicinity properties from consumption of fish tissue and inhalation of radioactive air particulates at the Femme Osage Slough as discussed above was 0.010 mrem (0.00010 mSv).

### 4.4.4 Collective Population Dose

This section discusses the estimated collective TEDE to the populations assumed to frequent the Katy Trail south of the quarry and the Busch Memorial Conservation Area. This scenario provides a conservative but plausible exposure assessment. Results of NESHAPs critical receptor measurements at locations where members of the public are likely to frequent indicated radioactive air particulate concentrations that were indistinguishable from background levels. However, low volume gross alpha measurements were found to be greater than background concentrations at station AP-1010, which is the monitoring location closest to the Katy Trail and at AP-2002, the WSCP perimeter monitor closest to the lakes at the Busch Memorial Conservation Area. Hence, users of the Katy Trail and visitors to the Busch Memorial Conservation Area were considered in estimating the collective population dose equivalent due to remediation activities at the WSSRAP. Dose contributions from radon gas and gamma radiation at these locations were not considered in the collective population dose estimates because they were indistinguishable from background levels during 1994.

The scenario for the Katy Trail is based on an exposure due to inhalation of airborne particulates as individuals traverse the portion of the trail near the quarry. This portion is 260 m (853 ft) in length, and at a walking speed of 3.2 km/hr (2 mi/hr) results in an exposure time of approximately 5 minutes. The scenario used for the Busch Memorial Conservation Area is based on recreational use for fishing and boating activities.

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

- No contribution from radon and its progeny was included in the Katy Trail or the Busch Memorial Conservation Area dose estimates. Results from the measurements near the trail indicated that there was no reason to suspect at the 95% confidence level that results were greater than background levels.

- Approximately 72,000 individuals use the Katy Trail each year (Ref. 54).

- The MDC estimates that approximately 160,000 persons per year use the Busch Memorial Conservation Area, 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 site, and all three lakes are utilized for fishing and boating purposes. Therefore, a population of 165,895 persons was assumed to have potential for exposure through ingestion of fish, water, and sediment from these lakes.

- 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 the fish collected from Lakes 34, 35, and 36 was 0.009 pCi/g (0.0003 Bq/g) (Section 8.3.1.1).

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

- The average time per fishing trip was 2.5 hours.

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

- Maximum water concentrations were 67.5 pCi/l (2.5 Bq/l) and sediment concentrations were 91.1 pCi/g (3.4 Bq/g).

- Net radioactive air particulate concentrations at the Katy Trail and Busch Conservation Area were 8.8E-4 pCi/$m^3$ (3.3E-5 Bq/$m^3$) and 5.0E-4 pCi/$m^3$ (1.9E-5 Bq/$m^3$), respectively.

The estimated population dose equivalent for users of the Katy Trail was 0.0008 person-rem (8E-6 person-Sv) due to inhalation of airborne particulates. The estimated population dose equivalent for the Busch lakes scenario was 0.028 person-rem (0.00028 person-Sv) for inhalation, 0.041 person-rem (0.00041 person-Sv) for ingestion of fish, 0.0016 person-rem (0.000016 person-Sv) for ingestion of water, and 0.0004 person-rem (4E-6 person-Sv) for

ingestion of sediment. Consequently, the collective population dose equivalent estimate for all applicable scenarios for exposure points was 0.072 person-rem (0.00072 person-Sv).

## 4.5 Radiation Dose to Native Aquatic Organisms

Benthic invertebrates were collected from off-site locations (see Section 9.3.1.2) to calculate dose to native aquatic organisms as required in DOE Order 5400.5. The dose calculation was made using the highest concentration detected in a benthic invertebrate sample from Burgermeister Spring that contained 44.2 pCi/g of total uranium.

The dose to native aquatic organisms was calculated for calendar year 1994 and compared to the DOE guideline of 1 rad/day. The absorbed dose rate to these organisms was found to be 0.01 rad/day (0.0001 Gy/day).

## 4.6 Highlights

- The largest committed effective dose equivalent to a maximally exposed individual from all pathways combined was 0.731 mrem (0.00731 mSv). This value represents 0.7% of the DOE guideline of 100 mrem (1 mSv) above background levels.

- The collective population dose equivalent estimate was calculated to be 0.072 person-rem (0.00072 person-Sv).

- The absorbed dose rate to native benthic invertebrates was estimated to be 0.01 rad/day (0.0001 Gy/day) which is less than the DOE guideline of 1 rad/day (0.01 Gy/day).

# 5 RADIATION AND ASBESTOS MONITORING PROGRAMS

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental monitoring and surveillance program in accordance with the U.S. Department of Energy (DOE) Orders in the 5400 series and with the *Environmental Monitoring Plan* (Ref. 42). This section describes monitoring results for radon, external gamma radiation, airborne radioactive particulates 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 is provided below for each parameter mentioned in the plan.

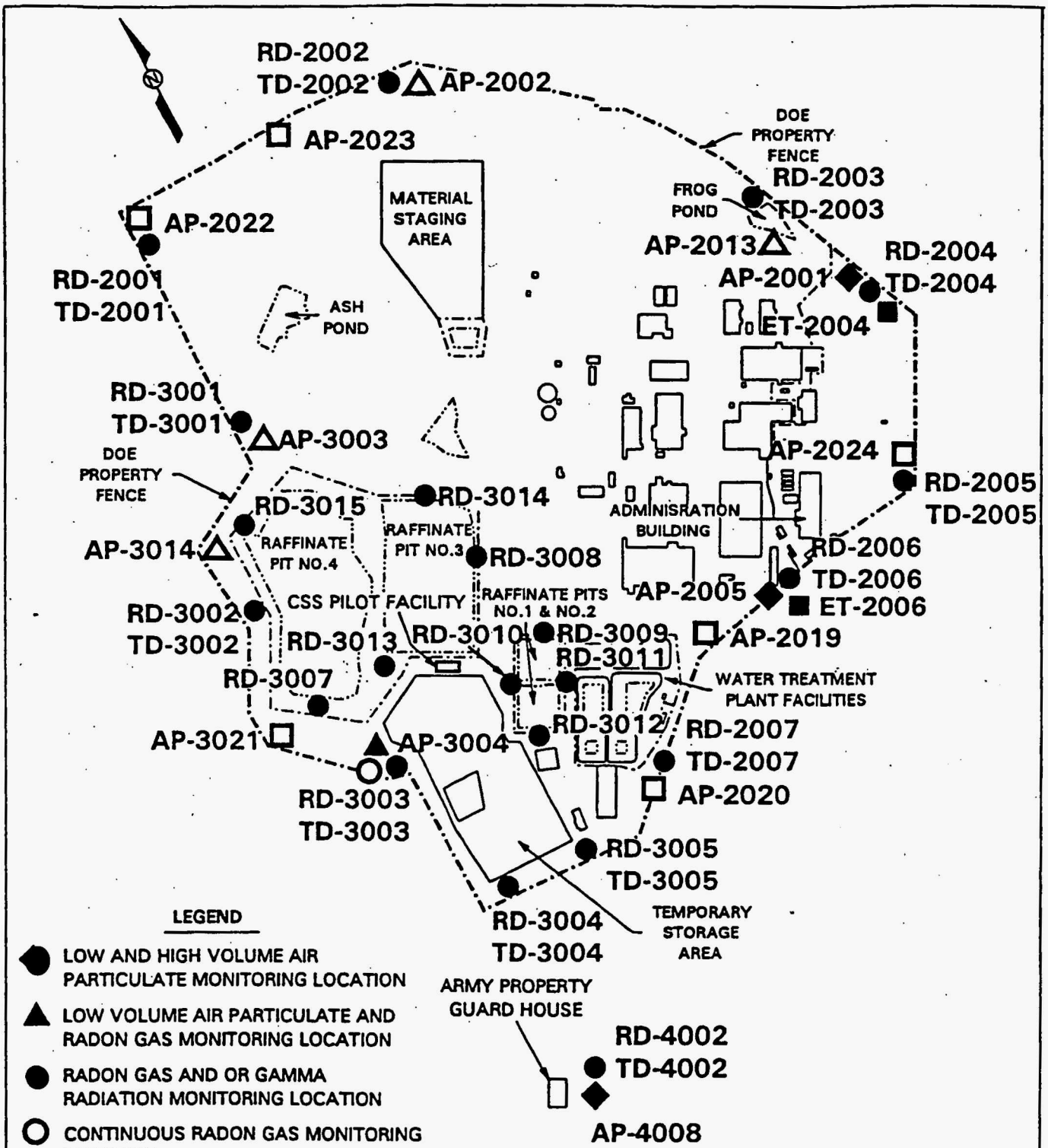
## 5.1 Radon Gas Monitoring Program

### 5.1.1 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, respectively. 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 concentrations fluctuate with both soil conditions and meteorological conditions. The amount of radon that actually enters the atmosphere varies depending on a number of parameters, including radium concentrations in soil, soil moisture content, soil porosity, soil density, and atmospheric pressure. Of these, the moisture content of the soil is the most variable and is primarily responsible for quarterly and annual changes in airborne radon concentrations.

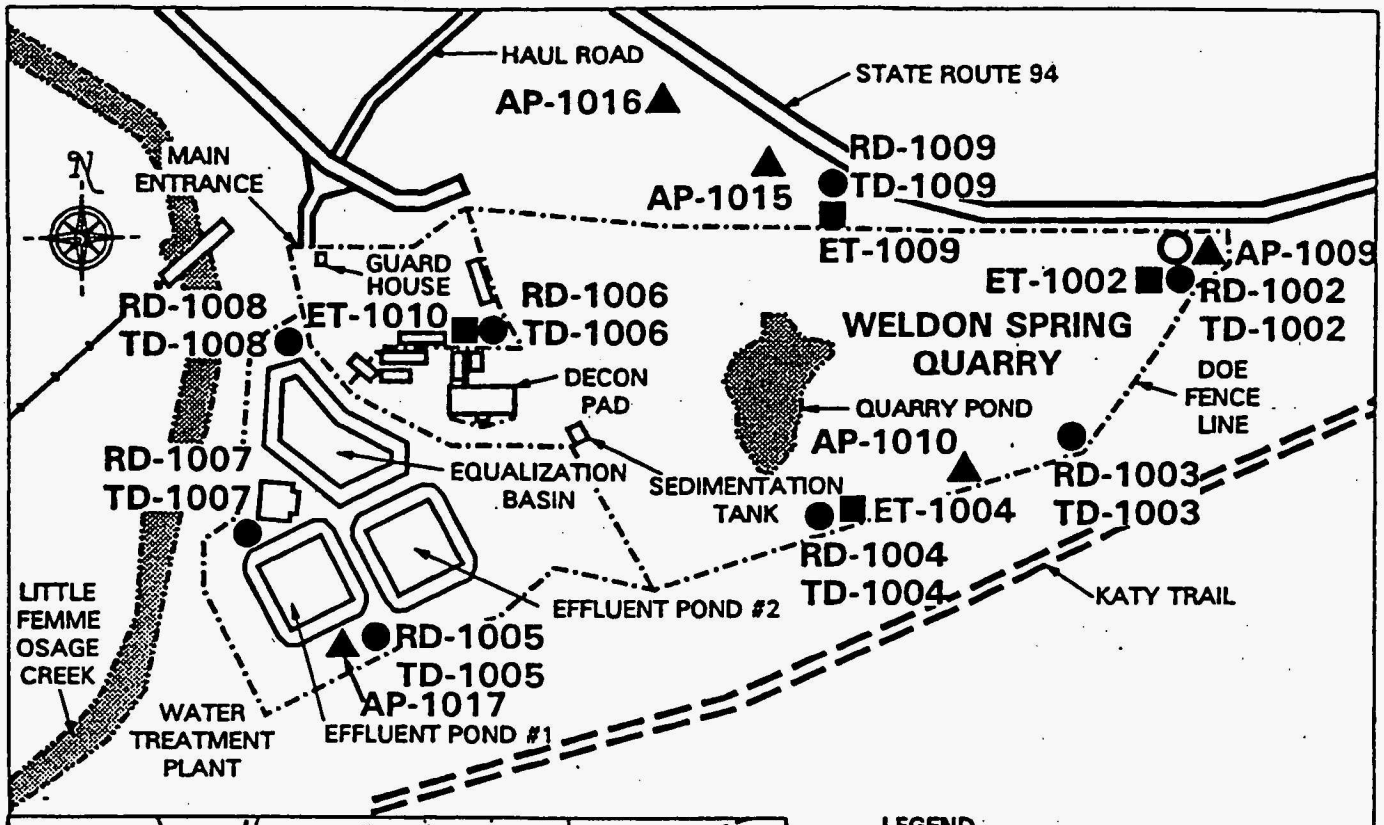
The environmental radon monitoring program includes deployment of a pair of alpha-track radon detectors at each of 37 permanent monitoring locations: seven at the Weldon Spring Chemical Plant (WSCP) perimeter, eight at the Weldon Spring Quarry (WSQ) perimeter, 13 at the raffinate pits area, and nine at off-site locations. Radon monitoring locations are identified with an "RD" prefix in Figures 5-1, 5-2, 5-3, and 5-4. WSCP and WSQ monitoring locations

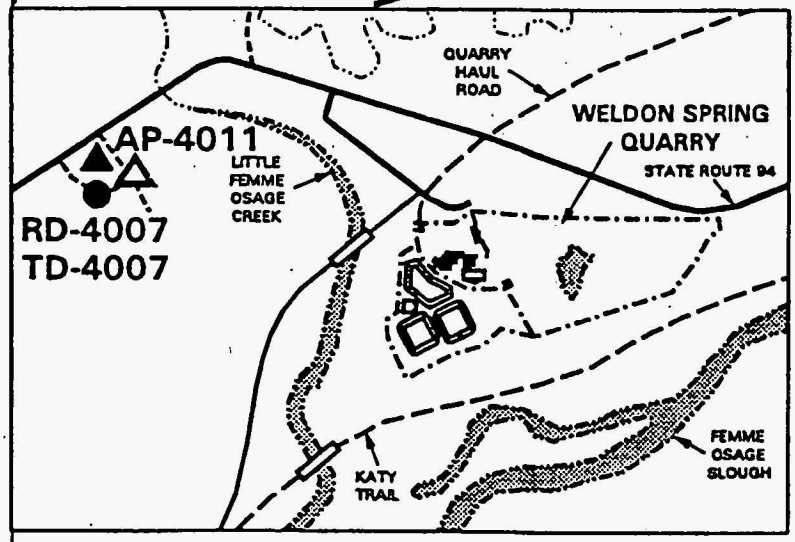



# AIR MONITORING LOCATIONS AT THE WSCP/WSRP AREA

## FIGURE 5-1

| | | | |
|---|---|---|---|
| REPORT NO.: DOE/OR/21548-512 | | EXHIBIT NO.: A/CP/010/0294 | |
| ORIGINATOR: MAP | DRAWN BY: GLN | DATE: 3/22/95 | |




**LEGEND**

- △ HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- ▲ LOW VOLUME AIR PARTICULATE MONITORING LOCATION
- ● RADON GAS AND OR GAMMA RADIATION MONITORING LOCATION
- ○ CONTINUOUS RADON GAS MONITORING LOCATION
- ■ ELECTRET MONITORING LOCATION
- RD RADON GAS MONITORING LOCATION
- TD GAMMA RADIATION MONITORING STATION
- AP AIR PARTICULATE MONITORING STATION
- ET ELECTRET MONITORING STATION

0 300 600 FT

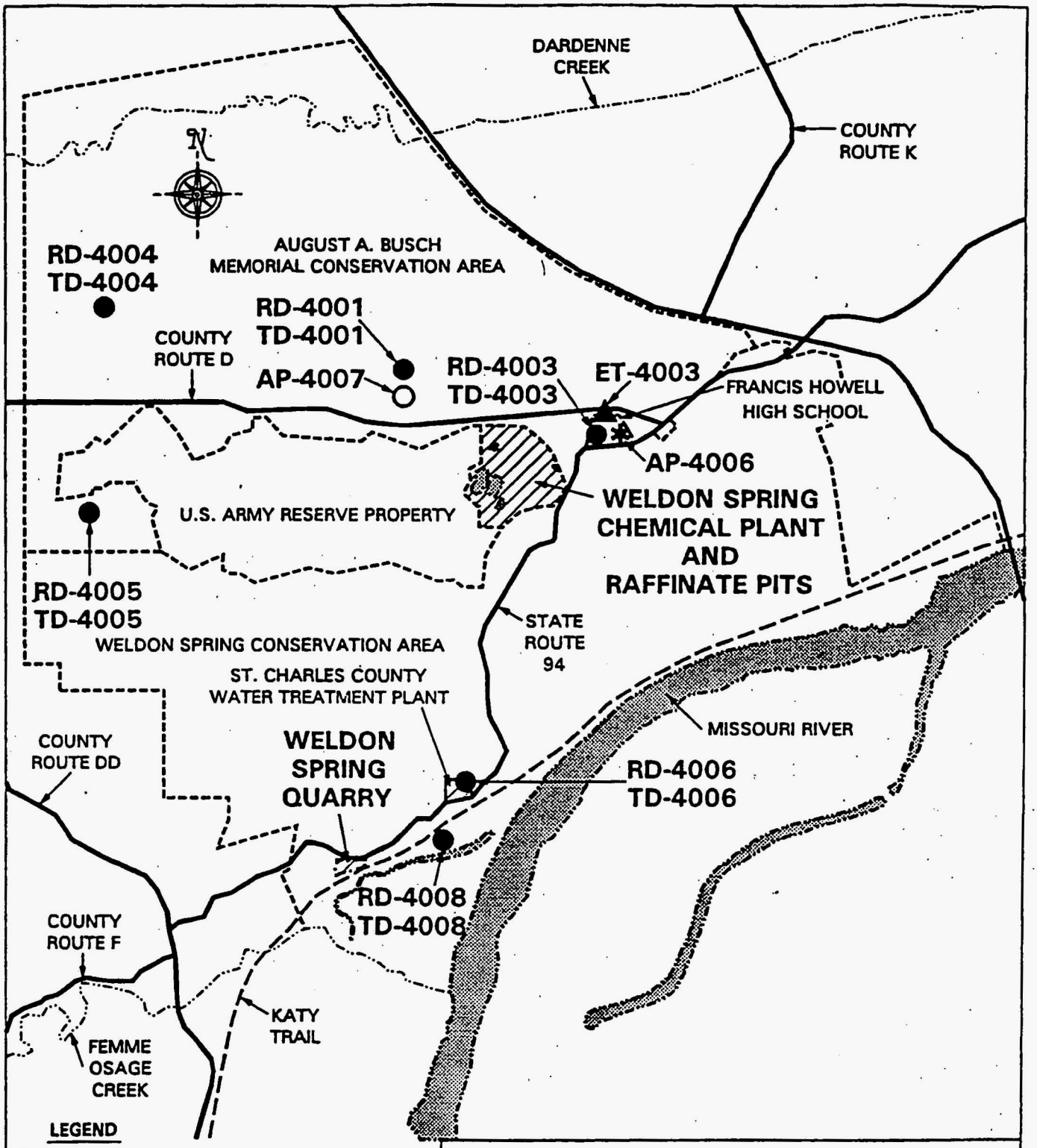
0 91.4 182.8 M

SCALE

# AIR MONITORING LOCATIONS AT THE WSQ AREA

## FIGURE 5-2

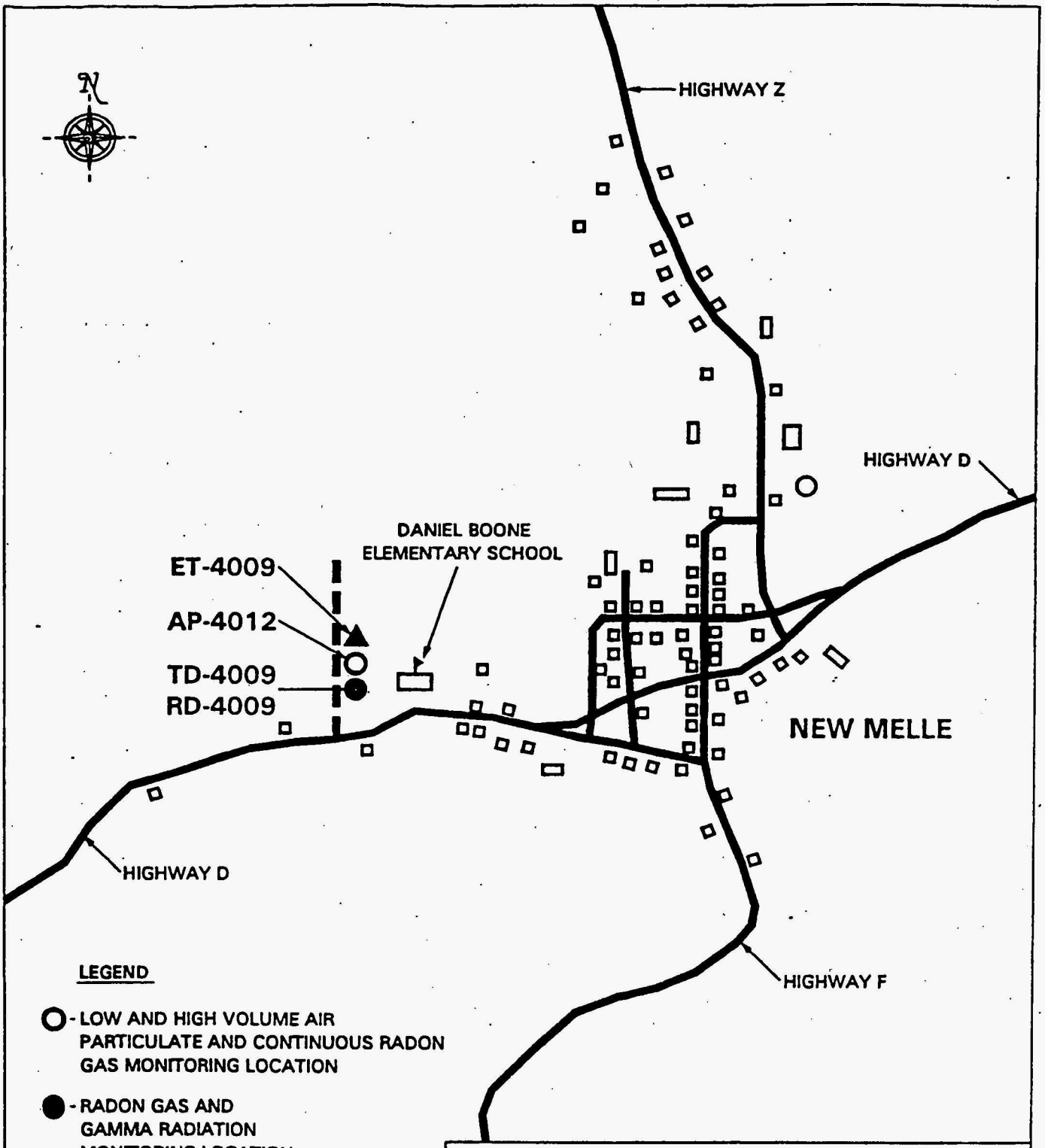
| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/QY/059/1194 | | |
| ORIGINATOR: | EKA | DRAWN BY: | GLN | DATE: | 3/22/95 |




OFF-SITE AIR MONITORING LOCATIONS

FIGURE 5-3

| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/VP/048/1194 |
|---|---|---|---|
| ORIGINATOR: | EKA | DRAWN BY: GLN | DATE: 3/22/95 |




# BACKGROUND AIR MONITORING STATION

## FIGURE 5-4

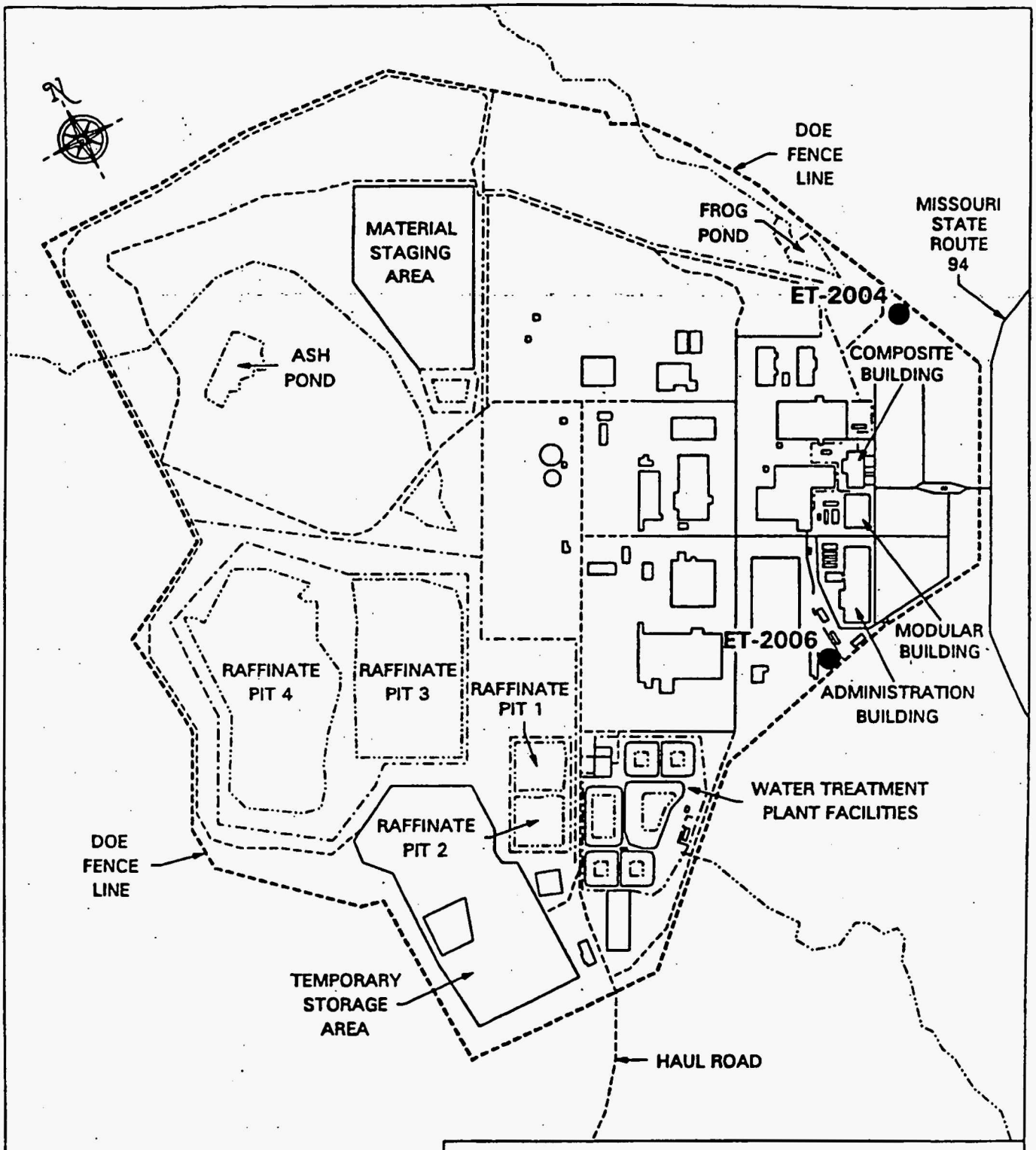
| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/VP/049/1194 | | |
| ORIGINATOR: | EKA | DRAWN BY: | GLN | DATE: | 12/20/94 |

are distributed around the perimeter to ensure adequate detection of radon dissipating from the site under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, RD-4006, and RD-4009 monitor background radon concentrations. Alpha track detectors are sensitive to all isotopes of radon and are deployed quarterly.

The environmental radon monitoring program also used continuous radon monitors. Continuous radon monitors were placed at locations AP-4012, AP-3004, AP-1009, and AP-4006, as shown in Figures 5-1, 5-2, and 5-4. These monitors measure hourly average radon concentrations and the data are collected and analyzed weekly. The monitors are calibrated once per year at a DOE radon chamber facility.

An additional enhancement to the radon monitoring program during 1994 was the deployment of modified alpha-track detectors at six monitoring locations. These detectors, which filter out Rn-220 (thoron), are placed alongside normal alpha-track monitors. This method allows the discrimination of radon from thoron. At locations where a significant thoron contribution was expected, modified alpha-track detectors were deployed in third quarter 1994 at stations RD-1002 and RD-3003, and additional monitors were deployed in the fourth quarter at stations RD-2005, RD-3010, and RD-1006. These detectors were also deployed at the background monitoring station (RD-4009) in third quarter 1994. Using Pearson's method (Ref. 49), individual concentrations of radon and thoron were calculated for these stations. Prior to deployment of the modified alpha-track detectors, data interpretation for first and second quarters required evaluation of the normal alpha-track data.

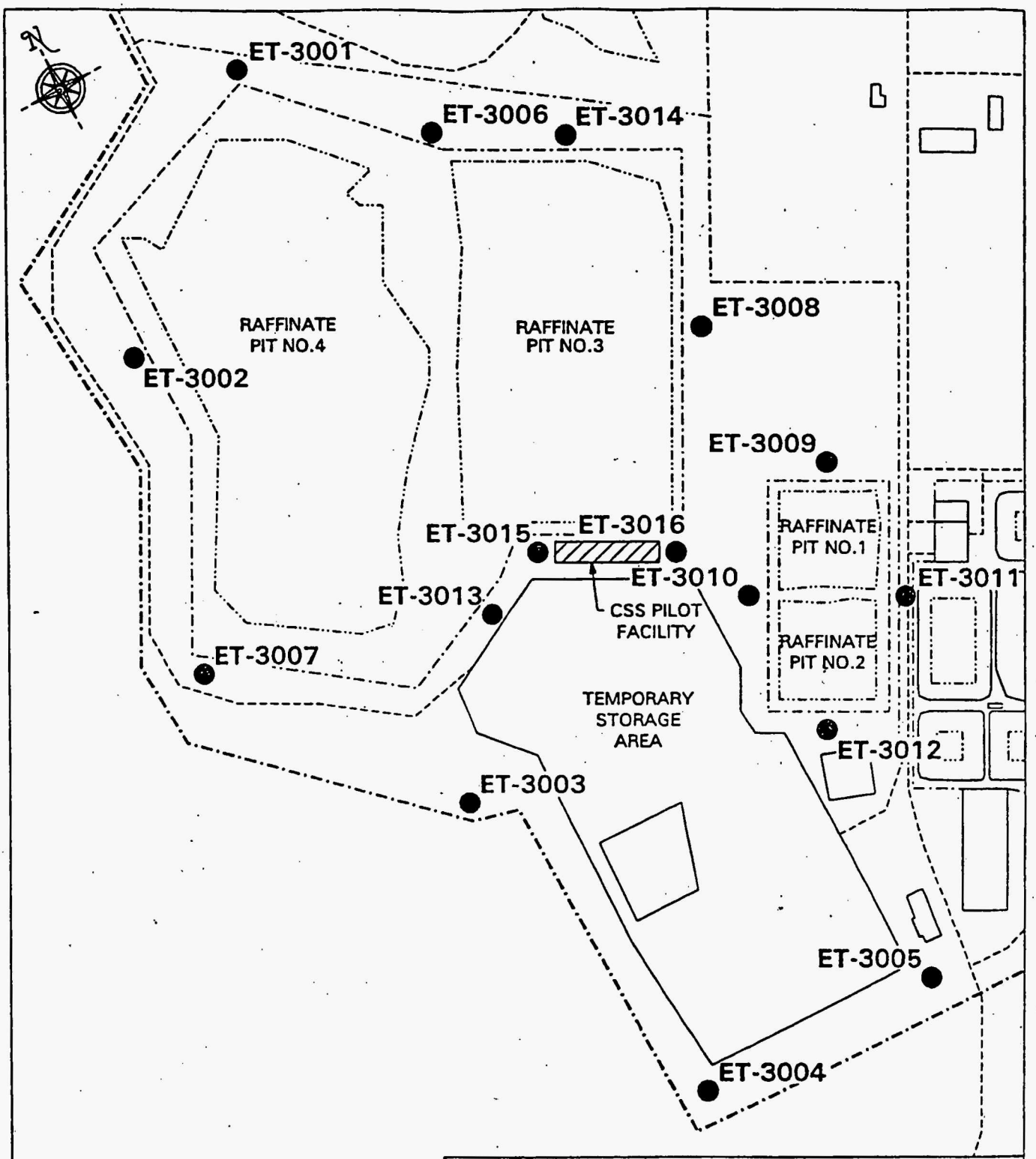
During the latter part of 1994, the WSSRAP radon monitoring program was enhanced by the addition of electret monitors. Electret monitors provide the means to measure both radon and thoron gas concentrations in air. A pair of electret monitors is deployed at each of 27 monitoring locations: 16 in the vicinity of the raffinate pits, five at the chemical plant perimeter, four at the quarry perimeter, and two off-site. These locations, designated by an "ET" prefix, are shown in Figures 5-1 through 5-6. These monitors were being evaluated in 1994 and reportable results are not anticipated until 1995.




# ELECTRET MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AREA

## FIGURE 5-5

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/CP/039/0694 | | |
| ORIGINATOR: | TWF | DRAWN BY: | GLN | DATE: | 2/3/95 |




ELECTRET MONITORING LOCATIONS AT THE WELDON SPRING RAFFINATE PIT AREA

FIGURE 5-6

NOT TO SCALE

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/RP/010/0694 | | |
| ORIGINATOR: | TWF | DRAWN BY: | GLN | DATE: | 2/3/95 |

### 5.1.2 Applicable Standards

The derived concentration guide (DCG) is a limiting airborne concentration of a specified radionuclide. The DCGs are based on a committed effective dose equivalent of 100 mrem/year (1.0 mSv/year) and assume continuous exposure. DOE Order 5400.5 specifies a DCG for both radon and thoron in unrestricted (off-site) areas of 3 pCi/l (111 Bq/$m^3$) above the background concentration. These DCGs assume 100% equilibrium for both radon and thoron. The DCG is not an appropriate indicator at the WSSRAP due to the less than 100% equilibrium and residence time at areas adjacent to the chemical plant and quarry properties.

### 5.1.3 Monitoring Results

Table 5-1 summarizes quarterly and annual average radon concentrations as measured by alpha-track 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 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 each location.

The results obtained from the pair of alpha track detectors for each location were averaged to determine the quarterly average radon concentration. These averages were then used to calculate the annual average radon gas concentration. The annual standard deviation reported reflects the error propagated by taking the standard deviation of the mean of the quarterly results.

The annual alpha track background concentration was calculated using the arithmetic average of the five background locations. The data yielded an annual background average radon concentration in 1994 of 0.2 pCi/l (7.4 Bq/$m^3$). The average background radon concentration did not significantly change from previous years' monitoring results.

Based on measurements from modified alpha-track monitors at locations where the combined release of radon and thoron was suspected, thoron concentrations at these stations were estimated for third and fourth quarter 1994 using Pearson's method (Ref. 49). The

# TABLE 5-1 1994 Alpha Track Radon Results[a]

| Location I.D. | 1st Quarter pCi/l[c] | 2nd Quarter pCi/l[c] | 3rd Quarter pCi/l[c] | 4th Quarter pCi/l[c] | Annual Average pCi/l[c] | Annual Standard Deviation | Percent of Guideline (b) |
|---|---|---|---|---|---|---|---|
| **Weldon Spring Quarry** | | | | | | | |
| RD-1002 | 9.2 | 4.0 | 3.0 | 3.5 | 4.9 | 2.49 | 157 |
| RD-1003 | 0.9 | 0.5 | 0.3 | 0.5 | 0.6 | 0.22 | 13 |
| RD-1004 | 0.1 | 0.2 | 0.1 | 0.5 | 0.2 | 0.16 | -- |
| RD-1005 | 0.2 | 0.3 | 0.1 | 0.5 | 0.3 | 0.15 | -- |
| RD-1006 | 0.3 | 0.3 | 0.2 | 0.5 | 0.3 | 0.11 | -- |
| RD-1007 | 0.3 | 0.2 | 0.1 | 0.6 | 0.3 | 0.19 | -- |
| RD-1008 | 0.1 | 0.1 | 0.1 | 0.6 | 0.2 | 0.22 | -- |
| RD-1009 | 0.2 | 0.2 | 0.2 | 0.5 | 0.3 | 0.13 | -- |
| **Weldon Spring Chemical Plant** | | | | | | | |
| RD-2001 | 0.1 | 0.1 | 0.2 | 0.6 | 0.3 | 0.21 | -- |
| RD-2002 | 0.1 | 0.3 | 0.1 | 0.4 | 0.2 | 0.13 | -- |
| RD-2003 | 0.1 | 0.3 | 0.1 | 0.4 | 0.2 | 0.13 | -- |
| RD-2004 | 0.1 | 0.3 | 0.2 | 0.5 | 0.3 | 0.15 | -- |
| RD-2005 | 0.1 | 0.1 | 0.2 | 0.4 | 0.2 | 0.12 | -- |
| RD-2006 | 0.1 | 0.2 | 0.1 | 0.5 | 0.2 | 0.16 | -- |
| RD-2007 | 0.1 | 0.2 | 0.1 | 0.5 | 0.2 | 0.16 | -- |
| **Weldon Spring Raffinate Pits** | | | | | | | |
| RD-3001 | 0.1 | 0.1 | 0.1 | 0.4 | 0.2 | 0.13 | -- |
| RD-3002 | 0.1 | 0.1 | 0.2 | 0.4 | 0.2 | 0.12 | -- |
| RD-3003 | 0.5 | 0.8 | 0.5 | 1.0 | 0.7 | 0.21 | 17 |
| RD-3004 | 0.1 | 0.2 | 0.2 | 0.4 | 0.2 | 0.11 | -- |
| RD-3005 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.04 | -- |
| RD-3007 | 0.1 | 0.1 | 0.1 | 0.5 | 0.2 | 0.17 | -- |
| RD-3008 | 0.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.11 | -- |
| RD-3009 | 0.2 | 0.3 | 0.3 | 0.5 | 0.3 | 0.11 | -- |
| RD-3010 | 0.4 | 0.6 | 0.4 | 0.6 | 0.5 | 0.10 | 10 |
| RD-3011 | 0.2 | 0.2 | 0.2 | 0.4 | 0.3 | 0.09 | -- |
| RD-3012 | 0.7 | 0.9 | 0.5 | 0.8 | 0.7 | 0.15 | 17 |
| RD-3013 | 0.8 | 0.8 | 0.5 | 0.7 | 0.7 | 0.12 | 17 |
| RD-3014 | 0.2 | 0.5 | 0.8 | 0.8 | 0.6 | 0.25 | 13 |
| RD-3015 | 0.2 | 0.4 | 0.1 | 0.4 | 0.3 | 0.13 | -- |

## TABLE 5-1 1994 Alpha Track Radon Results[a] (Continued)

| Location I.D. | 1st Quarter pCi/l[c] | 2nd Quarter pCi/l[c] | 3rd Quarter pCi/l[c] | 4th Quarter pCi/l[c] | Annual Average pCi/l[c] | Annual Standard Deviation | Percent of Guideline (b) |
|---|---|---|---|---|---|---|---|
| Off Site | | | | | | | |
| *RD-4001 | 0.1 | 0.2 | 0.1 | 0.4 | 0.2 | 0.12 | --- |
| RD-4002 | 0.1 | 0.4 | 0.1 | 0.4 | 0.3 | 0.15 | -- |
| RD-4003 | 0.1 | 0.3 | 0.1 | 0.3 | 0.2 | 0.10 | --- |
| *RD-4004 | 0.1 | 0.1 | 0.1 | 0.4 | 0.2 | 0.13 | --- |
| *RD-4005 | 0.1 | 0.4 | 0.1 | 0.5 | 0.3 | 0.18 | --- |
| *RD-4006 | 0.1 | 0.3 | 0.2 | 0.4 | 0.3 | 0.11 | --- |
| RD-4007 | 0.1 | 0.3 | 0.2 | 0.4 | 0.3 | 0.11 | 3 |
| RD-4008 | 0.5 | N/A | 0.3 | 0.6 | 0.5 | 0.15 | 10 |
| *RD-4009 | 0.1 | 0.2 | 0.1 | 0.3 | 0.2 | 0.08 | --- |

(a) Results include natural background levels.
(b) Percent of guideline is calculated by taking the year-to-date 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.
--- Annual average concentration less than or equal to background.
* Background station.
N/A Missing alpha track radon monitor.
(c) To convert from pCi/l to $Bq/m^3$, multiply by 37.

## TABLE 5-2 Thoron and Radon Concentrations as Determined Using Modified Alpha-Track Detectors

| Station ID | Third Quarter 1994 | | Fourth Quarter 1994 | |
|---|---|---|---|---|
| | Radon Concentration (pCi/l)[a] | Thoron Concentration (pCi/l)[a] | Radon Concentration (pCi/l)[a] | Thoron Concentration (pCi/l)[a] |
| RD-1002 | 0.6 | 3.4 | 0.4 | 3.7 |
| RD-1006 | -- | -- | 0.4 | 0.1 |
| RD-2005 | -- | -- | 0.3 | 0.1 |
| RD-3003 | 0.6 | 0.1 | 0.4 | 0.6 |
| RD-3010 | -- | -- | 0.4 | 0.1 |
| RD-4009* | 0.5 | 0 | 0.3 | 0.2 |

* Background station
(a) To convert from pCi/l to $Bq/m^3$, multiply by 37.
-- Measurement not collected.

measurements indicated the only significant thoron concentration was at the quarry at location RD-1002. Results of these calculations are presented in Table 5-2.

Average quarterly alpha track radon monitoring results at RD-1002 (quarry) and several monitoring locations around the raffinate pits and temporary storage area (TSA) indicated increased concentrations as compared to previous years. Due to excavation and placement of quarry bulk wastes on the TSA, elevated radon concentrations were expected. Also, the water level in some of the raffinate pits was lowered, exposing a raffinate sludge beach. These activities caused an increase in radon diffusion. In addition, during the first quarter of 1994, several hundred drums of Th-232 residues at the quarry were excavated in the proximity of RD-1002. Many of these deteriorated drums remained on the quarry waste surface exposed to the atmosphere for a number of days, thus releasing Rn-220, which was detected in the down wind direction at RD-1002. This situation is believed to have caused the elevated thoron concentrations during the first quarter at RD-1002. Since the first quarter, the excavated drums have been removed and buried at the TSA. Results comparable to the elevated results measured at station RD-1002 during the second, third, and fourth quarters of 1994 are expected to continue throughout bulk waste removal.

Table 5-3 summarizes the continuous radon monitoring results, shown as quarterly results, and annual averages for each monitoring location. The annual averages were also compared to the DCG for radon after subtracting the average background concentration measured by Station AP-4012 and are shown in the table.

The first quarter 1994 continuous radon gas monitoring results at AP-1009 indicated a notably elevated radon concentration as compared to the remaining quarters. This phenomenon is explained in the previous discussion of the first quarter alpha-track radon results.

The continuous radon gas monitors require annual off-site calibration, extensive maintenance, and have historically had significant downtime. Therefore, the continuous radon gas monitors will be eliminated from the environmental monitoring network and be used instead for periodic work zone monitoring during activities that have the potential for a significant release of radon gas. As previously mentioned, the electret radon monitors will be used to supplement the radon monitoring network.

TABLE 5-3 1994 Continuous Radon Monitoring Results[a]

| Location ID | 1st Quarter (pCi/l) | | 2nd Quarter (pCi/l) | | 3rd Quarter (pCi/l) | | 4th Quarter (pCi/l) | | Annual (pCi/l)[c] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average | Standard Deviation | Average | Standard Deviation | Average | Standard Deviation | Average | Standard Deviation | Average | Standard Deviation | Percent of Guideline (b) |
| AP-3004 | 0.44 | 0.23 | 0.48 | 0.29 | 0.63 | 0.38 | 1.11 | 0.55 | 0.64 | 0.44 | 7 |
| AP-4006 | 0.35 | 0.06 | 0.34 | 0.07 | 0.35 | 0.10 | 0.31 | 0.13 | 0.34 | 0.09 | -- |
| *AP-4012 | 0.45 | 0.06 | 0.35 | 0.09 | 0.48 | 0.15 | 0.49 | 0.11 | 0.44 | 0.11 | -- |
| AP-1009 | 3.32 | 2.22 | 1.50 | 1.07 | 1.57 | 0.72 | 1.48 | 0.66 | 2.11 | 1.70 | 56 |

(a) Results include natural background.
(b) Percent of guideline calculated by taking the year-to-date average minus the average of the background station divided by the DOE concentration guideline for Rn-222 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
(c) Because some quarters had more data points than others, the annual average concentration may not equal the average of quarterly results for a given station. Individual data points were averaged to obtain annual results.
* Denotes background station
--- Annual average concentration less than or equal to background.

## 5.1.4 Data Analysis

Statistical analysis of the alpha track radon detector results indicated that at the 95% confidence level, the measured concentrations at two of the eight monitoring locations at the quarry perimeter were greater than the background monitoring location concentrations. Furthermore, the analysis indicated that measurements from five of the 14 raffinate pit locations were greater than the background station results. The analysis indicates that the results for all other stations are not distinguishable from background levels.

**5.1.4.1 Chemical Plant and Raffinate Pits.** Statistical analysis of locations RD-3003, RD-3010, RD-3012, RD-3013, and RD-3014 indicated measured results greater than background levels. These stations are located around the raffinate pits perimeter. The average concentrations for the above monitoring stations exceeded background levels by 0.3 pCi/l (11.1 $Bq/m^3$) to 0.5 pCi/l (18.5 $Bq/m^3$). The quarterly measured radon concentrations from all stations ranged from 0.1 pCi/l (3.7 $Bq/m^3$) to 1.0 pCi/l (37 $Bq/m^3$) at the chemical plant/raffinate pits monitoring locations.

**5.1.4.2 Quarry.** Statistical analysis of locations RD-1002 and RD-1003 indicated measured results greater than background levels. These results were not unexpected, because the quarry contains significant radium contamination, and quarry bulk waste removal was

performed during the year. Furthermore, the quarry is surrounded by steep walls which tend to stagnate the air inside it. This inhibits dispersion and results in an increased concentration at the quarry perimeter. The impact of the above background radon concentrations to a hypothetical maximally exposed individual was assessed as described in Section 4.4.2. The quarterly measured results ranged from 0.1 pCi/l (3.7 $Bq/m^3$) to 9.2 pCi/l (340 $Bq/m^3$).

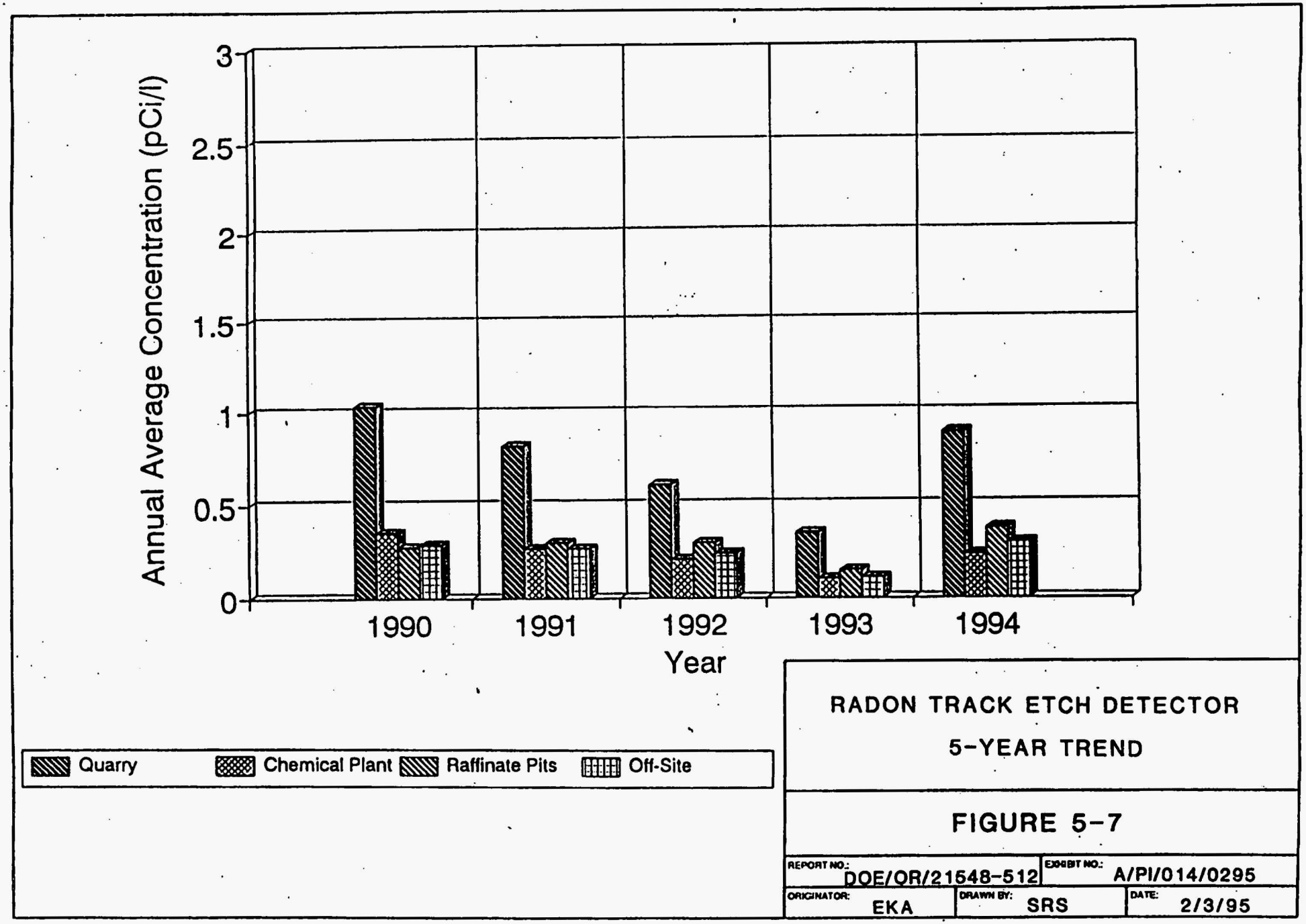
**5.1.4.3 Off Site.** Statistical analysis of monitoring results from off-site locations indicated that there was no reason to suspect at the 95% confidence level that measured concentrations at any of the stations were greater than background levels. The quarterly radon concentration measurements at off-site locations ranged from 0.1 pCi/l (3.7 $Bq/m^3$) to 0.6 pCi/l (22.2 $Bq/m^3$). These results are similar to results obtained during pervious years.

**5.1.4.4 Five Year Trend Analysis of Radon Gas.** Figure 5-7 shows five years of annual average 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. Although the yearly average radon concentration at RD-1002 was significantly higher in 1994, the remaining quarry monitoring locations had low or average concentrations. This results in an average quarry radon concentration that is greater than last year's results, but does not represent a significant increase over prior years. No significant trend was evident in 1994.

## 5.2 Gamma Radiation Monitoring

### 5.2.1 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 natural 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 for this area due to gamma exposure is 65 mrem/year (0.65 mSv/year).




RADON TRACK ETCH DETECTOR
5-YEAR TREND

FIGURE 5-7

| REPORT NO.: DOE/OR/21548-512 | EXHIBIT NO.: A/PI/014/0295 | |
|---|---|---|
| ORIGINATOR: EKA | DRAWN BY: SRS | DATE: 2/3/95 |

Gamma radiation is monitored at the site using environmental thermoluminescent dosimeters (TLDs) at 29 monitoring stations: seven at the site perimeter, five near the raffinate pits, eight along the quarry perimeter, and nine off-site. The locations are denoted by a "TD" prefix on Figures 5-1, 5-2, 5-3, and 5-4. Stations TD-4001, TD-4004, TD-4005, TD-4006, and TD-4009 measure natural background at locations unaffected by the site. The TLDs are changed every quarter.

### 5.2.2 Applicable Standards

There is no specific standard for gamma radiation 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.

### 5.2.3 Monitoring Results

Table 5-4 summarizes quarterly and annual average gamma radiation monitoring results. The table includes quarterly averages, annual totals, and the annual standard deviation for each station. The annual standard deviation reported reflects the error propagated by taking the standard deviation of the mean of the quarterly results.

The background levels of gamma radiation for 1994 were determined by averaging the quarterly measurements from the five background stations. The average rate from these stations was 57 mrem/year (0.57 mSv) with a standard deviation of 6 mrem/year (0.06 mSv). This average background is comparable to the UNSCEAR 1982 estimate of 65 mrem/year (0.65 mSv/year) (Ref. 33).

### 5.2.4 Data Analysis

Statistical analysis of TLD detector results at the 95% confidence level revealed above background levels at quarry monitoring stations TD-1003 and TD-1004. The higher of these two results was considered in dose estimates for the quarry.

# TABLE 5-4 1994 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 |
|---|---|---|---|---|---|---|
| **Weldon Spring Quarry** | | | | | | |
| TD-1002 | 22 | 14 | 14 | 18 | 68 | 3 |
| TD-1003[b] | -- | 20 | 17 | 19 | 75 | 1 |
| TD-1004 | 19 | 16 | 17 | 18 | 70 | 1 |
| TD-1005 | 19 | 14 | 15 | 18 | 66 | 2 |
| TD-1006 | 14 | 12 | 11 | 16 | 53 | 2 |
| TD-1007 | 18 | 15 | 15 | 20 | 68 | 2 |
| TD-1008 | 17 | 13 | 15 | 17 | 62 | 2 |
| TD-1009 | 16 | 12 | 13 | 15 | 56 | 2 |
| **Weldon Spring Chemical Plant** | | | | | | |
| TD-2001 | 15 | 14 | 14 | 17 | 60 | 1 |
| TD-2002 | 15 | 12 | 13 | 16 | 56 | 2 |
| TD-2003 | 16 | 14 | 14 | 17 | 61 | 1 |
| TD-2004 | 16 | 13 | 14 | 17 | 60 | 2 |
| TD-2005 | 15 | 12 | 13 | 16 | 56 | 2 |
| TD-2006 | 17 | 14 | 14 | 18 | 63 | 2 |
| TD-2007 | 16 | 13 | 15 | 17 | 61 | 1 |
| **Weldon Spring Raffinate Pits** | | | | | | |
| TD-3001 | 15 | 18 | 12 | 15 | 60 | 2 |
| TD-3002 | 12 | 11 | 9 | 15 | 47 | 2 |
| TD-3003 | 19 | 16 | 16 | 20 | 71 | 2 |
| TD-3004 | 15 | 12 | 11 | 15 | 53 | 2 |
| TD-3005 | 16 | 15 | 15 | 19 | 65 | 2 |
| **Off Site** | | | | | | |
| *TD-4001 | 15 | 11 | 13 | 17 | 56 | 2 |
| TD-4002 | 12 | 11 | 9 | 13 | 45 | 1 |
| TD-4003 | 12 | 11 | 9 | 13 | 45 | 1 |
| *TD-4004 | 18 | 15 | 16 | 19 | 68 | 2 |
| *TD-4005 | 15 | 11 | 11 | 14 | 51 | 2 |
| *TD-4006 | 14 | 14 | 14 | 16 | 58 | 1 |
| TD-4007 | 14 | 14 | 12 | 15 | 55 | 1 |
| TD-4008 | 18 | 10 | 15 | 18 | 61 | 3 |
| *TD-4009 | 14 | 12 | 12 | 15 | 53 | 1 |

* Denotes background location.

TABLE 5-4 1994 Environmental TLD Results[a] (Continued)

(a) Results include natural background gamma radiation.
(b) To calculate the annual total gamma radiation rate, the missing data and the first quarter data were replaced with the average of the remaining quarterly TLD results for those stations.
(c) To convert from mrem/year to mSv/year, divide by 100.
-- Denotes lost or damaged TLD.

**5.2.4.1 Chemical/Raffinate Pits.** The annual total gamma radiation measurements from TLDs at the chemical plant and raffinate pits ranged from 47 mrem (0.47 mSv) to 71 mrem (0.71 mSv). These results are comparable to previous years for these areas.

**5.2.4.2 Quarry.** The annual total gamma radiation measurements from TLDs at the quarry ranged from 53 mrem (0.53 mSv) to 75 mrem (0.75 mSv). These results are comparable to previous years for this area.

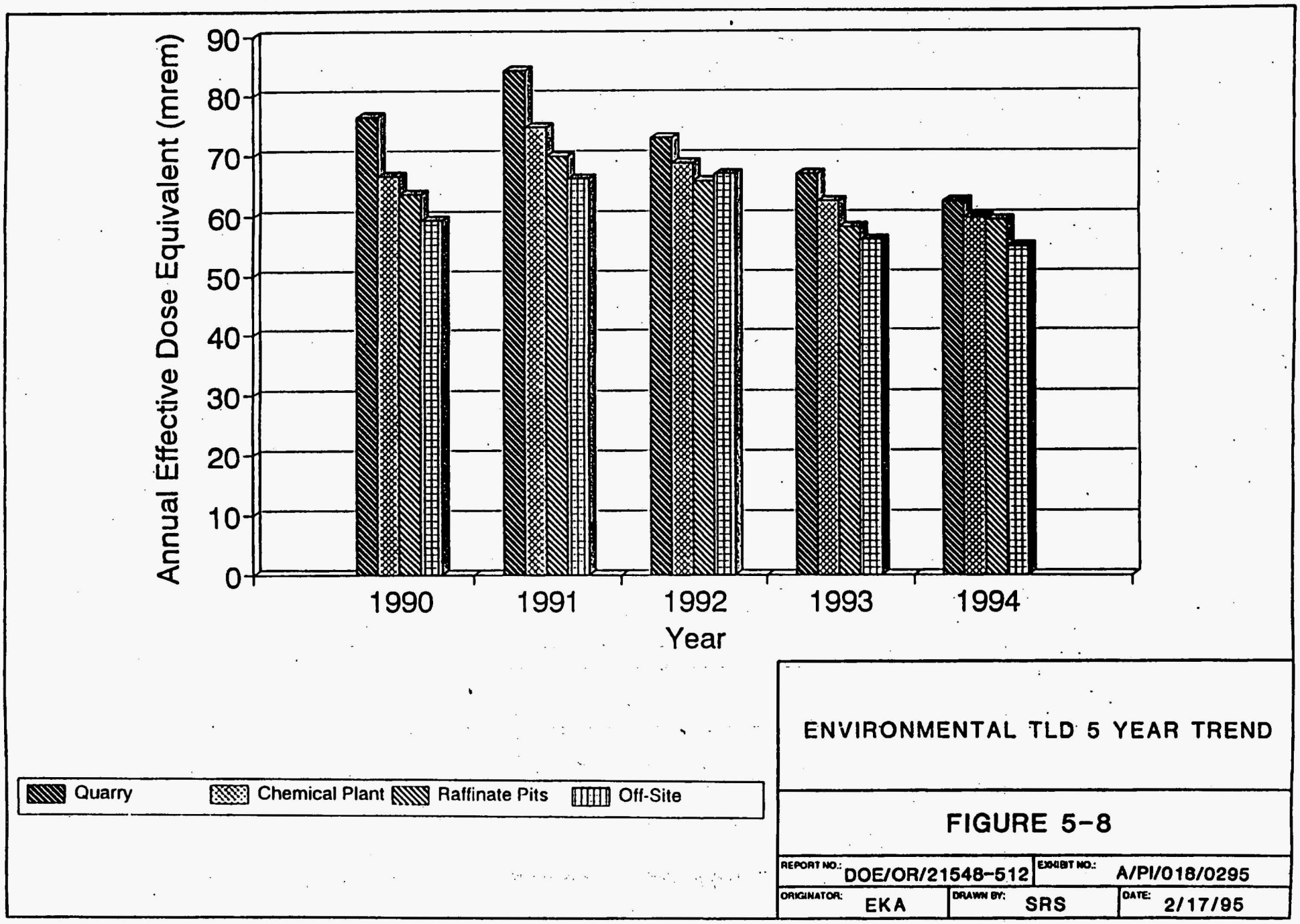
**5.2.4.3 Off-Site.** The annual total gamma radiation measurements from TLDs at off-site locations ranged from 45 mrem (0.45 mSv) to 68 mrem (0.68 mSv). These results are comparable to previous years for these areas.

**5.2.4.4 Five Year Trend Analysis of TLDs.** Gamma radiation exposure monitoring results from the last five years are shown graphically in Figure 5-8. The graph shows yearly monitoring result averages for the chemical plant, raffinate pits, quarry, and off site locations. The results include the natural background dose rate. Results seem to indicate a downward trend at the quarry.

## 5.3 Radioactive Air Particulate Monitoring

### 5.3.1 Program Overview

Radioactive air particulates are airborne dust particles that contain radioactive contaminants. Background concentrations of radioactive air particulates are affected by the amount of contaminants in the soil, moisture, atmospheric dispersion, and geological conditions. Many areas on site contain above background concentrations of soil contamination, which can




ENVIRONMENTAL TLD 5 YEAR TREND

FIGURE 5-8

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/PI/018/0295 | | |
| ORIGINATOR: | EKA | DRAWN BY: | SRS | DATE: | 2/17/95 |

result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emissions from the site can result from wind erosion or remedial work activities, such as moving equipment and vehicles in contaminated areas.

The WSSRAP monitors radioactive air particulates 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 5-1, 5-2, 5-3, and 5-4. In addition, six temporary low-volume air monitoring stations are deployed around the chemical plant perimeter. These portable air particulate samplers are deployed only at temporary stations when current activities warrant their use. In order to monitor alpha particles, low volume air sampler filters are analyzed for long-lived gross alpha activity. These samplers collect airborne particulates by drawing ambient air 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 gross alpha activity in the particulates present on the filter surface.

### 5.3.2 Applicable Standards

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

### 5.3.3 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 17 permanent and two temporary low volume stations are summarized in Table 5-5. 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.

The typical MDC for low volume air particulate sampling at the WSSRAP is $3.3 \times 10^{-16}$ $\mu$Ci/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 $7 \times 10^{-15}$ $\mu$Ci/ml (2.6E-10 Bq/ml) (DOE 5400.5). If

## TABLE 5-5 1994 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 |
|---|---|---|---|
| AP-2001 | 1.62 | 0.312 | 52/52 |
| AP-2002 | 1.58 | 0.531 | 50/51 |
| AP-3003 | 1.14 | 0.132 | 51/52 |
| AP-3004 | 1.59 | 0.855 | 52/52 |
| AP-2005 | 1.33 | 0.899 | 51/52 |
| AP-4006 | 1.38 | 3.12 | 48/51 |
| AP-4007 | 1.22 | 0.212 | 51/52 |
| AP-4008 | 1.19 | 0.120 | 51/51 |
| AP-1009 | 2.65 | 5.61 | 49/49 |
| AP-1010 | 1.94 | 1.63 | 48/49 |
| AP-4011 | 1.29 | 0.363 | 50/50 |
| AP-4012[a] | 1.08 | 0.176 | 51/52 |
| AP-2013 | 1.84 | 3.15 | 52/52 |
| AP-3014 | 1.15 | 0.215 | 51/52 |
| AP-1015 | 1.65 | 1.30 | 52/52 |
| AP-1016 | 1.33 | 0.405 | 51/52 |
| AP-1017 | 1.30 | 0.539 | 51/52 |
| AP-2020 | 1.04 | 0.935 | 14/16 |
| AP-2024 | 1.08 | 0.274 | 13/16 |

(a) Indicates background monitoring station. Background concentration is a 2-year average.
(b) The annual average gross alpha concentrations 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

an individual inhales airborne contaminants at the DCG for one year, the resulting committed effective dose equivalent is 100 mrem (1 mSv).

### 5.3.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that the concentrations of airborne radioactive particulates were greater than background levels at the chemical plant/raffinate pits stations AP-2001, AP-2002, AP-3004, and AP-2013, at quarry monitoring stations AP-1009, AP-1010, AP-1015, AP-1016, and AP-1017, and at off-site location AP-4011. The statistical analysis indicated that for all other stations there was no reason to suspect that the results were greater than background. Background monitoring station AP-4012 had a 1994 annual average of 1.15E-15 $\mu$Ci/ml (4.26E-11 Bq/ml) and a 1993 annual average of 1.02E-15 $\mu$Ci/ml (3.77E-11 Bq/ml) for a 2-year average of 1.08E-15 $\mu$Ci/ml (4.0E-11 Bq/ml). The 2-year average background concentration was used as a baseline for comparisons to the other measurements.

**5.3.4.1 Chemical Plant/Raffinate Pits.** The average concentrations at the chemical plant/raffinate pits perimeter ranged from 1.04E-15 $\mu$Ci/ml (3.85E-11 Bq/ml) to 1.84E-15 $\mu$Ci/ml (6.81E-11 Bq/ml). These results are slightly higher than those measured during previous years.

**5.3.4.2 Quarry.** The average concentrations at the quarry perimeter ranged from 1.30E-15 $\mu$Ci/ml (4.81E-11 Bq/ml) to 2.65E-15 $\mu$Ci/ml (9.81E-11 Bq/ml). These results are higher than those measured during previous years, due to increased quarry bulk waste excavation activities.

**5.3.4.3 Off-Site.** The average concentrations at off-site locations ranged from 1.19E-15 $\mu$Ci/ml (4.40E-11 Bq/ml) to 1.38E-15 $\mu$Ci/ml (5.11E-11 Bq/ml). These results are similar to those measured during previous years.

## 5.4 Radioactive Contamination Control Monitoring

### 5.4.1 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 and the quarry bulk waste haul road are monitored to ensure that removable contamination is kept from these accessible areas.

During 1994, 10 roadway areas outside the site controlled areas were routinely surveyed. Periodic contamination surveys were also conducted at 30 locations along the quarry bulk waste haul road. 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 to account for detector efficiency and background measurements, and the removable radioactivity is reported in dpm/100 $cm^2$.

### 5.4.2 Monitoring Results

The site roadway surveys indicated an annual removable average alpha radioactivity level for all monitoring locations of 1.67 dpm/100 $cm^2$. The highest level was 5 dpm/100 $cm^2$. The average minimum detectable activity (MDA) for alpha radioactivity was 5 dpm/100 $cm^2$. The roadway surveys indicated an annual average total alpha radioactivity level for all monitoring locations of 4.22 dpm/100 $cm^2$; the highest level was 19 dpm/100 $cm^2$. The average MDA for fixed alpha radioactivity was 15 dpm/100 $cm^2$.

The fourth quarter haul road surveys indicated a range of removable alpha radioactivity of 0 dpm/100 $cm^2$ to 5.46 dpm/100 $cm^2$, with an average of 0.91 dpm/100 $cm^2$. The range of

beta-gamma radioactivity was 0 dpm/100 $cm^2$ to 1100 dpm/100 $cm^2$, with an average of 171 dpm/100 $cm^2$. The MDA for removable alpha radioactivity and beta-gamma radioactivity was 4 dpm/100 $cm^2$ and 609 dpm/100 $cm^2$, respectively. Most measurements were below the MDA. The annual averages are based upon actual results, whether negative, positive, or zero.

### 5.4.3 Data Analysis

The site monitoring results show fixed contamination present in a few locations, but at levels well below the U.S. Department of Energy (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 Weldon Spring Uranium Feed Material Plant operations. No increase in removable contamination levels has been measured since the monitoring program was initiated.

The quarry haul road monitoring results indicate background radiation levels. These data indicate that no contamination from the quarry is migrating to the quarry haul road, and thus, there is no identifiable probability for radiological contamination of users of the haul road.

## 5.5 Airborne Asbestos Monitoring

During 1994, environmental monitoring for asbestos was conducted full time at Francis Howell High School (AP-4006), at the Weldon Spring site perimeter (AP-2002, AP-2005, AP-2013, and AP-3014), and at the Weldon Spring quarry perimeter (AP-1009, AP-1010, and AP-1016). These locations are identified in Figures 5-1 and 5-2. 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 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. TEM was used for primary asbestos analysis until December 1993, when all asbestos samples began to be analyzed using the PCM method. However, 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 5-6. A total of 363 samples were collected with 156 samples indicating results above the detection limits. The range of samples above the detection limit was 0.001 fibers per milliliter of air (f/ml) to 0.015 f/ml. All samples resubmitted for TEM analysis were determined to have asbestos concentrations below detection limits.

## TABLE 5-6 Summary of Asbestos Air Monitoring Results

| Location | Number of Samples/Samples Above Detection Limit | Range[a] | Average[a] |
|---|---|---|---|
| AP-2002 | 52/23 | 0.001 - 0.012* | 0.003 |
| AP-2005 | 26/13 | 0.001 - 0.013* | 0.0022 |
| AP-2013 | 52/22 | 0.001 - 0.005 | 0.002 |
| AP-2019 | 11/1 | 0.0016 - 0.0016 | 0.0016 |
| AP-2020 | 14/10 | 0.001 - 0.005 | 0.0015 |
| AP-3003 | 26/6 | 0.001 - 0.002 | 0.0013 |
| AP-3014 | 26/15 | 0.001 - 0.003 | 0.0016 |
| AP-1009 | 52/26 | 0.001 - 0.005 | 0.0017 |
| AP-1010 | 52/25 | 0.001 - 0.010* | 0.0019 |
| AP-1016 | 52/20 | 0.001 - 0.005 | 0.0016 |
| AP-4006 | 52/23 | 0.001 - 0.015* | 0.0019 |

* At least one sample resubmitted for TEM analysis; TEM results showed asbestos concentrations below detection limits.
(a) Includes only samples above detection limits.

PCM results of the environmental air samples collected from the site and quarry perimeters and Francis Howell High School are all below the fiber concentration limits defined by the EPA's acceptable clearance levels for schools. These results indicate that asbestos fibers were effectively contained during abatement operations and quarry bulk waste excavation.

## 5.6 Highlights

- Statistical analysis indicated that two radon monitors located at the quarry perimeter and one location at the site perimeter were statistically greater than background. The highest measured concentration was 157% of the derived concentration guideline (DCG) for integrated radon (Rn-222 and Rn-220). However, the total effective dose equivalent for the hypothetical maximally exposed individual was less than 1 mrem (0.01 mSv) (Section 4.4).

- The annual TLD results from the chemical plant perimeter, quarry perimeter, and off-site locations ranged from 45 mrem (0.45 mSv) to 75 mrem (0.75 mSv). Statistical analysis of monitoring results indicate at the 95% confidence level that two quarry stations measured results that were greater than background levels.

- Asbestos analysis showed fiber concentrations at the chemical plant perimeter, the quarry perimeter, and Francis Howell High School to be in compliance with the EPA acceptable clearance levels for schools.

- Statistical analysis indicated that four gross alpha airborne particulate monitors at the chemical plant and raffinate pits perimeter, five locations at the quarry, and one off-site monitoring location had annual average concentrations statistically greater than background levels. The highest measured net annual average concentration was 22% of the DCG for Th-232, which is the lowest DCG at the site, and 1.6% of the DCG for U-238, which is the primary contaminant at the site.

# 6 NESHAPS PROGRAM

This section provides information on 1994 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/compliance information related to sources of radioactive particulate emissions at the Weldon Spring Site Remedial Action Project (WSSRAP). This section is prepared in fulfillment of the required annual National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring report for the Weldon Spring site.

## 6.1 Facility Information

### 6.1.1 Site Description

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

### 6.1.2 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 or dust and dirt from building debris and fugitive dust generated during remedial actions. Operation of two water treatment plants, however, constitutes potential emission points ("point sources").

## 6.2 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 gross uncertainties. Measurement of the entrainment and emissions inventory is also extremely difficult and results are uncertain at best, because the emissions are highly variable both over time and location. Accurate measurements of area or volumetric fugitive emissions can only be made with complete knowledge of the micro-meteorology in and around the source and the use of many (usually greater than 10) measurement locations. Therefore, modeling of downwind dispersion and subsequent dose calculations using either assumed or measured emission rates leads to extremely uncertain results.

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 alternate approach has been approved by EPA Region VII.

### 6.2.1 Point Sources

The WSSRAP *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21) contains estimates of radionuclide point source emissions and associated effective dose equivalents from the site water treatment plant (SWTP) and quarry water treatment plant (QWTP) for members of the public. Table 6-1 briefly describes the two treatment plants and lists their nearest receptor locations. The highest estimated dose from the SWTP to the public during 1994 was approximately 1.0E-2 mrem (1.0E-4 mSv) at the WSSRAP administration building, which is located at a distance of 400 m (437 yd) from the SWTP. This result assumes no emission controls at the SWTP. The highest estimated dose from the QWTP to the public was approximately 6.7E-3 mrem (6.7E-5 mSv) at the residence located 700 m (765 yd) west of the quarry. This result also assumes no emission controls are used. Because both these values are less than 0.1 mrem and critical receptor monitoring is performed, the

WSSRAP is not required to perform additional effluent monitoring under the requirements of 40 CFR 61 Subpart H and DOE Order 5400.5. Point source emissions data and effective dose equivalents for the other WSSRAP critical receptor locations are listed in the above mentioned plan.

TABLE 6-1 WSSRAP Point Sources

| Point Source I.D. | Effluent Control | | Nearest Receptor | |
|---|---|---|---|---|
| | 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 |

### 6.2.2 Group Sources

The WSSRAP has not defined any grouped sources.

### 6.2.3 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. Activities within these areas literally change on a hourly basis. 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 daughter 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. Airborne emissions from the quarry result from the wind blown resuspension of radioactive particulates from quarry soils and resuspension of radioactive particulates due to remediation activities at the quarry, such as the operation of heavy equipment and the excavation of soils.

The Weldon Spring Chemical Plant and raffinate pits diffuse source encompasses 87 ha (217 acres) on which approximately 45 building foundations, 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/debris, and resuspension of radioactive particulates from site operations such as bulk waste placement and soil excavation. Because the WSSRAP does not attempt to determine emissions from specific diffuse sources within the chemical plant and quarry areas, it is impossible to provide a realistic estimate of total emissions. However, to provide this information, estimates are based on a simple box model. These estimates are provided in Section 4.2 of this report.

## 6.3 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. Critical receptor locations are places where members of the public abide or reside and have a potential to encounter off-site concentrations of radionuclides other than radon 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.

### 6.3.1 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 described in Table 6-2. They include: the common boundary of the Weldon Spring Chemical Plant and the Missouri Highway 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 is the designated background monitoring location (AP-4012).

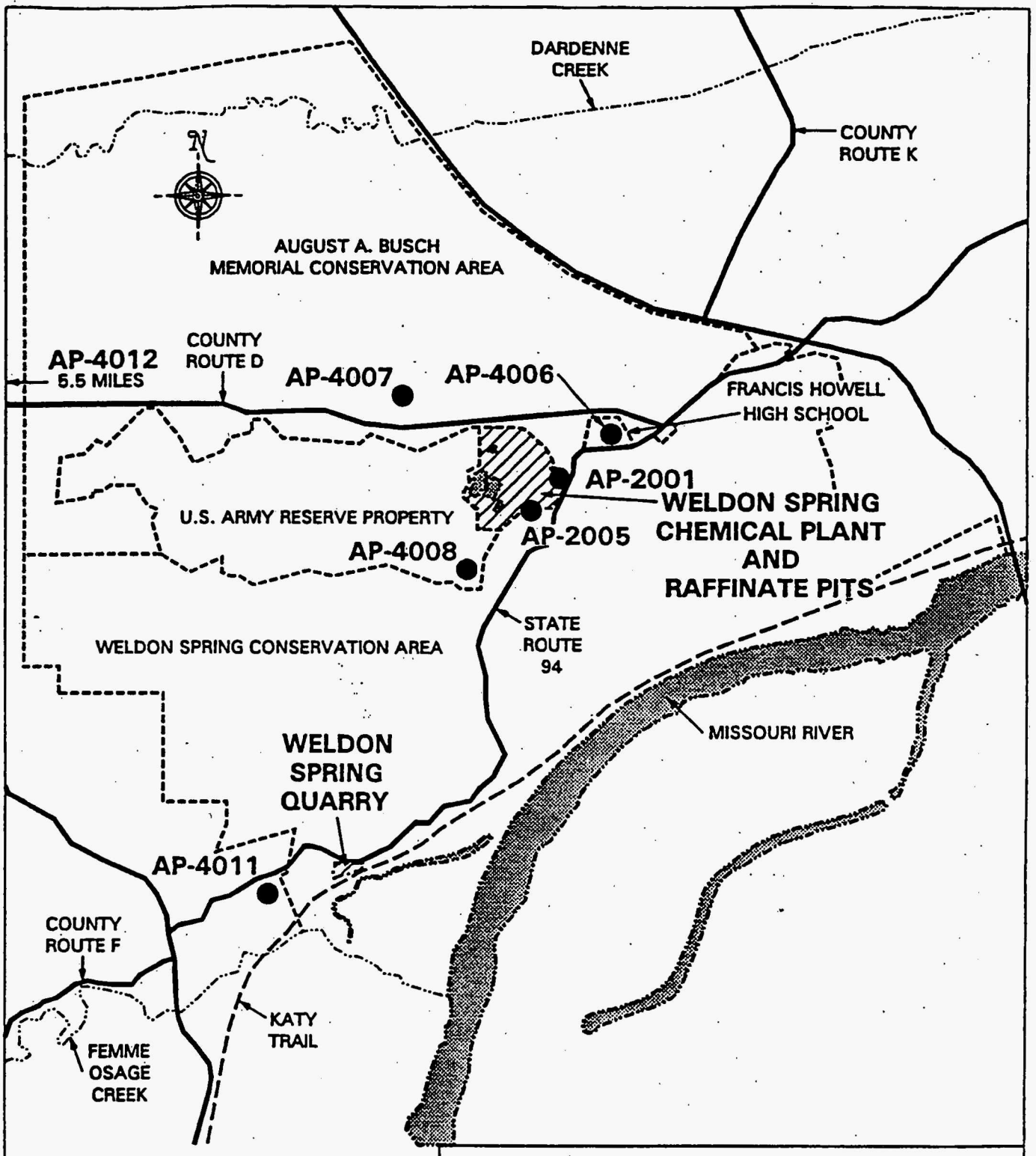
Each critical receptor location includes a low volume air sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples are collected on mixed cellulose ester membrane filters, approximately 1.5 m (5 ft) above the ground and are exchanged on a weekly basis. High volume samples are collected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

The high volume samples are analyzed for isotopic thorium, total uranium, Ra-226, and Ra-228. 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 background concentrations are subtracted from each sample concentration. If background concentrations are greater than the concentration of the critical receptor sample, a negative value is reported.

### 6.3.2 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 1.25 $m^3$/h (44.1 $ft^3$/h);
- 50-year committed effective dose equivalent conversion factors provided in EPA Federal Guidance Report No. 11 (Ref. 28);




NESHAPS CRITICAL RECEPTOR MONITORING LOCATIONS

FIGURE 6-1

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/VP/001/0195 | | |
| ORIGINATOR: | EKA | DRAWN BY: | GLN | DATE: | 3/3/95 |

## TABLE 6-2 Exposure Scenarios and NESHAPs Dose Estimates for 1994

| Critical Receptor | Sample ID | Total Individuals | Exposure Duration | Estimated Dose Equivalent (mrem) |
|---|---|---|---|---|
| Missouri Highway Maintenance Facility | AP-2001 | 9 | 2,000 hr/yr | 0.1165 ± 0.3422 |
| WSSRAP administration building | AP-2005 | 290 | 2,500 hr/yr | 0.2047 ± 0.4247 |
| Francis Howell High School - Assessment 1 | AP-4006 | 2,300 | 2,250 hr/yr | 0.0504 ± 0.3533 |
| Francis Howell High School - Assessment 2 | AP-4006 | 1[a] | 8,760 hr/yr | 0.1962 ± 1.376 |
| Busch Memorial Conservation Area | AP-4007 | 25 | 2,500 hr/yr | 0.0133 ± 0.3017 |
| Weldon Spring Training Area | AP-4008 | 1[b] | 2,000 hr/yr | 0.0883 ± 0.3050 |
| Nearest quarry residence | AP-4011 | 1[c] | 8,760 hr/yr | 0.177 ± 1.366 |

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

- Exposure duration listed in Table 6-2.

The dose calculations for each critical receptor are listed in Table 6-3. The maximum dose equivalent calculated for NESHAPs critical receptors was $0.2047 \pm 0.4247$ mrem (0.0020 mSv) CEDE at AP-2005 for an individual working in the WSSRAP administration building 2500 hours/year. Technically, because members of the public neither abide nor reside here, and because the area is under DOE control, this individual would not be a member of the public, but is hypothetically treated as such. All doses for critical receptor locations are less than 1 mrem (0.01 mSv) for the entire year, and are similar to those calculated for 1993. These values are well below the NESHAPs limit of 10 mrem total effective dose equivalent per year (0.10 mSv).

Based on the results of one-tailed Student's t-tests at the 95% confidence level, total uranium concentrations at one critical receptor location (AP-2001) remained at above background levels during 1994. These results are probably due to building dismantlement activities that occurred throughout the year. Analysis of total uranium measurements at all other critical receptor locations, however, indicated no annual average concentrations statistically above background levels. Additionally, measurements of other radioisotopes listed in Table 6-3 indicated no annual average values statistically above background levels at any of the critical receptors.

## 6.4 Additional Information

No unplanned releases to the atmosphere occurred in 1994.

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 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 accuracy were not met for the second, third, and fourth quarters of 1994. Accuracy tests indicated failure of

# TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1994

| AP-2001 | 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 | 5.5E-10 ± N/A | 0.0331 ± N/A | 2.92E-10 ± N/A | 0.0171 ± N/A | 3.6E-10 ± N/A | 0.0209 ± N/A | 2.3E-10 ± N/A | 0.0136 ± N/A | 0.0847 ± N/A |
| Ra-226 | -2.1E-11 ± 2.22E-10 | 0 ± 0.0009 | 0 ± 5.72E-10 | 0 ± 0.0024 | -3.1E-12 ± 1.37E-10 | 0 ± 0.0006 | 2.21E-11 ± 1.09E-9 | 0.0001 ± 0.0042 | 0.0001 ± 0.0050 |
| Ra-228 | -1.7E-10 ± 5.93E-10 | 0 ± 0.0014 | -5.1E-11 ± 6.1E-10 | 0 ± 0.0014 | 8.05E-12 ± 6.07E-10 | 0 ± 0.0014 | 2.09E-10 ± 5.49E-10 | 0.0005 ± 0.0013 | 0.0005 ± 0.0028 |
| Th-228 | -3.4E-12 ± 1.72E-10 | 0 ± 0.0283 | 0 ± 1.83E-10 | 0 ± 0.0300 | 3.35E-11 ± 1.91E-10 | 0.0055 ± 0.0314 | 5.37E-12 ± 2.62E-10 | 0.0009 ± 0.0429 | 0.0064 ± 0.0873 |
| Th-230 | -7.8E-11 ± 2.24E-10 | 0 ± 0.0350 | 2.66E-11 ± 2.02E-10 | 0.0042 ± 0.0310 | 5.48E-11 ± 2.13E-10 | 0.0086 ± 0.0333 | -4.5E-11 ± 2.73E-10 | 0 ± 0.0426 | 0.0128 ± 0.0717 |
| Th-232 | -2.3E-11 ± 1.8E-10 | 0 ± 0.1415 | 0 ± 1.82E-10 | 0 ± 0.1431 | 1.53E-11 ± 1.79E-10 | 0.0120 ± 0.1406 | -8.1E-12 ± 2.76E-10 | 0 ± 0.2170 | 0.0120 ± 0.3277 |
| EDE | | 0.0331 ± 0.1485 | | 0.0213 ± 0.1496 | | 0.047 ± 0.1478 | | 0.0151 ± 0.2253 | 0.1165 ± 0.3422 |

| AP-2005 | 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 | 2.0E-9 ± N/A | 0.1505 ± N/A | 3.00E-10 ± N/A | 0.0225 ± N/A | 1.91E-10 ± N/A | 0.0139 ± N/A | 1.75E-12 ± N/A | 0.0001 ± N/A | 0.187 ± N/A |
| Ra-226 | -1.2E-11 ± 2.2E-10 | 0 ± 0.0011 | 1.17E-10 ± 7.55E-10 | 0.0006 ± 0.0039 | -3.1E-12 ± 1.52E-10 | 0 ± 0.0008 | 7.61E-11 ± 1.06E-9 | 0.0004 ± 0.0055 | 0.0010 ± 0.0069 |
| Ra-228 | -8.1E-11 ± 5.95E-10 | 0 ± 0.0017 | -1.2E-10 ± 5.83E-10 | 0 ± 0.0017 | -6.8E-11 ± 6.23E-10 | 0 ± 0.0018 | 2.09E-10 ± 5.54E-10 | 0.0006 ± 0.0016 | 0.0006 ± 0.0034 |
| Th-228 | -8.5E-12 ± 1.79E-10 | 0 ± 0.0367 | 2.77E-13 ± 1.83E-10 | 0.0001 ± 0.0374 | 7.65E-12 ± 1.95E-10 | 0.0016 ± 0.0400 | 0 ± 2.55E-10 | 0 ± 0.0522 | 0.0017 ± 0.0841 |
| Th-230 | -9.4E-11 ± 2.2E-10 | 0 ± 0.0420 | 4.55E-11 ± 2.05E-10 | 0.0089 ± 0.0400 | 2.82E-11 ± 2.11E-10 | 0.0055 ± 0.0415 | -2.6E-11 ± 2.84E-10 | 0 ± 0.0555 | 0.0144 ± 0.0904 |
| Th-232 | -2.2E-12 ± 1.9E-10 | 0 ± 0.1937 | 0 ± 1.81E-10 | 0 ± 0.1783 | 0 ± 1.7E-10 | 0 ± 0.1676 | -1.0E-11 ± 2.64E-10 | 0 ± 0.2601 | 0 ± 0.4063 |
| EDE | | 0.1505 ± 0.2016 | | 0.0315 ± 0.1866 | | 0.0210 ± 0.1771 | | 0.0011 ± 0.2711 | 0.2047 ± 0.4247 |

## TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1994 (Continued)

| AP-4006 | 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 | 8.03E-11 ± N/A | 0.0039 ± N/A | 8.19E-11 ± N/A | 0.0053 ± N/A | -1.9E-11 ± N/A | 0 ± N/A | 2.78E-11 ± N/A | 0.0019 ± N/A | 0.0111 ± N/A |
| Ra-226 | -2.3E-11 ± 2.3E-10 | 0 ± 0.0011 | 0 ± 7.31E-10 | 0 ± 0.0034 | -3.1E-12 ± 2.28E-10 | 0 ± 0.0011 | 1.02E-10 ± 1.06E-9 | 0.0005 ± 0.0049 | 0.0005 ± 0.0062 |
| Ra-228 | -1.0E-10 ± 5.9E-10 | 0 ± 0.0015 | -4.0E-11 ± 6.49E-10 | 0 ± 0.0017 | -2.4E-11 ± 5.84E-10 | 0 ± 0.0015 | 9.85E-11 ± 5.67E-10 | 0.0003 ± 0.0015 | 0.0003 ± 0.0031 |
| Th-228 | 9.53E-13 ± 1.58E-10 | 0.0002 ± 0.0291 | 0 ± 1.89E-10 | 0 ± 0.0349 | 1.9E-11 ± 1.02E-10 | 0.0035 ± 0.0189 | 0 ± 2.46E-10 | 0 ± 0.0454 | 0.0037 ± 0.0670 |
| Th-230 | -6.7E-11 ± 2.12E-10 | 0 ± 0.0373 | 1.33E-11 ± 2.01E-10 | 0.0023 ± 0.0354 | 2.5E-11 ± 1.57E-10 | 0.0044 ± 0.0276 | -5.1E-11 ± 2.6E-10 | 0 ± 0.0457 | 0.0067 ± 0.0741 |
| Th-232 | 2.11E-11 ± 1.81E-10 | 0.0187 ± 0.1599 | 0 ± 1.86E-10 | 0 ± 0.1645 | 9.91E-12 ± 1.02E-10 | 0.0088 ± 0.0903 | 6.8E-13 ± 2.63E-10 | 0.0008 ± 0.2326 | 0.0281 ± 0.3389 |
| EDE | | 0.0228 ± 0.1668 | | 0.0076 ± 0.1719 | | 0.0167 ± 0.0963 | | 0.0033 ± 0.2413 | 0.0504 ± 0.3533 |

| AP-4007 | 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 | 1.3E-11 ± N/A | 0.0008 ± N/A | 1.84E-11 ± N/A | 0.0011 ± N/A | 1.5E-11 ± N/A | 0.0009 ± N/A | -6.0E-11 ± N/A | 0 ± N/A | 0.0028 ± N/A |
| Ra-226 | -1E-11 ± 2.27E-10 | 0 ± 0.0009 | 0 ± 7.99E-10 | 0 ± 0.0033 | 1.13E-11 ± 2.38E-10 | 0 ± 0.0010 | 1.31E-10 ± 1.1E-9 | 0.0005 ± 0.0045 | 0.0005 ± 0.0057 |
| Ra-228 | -2.5E-11 ± 5.77E-10 | 0 ± 0.0013 | -9.4E-11 ± 6.735E-10 | 0.0002 ± 0.0015 | 6.21E-11 ± 6.49E-10 | 0.0001 ± 0.0015 | 6.52E-11 ± 5.79E-10 | 0.0002 ± 0.0013 | 0.0005 ± 0.0028 |
| Th-228 | 3.58E-12 ± 1.51E-10 | 0.0006 ± 0.0247 | 0 ± 1.78E-10 | 0 ± 0.0291 | 1.41E-11 ± 1.08E-10 | 0.0023 ± 0.0178 | 5.6E-12 ± 2.4E-10 | 0.0010 ± 0.0394 | 0.0039 ± 0.0577 |
| Th-230 | -5.6E-11 ± 2.12E-10 | 0 ± 0.0330 | 1.11E-11 ± 2.0E-10 | 0.0017 ± 0.0312 | 1.02E-11 ± 1.48E-10 | 0.0016 ± 0.0231 | -3.5E-11 ± 2.57E-10 | 0 ± 0.0401 | 0.0033 ± 0.0648 |
| Th-232 | -1.1E-11 ± 1.61E-10 | 0 ± 0.1264 | 2.7E-12 ± 2.0E-10 | 0.0021 ± 0.1573 | 2.72E-13 ± 9.65E-11 | 0.0002 ± 0.0760 | -1.0E-11 ± 2.44E-10 | 0 ± 0.1923 | 0.0023 ± 0.2889 |
| EDE | 0.0014 ± 0.1329 | | 0.0051 ± 0.1630 | | 0.0051 ± 0.0814 | | | 0.0017 ± 0.2004 | 0.0133 ± 0.3017 |

## TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1994 (Continued)

| AP-4008 | 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 | 8.02E-11 ± N/A | 0.0048 ± N/A | -1.9E-12 ± N/A | 0 ± N/A | 2.39E-11 ± N/A | 0.0014 ± N/A | -1E-10 ± N/A | 0 ± N/A | 0.0062 ± N/A |
| Ra-226 | -3.7E-11 ± 2.17E-10 | 0 ± 0.0008 | 0 ± 7.64E-10 | 0 ± 0.0032 | -3.1E-12 ± 1.34E-10 | 0 ± 0.0008 | -2.9E-11 ± 9.72E-10 | 0 ± 0.0040 | 0 ± 0.0052 |
| Ra-228 | 9.07E-11 ± 5.72E-10 | 0.0002 ± 0.0013 | -6.8E-11 ± 7.18E-10 | 0 ± 0.0010 | -2.1E-11 ± 6.35E-10 | 0 ± 0.0015 | 1.78E-10 ± 5.76E-10 | 0.0004 ± 0.0013 | 0.0008 ± 0.0029 |
| Th-228 | 4.96E-11 ± 1.79E-10 | 0.0081 ± 0.0294 | 0 ± 1.92E-10 | 0 ± 0.0315 | 2.87E-11 ± 1.19E-10 | 0.047 ± 0.0195 | 1.05E-12 ± 2.35E-10 | 0.0002 ± 0.0385 | 0.0553 ± 0.0610 |
| Th-230 | -5.6E-12 ± 2.31E-10 | 0.0009 ± 0.0362 | -6.9E-13 ± 1.95E-10 | 0.0001 ± 0.0305 | 2.43E-11 ± 1.55E-10 | 0.0038 ± 0.0242 | -6.6E-11 ± 2.37E-10 | 0 ± 0.0371 | 0.0048 ± 0.0848 |
| Th-232 | 8.91E-12 ± 1.7E-10 | 0.0070 ± 0.1340 | 0 ± 1.95E-10 | 0 ± 0.1531 | 1.84E-11 ± 1.11E-10 | 0.0144 ± 0.0877 | -9.7E-12 ± 2.41E-10 | 0 ± 0.1897 | 0.0214 ± 0.2917 |
| EDE | | 0.0210 ± 0.1419 | | 0.0001 ± 0.1592 | | 0.0688 ± 0.0930 | | 0.0006 ± 0.1971 | 0.0883 ± 0.3050 |
| 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 | 1.06E-11 ± N/A | 0.0027 ± N/A | -1.8E-11 ± N/A | 0 ± N/A | -2.1E-11 ± N/A | 0 ± N/A | -8.3E-11 ± N/A | 0 ± N/A | 0.0027 ± N/A |
| Ra-226 | -3.1E-11 ± 2.15E-10 | 0 ± 0.0039 | 0 ± 7.24E-10 | 0 ± 0.0131 | -3.1E-12 ± 1.36E-10 | 0 ± 0.0024 | -2.9E-11 ± 1.01E-9 | 0 ± 0.0183 | 0 ± 0.0230 |
| Ra-228 | -1.2E-11 ± 5.61E-10 | 0 ± 0.0056 | -1.2E-10 ± 6.19E-10 | 0 ± 0.0062 | -3.3E-11 ± 6.29E-10 | 0 ± 0.0063 | 2.39E-10 ± 5.92E-10 | 0.0025 ± 0.0059 | 0.0025 ± 0.0120 |
| Th-228 | -3.6E-12 ± 1.51E-10 | 0 ± 0.1084 | 5.23E-12 ± 1.84E-10 | 0.0038 ± 0.1318 | 1.17E-11 ± 1.03E-10 | 0.0084 ± 0.0740 | 0 ± 2.46E-10 | 0 ± 0.1768 | 0.0122 ± 0.2566 |
| Th-230 | -2.9E-11 ± 2.2E-10 | 0 ± 0.1513 | 3.88E-11 ± 1.99E-10 | 0.0266 ± 0.1362 | 3.03E-12 ± 1.41E-10 | 0.0021 ± 0.0965 | -2.7E-11 ± 2.7E-10 | 0 ± 0.1848 | 0.0287 ± 0.2914 |
| Th-232 | 1.95E-11 ± 1.8E-10 | 0.0672 ± 0.6047 | 0 ± 1.72E-10 | 0 ± 0.5913 | 1.8E-11 ± 1.08E-10 | 0.0622 ± 0.3718 | 4.28E-13 ± 2.69E-10 | 0.0015 ± 0.9285 | 0.1309 ± 1.3098 |
| EDE | | 0.0699 ± 0.6327 | | 0.0304 ± 0.6211 | | 0.0727 ± 0.3912 | | 0.0040 ± 0.9632 | 0.177 ± 1.3663 |

## TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1994 (Continued)

| 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 | 1.47E-10 ± N/A | 1.28E-10 ± N/A | 1.45E-10 ± N/A | 2.48E-10 ± N/A | -- |
| Ra-226 | 3.67E-11 ± 1.75E-10 | 0 ± 5.48E-10 | 3.14E-12 ± 9.73E-11 | 2.89E-11 ± 1.5E-10 | -- |
| Ra-228 | 2.32E-10 ± 4.24E-10 | 2.08E-10 ± 4.21E-10 | 7.13E-11 ± 4.3E-10 | 9.71E-11 ± 3.64E-10 | -- |
| Th-228 | 2.17E-11 ± 1.14E-10 | 0 ± 1.31E-10 | 2.85E-13 ± 6.76E-11 | 0 ± 9.76E-11 | -- |
| Th-230 | 1.28E-10 ± 1.7E-10 | 2.14E-11 ± 1.35E-10 | 3.31E-11 ± 9.97E-11 | 8.13E-11 ± 1.46E-10 | -- |
| Th-232 | 2.87E-11 ± 1.25E-10 | 0 ± 1.35E-10 | 0 ± 6.76E-11 | 1.05E-11 ± 1.08E-10 | -- |

N/A Not available
-- Background annual dose not calculated
EDE Effective Dose Equivalent
Multiply by 0.01 to convert mrem to mSv.
Multiply by 37,000 to convert $\mu Ci/m^3$ to $Bq/m^3$.

five of the six Th-230 spikes to meet the known values objective of ±50% for 85% of the samples. All uranium spikes met this objective.

A series of corrective actions to address this issue has been established and includes the following elements:

- Obtain a National Institute for Standards and Testing (NIST) traceable Th-230 spike and use this to make new Th-230 spikes for the NESHAPs program.
- Send a duplicate sample to a second qualified laboratory to compare results.
- Perform a careful review of the sample preparation process. Ensure proper addition of nitric acid for sample preservation and proper agitation prior to drawing the sample.

The laboratory was contacted in order to verify the method used to prepare and analyze the composited filters. Discussions revealed that the filters were being cut in half and then were digested in acid. From this solution, three aliquots were produced for analysis. This would introduce an error for the spiked samples that do not have the radioactivity evenly distributed over the filter. The laboratory was asked to analyze the archived portion of the spiked filters for the second, third, and fourth quarters 1994. The results will be averaged with the initial results and compared to the spiked value. In the future the laboratory will digest the quarterly composited filters for each monitoring location and then prepare three aliquots for analysis. This should allow the accuracy data quality objectives for the Th-230 spike samples to be met.

## 6.5 Supplemental Information

Although not required by 40 CFR 61, this supplemental information is provided to assist the DOE in guidance development and for 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.

### 6.5.1 Collective Population Dose Equivalent

The estimated 1994 collective population dose equivalent due only to radioactive airborne releases from the Weldon Spring site was 0.029 person-rem (2.9E-4 person-Sv). The total 1994 collective population dose equivalent was 0.072 person-rem (7.2E-4 person-Sv). These estimates were calculated for a combination of users of the August A. Busch Memorial Conservation Area and the Katy Trail. The approximations were based on the annual average gross alpha concentrations measured by the Weldon Spring Chemical Plant perimeter monitoring station closest to the Conservation Area lakes (station AP-2002, shown in Figure 5-1), and the station located along the upper rim area of the Weldon Spring Quarry closest to the Katy Trail (station AP-1010, shown in Figure 5-2). The NESHAPs monitoring results at both the conservation headquarters building (station AP-4007) and at the station nearest to the Katy Trail (AP-4011), however, indicated no above background concentrations of radionuclides. Stations AP-4007 and AP-4011 are shown in Figures 5-3 and 5-2, respectively.

### 6.5.2 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. Since the Weldon Spring site does not yet have an interim storage or disposal source, Subpart Q does not apply at present.

The regulations contained in 40 CFR 61 Subpart T applies 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.

### 6.5.3 Radon Emissions from WSSRAP Non-Storage Sources

**6.5.3.1 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. Included in the radiologically contaminated waste disposal inventory is at least 800 cu yd (612 $m^3$) 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 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 in the quarry is contained in the *Remedial Investigation for Quarry Bulk Wastes* (DOE/OR/21548-066).

To estimate the airborne Rn-220 emissions from the quarry during 1994, the above background modified alpha-track radon detector 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 to close-in receptors. The estimated Rn-220 release was 84 Ci (3.1E12 Bq). This corresponds to a committed effective dose equivalent to the hypothetical maximally exposed individual of 0.7 mrem (0.007 mSv). Calculations and assumptions are provided in Appendix B.

Other potential Rn-220 sources are the temporary storage area (TSA), which is currently receiving quarry bulk wastes, and the four raffinate pits used for the storage of wastes from past uranium refinery operations. The chemical plant perimeter is monitored for radon gas at 12 locations using alpha track radon monitors. These monitors are sensitive to all isotopes of radon. Statistical analysis at the 95% confidence level of the alpha track detector results indicated that perimeter radon concentrations during 1994 were not different than background levels.

**6.5.3.2 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 quarry is a non-storage source of Rn-222. 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 and covered approximately 1 acre of the quarry floor to a depth of about 30 feet (9.1 m). Also, several buildings at the chemical plant were decontaminated and approximately 5,500 cu yd (4,200 $m^3$) of waste materials were dumped in the quarry. The wastes contained uranium and its progeny and were placed on the quarry floor. The extent of the radiological contamination of this material is unknown. 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

in the quarry is contained in the *Remedial Investigation for Quarry Bulk Wastes* (DOE/OR/21548-006).

As in the technique used for Rn-220 (see previous section), the airborne Rn-222 emissions from the quarry during 1994 were estimated by incorporating the above background alpha track radon detector results into a series of box models. The estimated Rn-222 release was 32 Ci (1.2E12 Bq). This corresponds to a committed effective dose equivalent to the hypothetical maximally exposed individual of 0.01 mrem (1E-4 mSv). Calculations and assumptions are provided in Appendix B.

The other non-storage source of Rn-222 during 1994 was the four raffinate pits which were used for the storage of waste resulting from past uranium refinery operations. As stated previously, the perimeter of the chemical plant is monitored for radon gas at 12 locations using alpha track radon monitors. These monitors are sensitive to all isotopes of radon. Statistical analysis at the 95% confidence level of the alpha track monitoring results indicated that no annual average perimeter concentrations exceeded background levels.

### 6.5.4 Effluent Monitoring Requirements

The site water treatment plant and the quarry water treatment plant were operated in 1994 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* (DOE/OR/21548-127), 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 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) includes monitoring discharge points permitted under the National Pollutant Discharge Elimination System (NPDES) program and monitoring 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 NPDES permit requirements and to characterize water released from the site to protect the environment and the health of downstream water users.

To protect surface waters, the monitoring program monitors for existing or potential surface water contamination. Additional goals include demonstrating compliance with all applicable regulations and Department of Energy Orders, providing sufficient data to determine long term build up of contaminants, and the detection and quantification of unplanned releases.

## 7.2 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 1994 were authorized by five NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be sampled under each permit. Each parameter is assigned 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, respectively. These permits were reissued on March 4, 1994, and June 10, 1994, respectively.

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

| Parameter | Location | | |
|---|---|---|---|
| | NP-0002, NP-0003, NP-0005, NP-0010[a] | NP-0001, NP-0004[a] | NP-0006 |
| Sampling Frequency | once/month | once/quarter | once/quarter |
| Flow | GPD (monitor only) | GPD (monitor only) | GPD (monitor only)[b] |
| Settleable Solids | 1.0 ml/l/hr | 1.0 ml/l/hr | --- |
| TSS | mg/l (monitor only)[c] | mg/l (monitor only)[c] | 15 / 20 mg/l[d] |
| Nitrate as N[e] | mg/l (monitor only) | mg/l (monitor only) | --- |
| Lithium[f] | mg/l (monitor only) | mg/l (monitor only) | --- |
| Uranium, total | mg/l (monitor only)* | mg/l (monitor only)* | --- |
| Gross $\alpha$ | pCi/l (monitor only) | pCi/l (monitor only) | --- |
| pH | 6 - 9 standard units | 6 - 9 standard units | 6 - 9 standard units |
| Fecal coliform | --- | --- | 400/1000 colonies/ 100 ml[g] |
| BOD | --- | --- | 10/15 mg/l[d] |

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

* Permit requires reporting in both mg/l and pCi/l.
(a) NP-0010 was added and outfall NP-0004 deleted with the reissuance of NPDES permit MO-0107701.
(b) Frequency is once/month.
(c) Limit is 50 mg/l if erosion control is not designed for a 1 in 10 year, 24-hour storm.
(d) Monthly average and weekly average.
(e) Changed to nitrate and nitrite (as N) on reissuance of NPDES Permit MO-0107701.
(f) Lithium deleted on reissuance of NPDES permit MO-0107701.
(g) Monthly average/daily maximum.
--- 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 | | Parameter | Location | |
|---|---|---|---|---|---|
| | NP-0007<br>NP-1001 | SW-1011[a]<br>SW-1016[a]<br>SW-1015[a] | | NP-0007<br>NP-1001 | SW-1011[a]<br>SW-1016[a]<br>SW-1015[a] |
| Gross $\alpha$ | pCi/l[b] | pCi/l[b] | Pb, total | 0.10 mg/l | NR |
| Gross ß | pCi/l[b] | pCi/l[b] | Mn, total | 0.10 mg/l | NR |
| Uranium, total | pCi/l[b][c] | pCi/l[b] | Hg, total | 0.004 mg/l | NR |
| Ra-226[d] | pCi/l[b] | pCi/l[b] | Se, total | 0.02 mg/l | NR |
| Ra-228[d] | pCi/l[b] | pCi/l[b] | Ag, total[e] | 0.10 mg/l | NR |
| Th-230[d] | pCi/l[b] | pCi/l[b] | Zn, total[e] | 5.00 mg/l | NR |
| Th-232[d] | pCi/l[b] | pCi/l[b] | Cyanide, total[f] | 0.0075 mg/l | NR |
| Flow | GPD[b] | NR | Asbestos[e] | fibers/l[b] | NR |
| BOD[e] | mg/l[b] | NR | 2,4-DNT | 0.22 µg/l | NR |
| COD | 90/60 mg/l [g] | NR | Fluoride, total | 4.0 mg/l | NR |
| TSS | 50/30 mg/l[g] | NR | Nitrate as N[h] | 20 mg/l[i] | NR |
| pH | 6-9 standard units | NR | Sulfate as $SO_4$ | 500 mg/l | NR |
| As, total | 0.10 mg/l | NR | Chloride | mg/l[b] | NR |
| Ba, total[e] | 1.5 mg/l | NR | Priority Pollutants[j] | mg/l[b][k] | NR |
| Cd, total[e] | 0.02 mg/l | NR | Whole Effluent Toxicity | 10% Mortality[l][m] | NR |
| Cr, total | 0.1 mg/l | NR | Po-210[n] | pCi/l[b][o] | NR |
| Cu, total[p][d] | 1.00 mg/l | NR | Ac-227[n] | pCi/l[b][o] | NR |
| Fe, total[e] | 0.60 mg/l | NR | Radon[n] | pCi/l[b][o] | NR |

NOTE: Refer to Figure 7-2 for NPDES monitoring locations
NR Not Required
Frequency = once per batch unless otherwise noted.

(a) River monitoring locations were deleted on reissuance of NPDES permits.
(b) Monitoring only.
(c) Water treatment plants designed for an average concentration of 30 pCi/l and never to exceed concentrations of 100 pCi/l.
(d) Monitoring changed to once per month with reissuance of NPDES permits.
(e) Eliminated with reissuance of NPDES permits.
(f) Changed to cyanide-amenable with reissuance of NPDES permit.
(g) Daily maximum/monthly average.

(h) Changed to nitrate and nitrite (as N) with reissuance of NPDES permit.
(i) Limit applies to chemical plant; monitoring only at quarry.
(j) Changed to include priority pollutant metals, total phenols, and total cyanide with reissuance of the NPDES permits.
(k) Annual monitoring.
(l) Quarterly monitoring.
(m) Changed to "no statistical difference between effluent and upstream results at 95% confidence level" with reissuance of NPDES permit.
(n) NP-1001 only.
(o) Semiannual monitoring, changed to annual monitoring on reissuance of NPDES permit.
(p) Quarry only, with reissuance of NPDES permits.

The site water treatment plant effluent pipeline land disturbance permit (MO-R101389) required settleable solids to be measured once per quarter. Discharge monitoring reports were not required for this permit, although MDNR notification was required if settleable solids exceeded the reporting level of 2.5 ml/l/hr. This permit was terminated during 1994.

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 monitoring program will be developed in the *Environmental Monitoring Plan*. Permit MO-G679035, issued August 31, 1994, is for hydrostatic test water from site water treatment plant Train 2 plant and facilities construction. This permit requires sampling once per release for total suspended solids (TSS), oil and grease, and flow and reporting analytical results within 30 days of discharge. There were no discharges under NPDES permits MO-R100B69 or MO-G597035 during 1994.

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 the outfall exceeds the derived concentration guideline (DCG) for natural uranium (600 pCi/l). Measures are also taken to keep uranium concentrations as low as reasonably achievable (ALARA).

The main criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards established under the Missouri Clean Water Commission Regulation (10 CSR 20-7.031) and the proposed U.S. Environmental Protection Agency drinking water standards for radionuclides. A list of applicable water standards for contaminants routinely monitored in the surface water program can be found in Table 8-1.

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 (see Table 8-2).

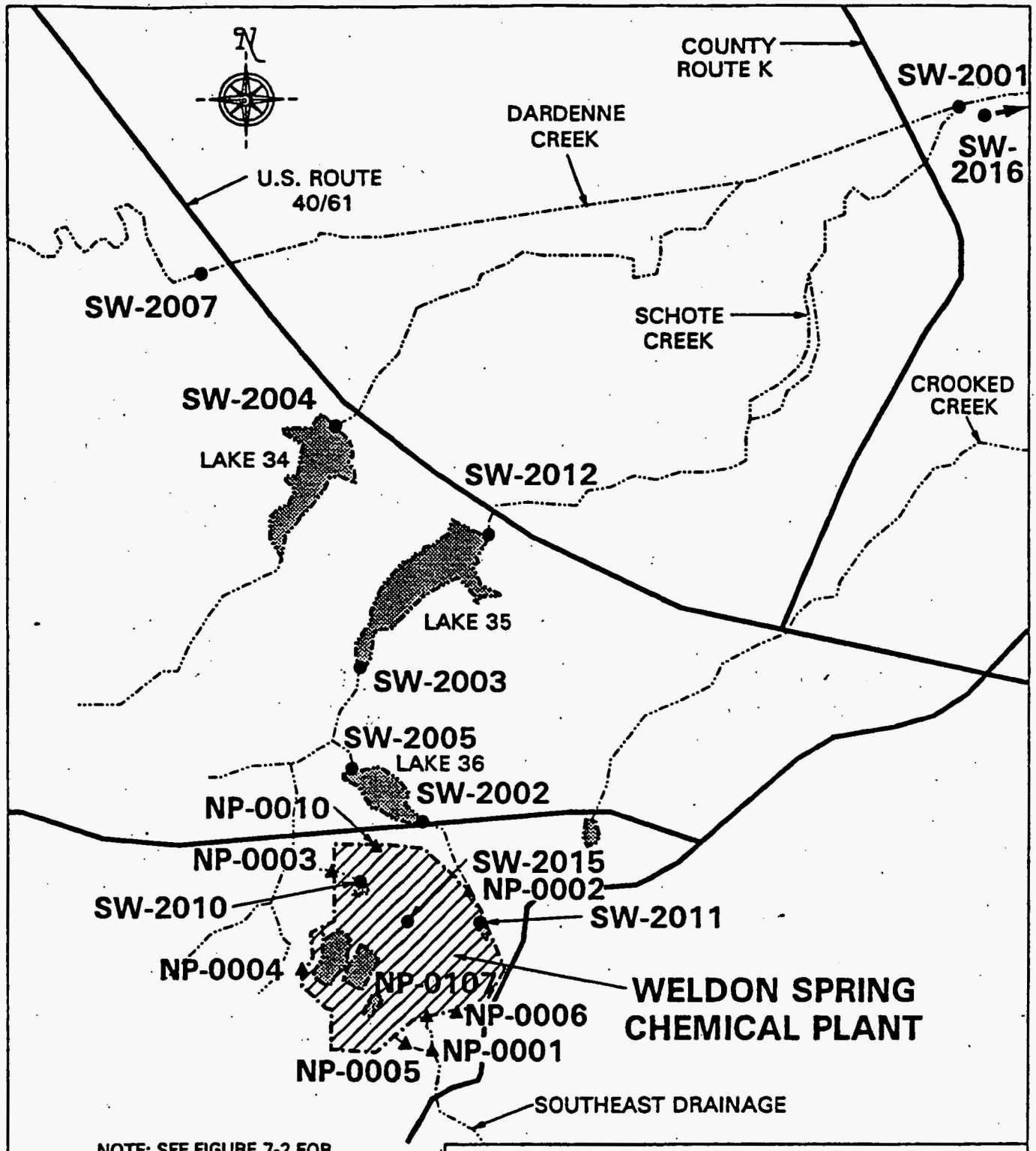
## 7.3 Hydrology

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 and groundwater movement.

### 7.3.1 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 northern and western portions of the site drain 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). Surface drainage from the chemical plant's abandoned storm water sewer and Frog Pond also discharges to Dardenne Creek after flowing through Busch Lakes 35 and 36 and into Schote Creek. Runoff from the southern portion of the chemical plant site flows southeast to the Missouri River via the Southeast Drainage (Valley 5300).

The four raffinate pits, located in the southwestern portion of the chemical plant area, have no discharge structures and collect only direct precipitation. The material staging area basin (SW-2015) is a temporary holding pond that collects storm water runoff from the staging area. After monitoring, and meeting specified release levels, 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

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/21548-512 | EXHIBIT NO.: | A/VP/079/1193 |
|---|---|---|---|
| ORIGINATOR: | MGL | DRAWN BY: | GLN |
| DATE: | 3/3/95 | | |

### 7.3.2 Weldon Spring Quarry

Surface water bodies routinely monitored at the quarry consist of 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.

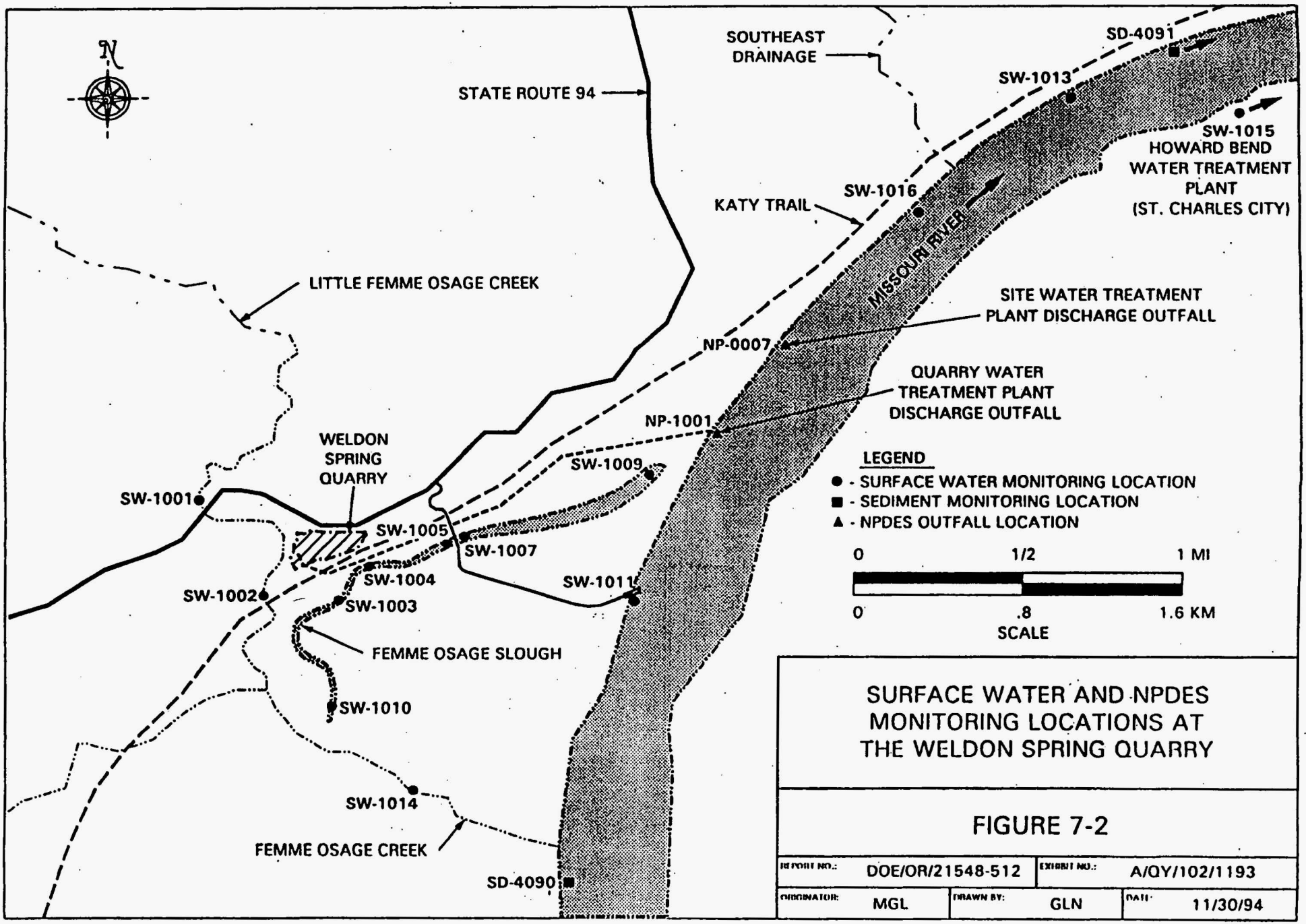
The Femme Osage Slough is located directly south of the quarry and receives contaminated groundwater from the quarry through subsurface recharge. The Little Femme Osage Creek is located west of the quarry and discharges into the Femme Osage Creek approximately 0.5 km (0.3 mi) southwest of the quarry. Although there has been no evidence of impact from groundwater migration on the creeks via stream emergence, they are monitored to detect any changes in the system.

## 7.4 Monitoring Programs

### 7.4.1 National Pollutant Discharge Elimination System Program

Basic physical, chemical, and radiological parameters were monitored at all storm water outfalls. Additional parameters were monitored in the quarry water treatment plant and site water treatment plant effluents and in storm water samples collected for establishing baseline contaminant levels prior to later planned remedial actions, including removal of building foundations.

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 material staging area (MSA) pond and Ash Pond to monitor the effects of materials stored in those areas on contaminant levels in the storm water runoff.




# SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

## FIGURE 7-2

| | | | |
|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/QY/102/1193 |
| ORIGINATOR: MGL | DRAWN BY: GLN | DATE: | 11/30/94 |

### 7.4.2 Surface Water Program

**7.4.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits.** Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled semiannually for total uranium analyses. The raffinate pits are now monitored under treatment plant operations sampling. The material staging area (MSA) and, Ash Pond, and Frog Pond are now sampled under the NPDES program.

**7.4.2.2 Weldon Spring Quarry.** Seven locations within the Femme Osage Slough are 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 are monitored to provide data on areas of potential impact from the quarry.

Surface water locations SW-1003 through SW-1005 are monitored bimonthly for total uranium due to the previous contaminant levels in these areas, fluxuations in concentrations as a result of changes in the water levels in the slough and the groundwater potentiometric surface, and the potential impact of surface water contaminants on groundwater south of the slough. The remainder of the locations are sampled quarterly to provide sufficient data to identify possible changes in these areas. Locations SW-1003 through SW-1005 are also monitored quarterly for nitroaromatic compounds because these locations are downgradient of the area of greatest nitroaromatic groundwater contamination. The remainder of the locations were deleted based on sufficient data indicating no impact on these locations, and no potential for impact, from source areas without first detecting contaminants at surface water locations closer to the source.

## 7.5 Monitoring Results

### 7.5.1 National Pollutant Discharge Elimination System Program

**7.5.1.1 Radiochemical Analysis.** The 1994 average uranium concentrations at the storm water discharge points ranged from 12 pCi/l (0.44 Bq/l), at NP-0004 to 1226 pCi/l (45.4 Bq/l) at NP-0001, which are 2.0% and 204% of the DCG for natural uranium respectively. Average annual gross alpha concentrations ranged from 18 pCi/l (0.67 Bq/l) at NP-0004 to 864 pCi/l (32 Bq/l) at NP-0001. The annual average radionuclide concentrations

TABLE 7-3 1994 Annual Average NPDES Results for the Weldon Spring Chemical Plant Storm Water Outfalls

| Location | Number of Sample Events | pH Range | Total Uranium (pCi/l)** | Gross Alpha (pCi/l) | Nitrate as N (mg/l) | Lithium (mg/l) | Total Suspended Solids (mg/l) | Settleable Solids (ml/l) |
|---|---|---|---|---|---|---|---|---|
| NP-0001 | 6 | (a) | 1226 | 864 | 0.112 | 0.025 | 3.25 | <0.1 |
| NP-0002 | 12 | (a) | 182 | 250 | 0.490 | 0.017 | 69.58 | <0.1 |
| NP-0003 | 12 | (a) | 332 | 315 | 5.515 | 0.011 | 26.75 | <0.1 |
| NP-0004 | 1 | (a) | 12 | 18 | 0.031 | 0.009 | 53 | <0.1 |
| NP-0005 | 14 | (a) | 347 | 388 | 0.280 | 0.007 | 56.21 | <0.1 |
| NP-0010 | 2 | (a) | 82 | 82 | 0.730 | NS | 9.00 | <0.1 |

(a) All pH readings were in permitted range of 6.0 to 9.0.
** Flow proportional averages.
NS Not Sampled
Note: 1 pCi/l = 0.037 Bq/l

for all the permitted storm water outfalls are shown in Table 7-3. Uranium concentration averages were calculated on a flow proportional basis in Table 7-4. Flow weighted averages were used for uranium to give a more accurate estimate of the total uranium that migrated off site during 1994. The averages were flow weighted by adding the total daily flows for the days the samples were collected and adding the total activity (pCi) for the days the samples were collected. The total activity for all samples was then divided by the total 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 1994. Twelve batches were discharged from the QWTP and 31 batches were discharged from the SWTP. No daily maximum or monthly average limits are established for uranium; the design of the treatment plant is based on achieving an average discharge 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 both treatment plants were below 1.6 pCi/l (0.06 Bq/l). In addition to effluent monitoring, the NPDES permit for the quarry, MO-0108987, required that river sediment sampling and aquatic and terrestrial flora sampling be conducted upstream and downstream of the quarry water treatment plant outfall (NP-1001) semiannually. The river

## TABLE 7-4 1994 Estimated Annual Release of Natural Uranium from NPDES Outfalls

| Outfall | Drainage Area Acres (Hectares) | Estimated % of Precipitation as Runoff[b] | Average Concentration (pCi/l) | Total Rainfall Volume (Mgal/yr) | Total Runoff (Mgal/yr) | Total U Release (Ci/yr) | Total U Release (Kg/yr) |
|---|---|---|---|---|---|---|---|
| NP-0001 | (a) | (g) | 1226[c] | (a) | 0.873[f] | $4.051 \times 10^{-3}$ | 5.957 |
| NP-0002 | 75.1 (30.4) | (g) | 182 | 70.72 | 35.308 | $24.323 \times 10^{-3}$ | 35.769 |
| NP-0003 | 74.6 (30.2) | (g) | 332 | 70.25 | 26.359 | $33.123 \times 10^{-3}$ | 48.710 |
| NP-0004 | 5.6 (2.3) | 81 | 12[d] | 5.27 | 4.270 | $0.194 \times 10^{-3}$ | 0.285 |
| NP-0005 | 20.2 (8.17) | (g) | 347 | 19.02 | 6.288 | $8.259 \times 10^{-3}$ | 12.146 |
| NP-0010 | 5.0 (2.02) | 20 | 82[e] | 4.71 | 0.940 | $0.292 \times 10^{-3}$ | 0.429 |
| NP-0007 | N/A | (g) | 0.74 | N/A | 29.575 | $0.083 \times 10^{-3}$ | 0.122 |
| NP-1001 | N/A | (g) | 1.60 | N/A | 8.734 | $0.053 \times 10^{-3}$ | 0.078 |
| TOTAL | 180.5 (73.12) | N/A | N/A | 169.97 | 112.347 | $70.378 \times 10^{-3}$ | 103.50 |

(a) Included in NP-0005.
(b) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 55).
(c) Discharge only through May 1994, total U based on 5 months.
(d) Outfall removed from permit during March 1994.
(e) Outfall added to permit during March 1994. Total U based on entire year.
(f) Assuming flow is one third flow at NP-0005.
(g) Not required to calculate total runoff. Total runoff taken from flow meters.
N/A Not Applicable.
Note: To convert from Ci/yr to Bq/yr multiply Ci/yr by $3.7 \times 10^{10}$

sediment was sampled for uranium at locations SD-4090 (upstream) and SD-4091 (downstream). The monitoring frequency was changed to once per year when the permit was reissued. Aquatic and terrestrial flora monitoring was not conducted because vegetation was never established immediately above or below the outfall. This requirement was eliminated when the permit was reissued.

Estimated quantities of total uranium released off site through surface water runoff and treatment plant discharges are presented in Table 7-4. The total volume of storm water at the three major outfalls was determined from totalizing flow meters. Where flow meters were not

available, the flow was determined by total precipitation and runoff curve numbers cited in the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 34). Total uranium released from the treatment plants was calculated using flow meter and effluent data. The estimated mass of uranium released off-site in storm water and treated effluent during 1994 was 103.5 kg ($70.378 \times 10^{-3}$ Ci). This is a 60.3% reduction of the amount released during 1993. This great reduction may be attributed to several factors: the return to normal precipitation rates during 1994, the elimination of outfall NP-0001, and ALARA actions taken by the project's Surface Water Task Force (such as capping contaminated areas, blocking storm water inlets, etc. See Section 11).

Annual average uranium concentrations for NPDES outfalls from 1990 to 1994 are shown in Table 7-5. Concentrations in 1994 increased at Outfalls NP-0001 and NP-0005; decreased at Outfalls NP-0002 and NP-0003; and did not change appreciably at Outfalls NP-0004, NP-0007, and NP-1001 compared to 1993 concentrations. 1994 was the first year for sampling Outfall NP-0010. Each outfall is discussed below individually.

TABLE 7-5 Five-Year Annual Average Uranium Concentrations at NPDES Outfalls

| Outfall | Annual Average Total Uranium (pCi/l) | | | | |
|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 |
| NP-0001 | 413 | 475 | 516 | 1003* | 1226* |
| NP-0002 | 139 | 158 | 228 | 230* | 182* |
| NP-0003 | 89 | 456 | 478 | 607* | 332* |
| NP-0004 | 8 | 6 | 6 | 9* | 12 |
| NP-0005 | 364 | 581 | 296 | 133* | 347* |
| NP-0010 | -- | -- | -- | -- | 82 |
| NP-0007 | -- | -- | -- | 0.363 | 0.74 |
| NP-1001 | -- | -- | <0.0003 | 1.881 | 1.60 |

* Flow proportional average.
-- Not applicable.

Outfall NP-0001 is the outlet of an abandoned process sewer outfall pipeline. Prior to 1993, this sewer had been blocked at a manhole upstream of the outfall and the contents of the process sewer upstream of the manhole were pumped to the site water treatment plant. The only water in the process sewer downstream of the manhole was storm water infiltration or inflow. The annual average uranium concentration rose above the DCG of 600 pCi/l, during 1993 and remained high during 1994.The high levels are attributed to inflow from a storm water source upstream of Outfall NP-0005. This source water flows in a ditch that crosses over the process sewer. It was discovered that the flow in the ditch was going underground and entering the process sewer. This source is a minor contributor to Outfall NP-0005, but when it was entering the process sewer it comprised the major portion of NP-0001 flow. The ditch over the outfall lines was subsequently sealed, and Outfall NP-0001 was effectively eliminated during May 1994 when most of the outfall line was removed and approximately 24.4 m (80 ft) of pipe remaining under the Army road was blocked and backfilled. Although there is no discharge, the outfall will not be officially eliminated from the permit until the remaining pipe is either removed or grouted.

The average uranium concentration for Outfall NP-0002 in 1994 was reduced over the 1993 average. Higher than normal uranium levels were detected late in 1993 and during January of 1994. The source of the elevated levels was discovered to be storm water runoff and dust control water from the demolition of Building 201. The water was diverted to the site water treatment plant until the source concentrations returned to normal levels (see Section 7.5.2.1).

The average uranium concentration for outfall NP-0003 was 332 pCi/l (12.3 Bq/l) which was greatly reduced from the average for 1993. The uranium levels were reduced due to the return of normal precipitation rates for 1994. This caused Ash Pond to dry up and cease to discharge during most of the year. Also, the Ash Pond area became a managed area during 1994, and no water with a uranium concentration greater than 600 pCi/l (22.2 Bq/l) was allowed to discharge from the pond after the pond had dried up. The South Dump area of the pond and the pond bottom have been capped with soil to help reduce uranium levels in Ash Pond water. The capping of the pond bottom has also eliminated the ponding of water.

Uranium levels at Outfall NP-0004 remained essentially the same as for the previous years. The outfall was removed from the permit with the reissuance of permit MO-0107701 on March 4, 1994.

The annual average uranium level at Outfall NP-0005 increased for 1994 over the 1993 average. The increase may be attributable to the diversion of water from Outfall NP-0001 to Outfall NP-0005. The Project Management Contractor (PMC) has taken measures to reduce levels at NP-0005 (e.g., plugging storm sewers, capping contaminated soil areas, etc.).

Outfall NP-0010 was added to NPDES permit MO-0107701 when it was reissued on March 4, 1994. There are no previous data for comparison. This outfall is located at the west end of the north perimeter fence in the proposed construction materials staging area (CMSA), and drains a shallow wooded swale where there was often no discharge. The annual average uranium concentration was 82 pCi/l (3 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l).

In addition to uranium and gross alpha, Outfalls NP-0002, NP-0003, and NP-0005 were sampled for Ra-226, Ra-228, Th-228, Th-230, and Th-232 on a monthly basis starting with the September sampling events. Sampling of these parameters will continue through February 1995. These parameters were analyzed to establish baseline concentrations prior to foundation removal. Radium and thorium were detected at very low levels and were often not detected. The results through the end of 1994 are reported in Table 7-6.

TABLE 7-6 Average Radiological Concentrations (pCi/l) for Storm Water Outfalls

| Location | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | Gross Alpha |
|---|---|---|---|---|---|---|
| NP-0002 | 0.62 | 0.75 | 0.62 | 0.30 | 0.40 | 250 |
| NP-0003 | 0.55 | 0.42 | 0.41 | 0.45 | 0.30 | 315 |
| NP-0005 | 0.43 | 1.01 | 0.32 | 0.31 | 0.22 | 388 |
| SW-2010 | 0.22 | 1.27 | 0.32 | 0.31 | 0.22 | 910 |
| SW-2015 | NS | NS | NS | NS | NS | 137 |

NS - Location not sampled
Note: 1 pCi/l = 0.037 Bq/l

The MSA pond (SW-2015) was sampled quarterly for gross alpha, and uranium to monitor the effects of MSA discharges on NPDES Outfall NP-0003. The uranium average was

153 pCi/l (5.7 Bq/l), well below the release criteria of 600 pCi/l (the DCG for uranium). The average gross alpha result is reported in Table 7-6.

Ash Pond (SW-2010) was sampled quarterly, when water was in the pond, 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 the pond area on Ash Pond water and subsequently to Outfall NP-0003. Radium and thorium were detected at low levels or not detected. The average results are reported in Table 7-6.

### 7.5.1.2 Physical and Chemical Results.

**7.5.1.2.1 Chemical Plant Storm Water.** The annual averages for the physical and chemical parameters for storm water Outfalls NP-0001 through NP-0005 and NP-0010 are shown in Table 7-3. In addition to the permitted parameters, Outfalls NP-0002, NP-0003, and NP-0005 were sampled monthly for 2,4-dinitrotoluene (DNT), 2,4,6-trinitrotoluene (TNT), Hazardous Substance List (HSL) metals, polychlorinated biphenyls (PCBs), and polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) starting in September 1994. None of these parameters were detected at elevated levels. Sampling for these parameters continued through February 1995. These parameters were analyzed to establish pre-foundation removal baseline concentrations.

The site water treatment plant effluent pipeline land disturbance storm water permit required once-per-quarter sampling at three outfalls. A sample collected on April 11, 1994, at Outfall NP-0039 exceeded the 2.5 ml/l/hr notification level for settleable solids required by Permit MO-R101389. The Missouri Department of Natural Resources was notified and erosion control was modified above the outfall. Subsequent monitoring showed settleable solids levels all below 2.5 ml/l/hr. The pipeline construction area was stabilized and the permit was terminated on September 28, 1994.

The MSA pond (SW-2015) was sampled quarterly for pesticides, PCBs, total organic carbons, total petroleum hydrocarbons, and toxicity metals at a minimum. None of these contaminants were detected at elevated levels. The MSA pond was sampled to monitor contaminant levels in water being released to Outfall NP-0003.

The Ash Pond outlet (SW-2010) was sampled quarterly during discharge for 2,4-DNT, 2,4,6-TNT, PCBs, and the metals arsenic, barium, cadmium, copper, iron, lead, manganese, mercury, selenium, silver and zinc. None of these parameters were detected at elevated levels. The Ash Pond was sampled to monitor the effect of demolition debris and soils placed in Ash Pond on contaminants in the Ash Pond water and subsequently at Outfall NP-0003.

**7.5.1.2.2 Administration Building Sewage Treatment Plant.** The parameters required by the NPDES permit for the sewage treatment plant are all physical and chemical. Monitoring results for sewage treatment plant Outfall NP-0006 are given in Table 7-7. During April, one noncompliance with permit limits occurred for biochemical oxygen demand (BOD). The subcontractor has implemented accelerated monitoring to allow more information for operational changes to maintain compliance.

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

| | Parameter[a] (permit limits) | | | |
|---|---|---|---|---|
| Month | TSS (15/20 mg/l)* | BOD (10/15 mg/l)* | FC[b] (400/ 1000 col/100 ml)** | pH (6.0-9.0 SU) |
| January | NS | NS | NS | NS |
| February | 7 (1) | 6 (1) | 0 (1) | 7.5 (1) |
| March | NS | NS | NS | NS |
| April | 14 (1) | 16.5 (2) | 0 (1) | 6.9 (2) |
| May | NS | NS | NS | NS |
| June | 2 (1) | 6 (1) | 260 (1) | 7.0 (1) |
| July | 4 (2) | 9.75 (2) | 0 (2) | 6.8 (2) |
| August/September | NS | NS | NS | NS |
| October | 3(1) | 5(1) | 10(1) | 7.0(1) |
| November/December | NS | NS | NS | NS |

(a) Number of samples given in parentheses after average.
(b) F.C - fecal coliform.
NS Not Sampled
* Monthly average/weekly average
** Monthly average/daily maximum

**7.5.1.2.3 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 1994, whole effluent toxicity (WET) tests were required quarterly on site water treatment plant effluent, and quarterly (starting with the second quarter) for the quarry water treatment plant. 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 effluent and in test controls of upstream river water and laboratory control water. The overall results of the WET tests indicate that the site and quarry water treatment plant effluent was not toxic to test organisms during 1994. Individual WET tests have failed, but, except for one test, the river control also failed. Where the river control failed, the MDNR directed the DOE to run a test on the next available batch of treated water. In all cases, the second test passed. Whole effluent toxicity test results are summarized in Table 7-8. A test of Batch S048 was a followup to Batch S046 and passed during January 1995. A wet test on Batch S019, which was conducted under the previous permit, failed with no failure of the controls. The permit allowed one retest. The retest on Batch S020 passed.

### 7.5.2 Surface Water Program

**7.5.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits.** There were two historic high levels and two second highest historic levels recorded for uranium concentrations at surface water locations associated with the chemical plant. Water from Outfall NP-0002 flows into Lake 36 where a historic high of 390 pCi/l (14.4 Bq/l) was recorded at the lake inlet (SW-2002) on January 6, 1994, and a second highest historic level of 45 pCi/l (1.7 Bq/l) was recorded at the outlet (SW-2005) on the same date. Water from Lake 36 then joins flow with a stream that contains the flow from NP-0003 and flows to Lake 35 where no unusual levels were noted at the inlet (SW-2003), but a second highest historic level of 16.5 pCi/l (0.6 Bq/l) was recorded at the outlet (SW-2012) on April 15, 1994. Water flowing from Lake 34 and Lake 35 flows to Dardenne Creek where a historic high of 7.79 pCi/l (0.3 Bq/l) was recorded at location SW-2016 on April 15, 1994.

The cause of the high levels at SW-2002 and SW-2005 was higher than normal uranium concentrations at Outfall NP-0002. Uranium levels at Outfall NP-0002 on November 15, 1993, December 3, 1993, and January 11, 1994, were 180 pCi/l (6.7 Bq/l), 847 pCi/l (31.3 Bq/l) and 880 pCi/l (32.6 Bq/l), respectively, indicating that the uranium concentration began increasing during the second half of November. The source of the increased uranium concentration at Outfall NP-0002 was confirmed by upstream sampling to be storm water and dust control water runoff from the demolition of Building 201.

In response to the discovery of the source of elevated uranium concentrations at Outfall NP-0002, the runoff from the Building 201 demolition area was diverted to the site water treatment plant until the demolition was completed and uranium concentrations in the runoff declined. Subsequent sampling at Outfall NP-0002 on February 22 and March 8, 1994, showed uranium concentrations of 67 pCi/l (2.5 Bq/l) and 276 pCi/l (10.2 Bq/l), respectively and at locations SW-2002 on September 16, 1994, and SW-2005 on August 24, 1994, showed uranium concentrations of 40.3 (1.5 Bq/l) and 31.0 pCi/l (1.1 Bq/l), repectively, indicating that the implemented action was successful in reducing uranium levels.

The uranium levels at locations SW-2003, SW-2004 and SW-2001 were all within historic ranges. Average uranium results for all the chemical plant surface water locations can be found in Table 7-9.

#### 7.5.2.2 Weldon Spring Quarry.

Total Uranium. The average total uranium values continue to indicate the highest levels for surface water are found in the portion of the Femme Osage Slough (SW-1003 through SW-1005 and SW-1010) down gradient of the quarry. The annual averages for the surface water locations are summarized in Table 7-10. The uranium levels in the Femme Osage Slough are within historical ranges. The total uranium levels in the Little Femme Osage Creek and the Femme Osage Creek remained at background levels.

The DCG for total uranium in drinking water systems is 24 pCi/l, which is 4% of the DCG for total uranium in discharge waters (600 pCi/l). This criterion was used for the Little Femme Osage Creek (SW-1001 and SW-1002) and the Femme Osage Creek (SW-1014) because these creeks ultimately discharge into the Missouri River, which is a source of drinking water.

## TABLE 7-8 1994 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 |
|---|---|---|---|---|---|
| S019 | 02/17/94 | 70 | 0 | 0,0 | 5,0 |
| S020 | 03/01/94 | 0 | 0 | 0,0 | 0,0 |
| S030 | 06/20/94 | 60 | 15 | 40,0 | 0,0 |
| S034 | 08/01/94 | 0 | 0 | 0,0 | 0,0 |
| S040 | 10/17/94 | 0 | NT | 0,NT | 0,NT |
| S046 | 12/19/94 | 80 | 0 | 75,0 | 0,0 |
| Q019 | 04/18/94 | 0 | 0 | 0,0 | 0,0 |
| Q023 | 08/09/94 | 0 | 0 | 0,0 | 0,0 |
| Q025 | 10/24/94 | 65 | 25 | 0,75 | 0,5 |
| Q027 | 12/14/94 | 0 | 0 | 0,0 | 0,0 |

NT Not Tested
P Pimephales
D Daphnia (Ceriodaphnia)

## TABLE 7-9 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations

| Location | Average | Maximum | Minimum |
|---|---|---|---|
| SW-2001 | 2.35 | 2.57 | 2.12 |
| SW-2002 | 215.15 | 390 | 40.3 |
| SW-2003 | 10.02 | 10.1 | 9.94 |
| SW-2004 | 14.95 | 18.3 | 11.6 |
| SW-2005 | 38.0 | 45.0 | 31.0 |
| SW-2012 | 16.5 | 16.5 | (a) |
| SW-2016 | 5.09 | 7.79 | 2.38 |

(a) Only one sample collected.
Note 1: 1 pCi/l = 0.037 Bq/l.
Note 2: Two samples were collected at all locations except SW-2012.

TABLE 7-10 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Monitoring Locations

| Location | Annual Average | Maximum | Minimum |
|---|---|---|---|
| SW-1001* | 0.72 | 1.14 | 0.50 |
| SW-1002* | 0.72 | 1.11 | 0.50 |
| SW-1003 | 25.6 | 38.0 | 11.6 |
| SW-1004 | 29.6 | 37.0 | 20.6 |
| SW-1005 | 19.9 | 27.9 | 11.3 |
| SW-1007 | 13.2 | 24.5 | 6.6 |
| SW-1009 | 10.5 | 13.5 | 6.0 |
| SW-1010 | 16.7 | 24.8 | 6.39 |
| SW-1014* | 1.27 | 1.99 | 0.60 |

Note: 1 pCi/l = 0.037 Bq/l
* Creek locations

This value was not exceeded in any of the creek samples. Furthermore, the proposed U.S. Environmental Protection Agency Drinking Water Standard of 20 $\mu$g/l (13.6 pCi/l) for total uranium was not exceeded at any of the creek monitoring locations.

Nitroaromatic Compounds

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

## 7.6 Highlights

- Total uranium levels in the Femme Osage Slough were within historical ranges.
- No detectable concentrations of nitroaromatic compounds were observed in the Femme Osage Slough.
- Total uranium levels in the Femme Osage Creek and Little Femme Osage Creek were at background.

- Forty-three batches of water were released from the site and quarry water treatment plants during 1994 with no NPDES permit violations.

- The mass of uranium migrating off-site in storm water and treated effluent was greatly reduced over the 1993 mass.

- The overall results of the WET tests indicate that the site and quarry water treatment plant effluent was not toxic to test organisms during 1994.

# 8 GROUNDWATER PROTECTION

## 8.1 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 Quarry, the Weldon Spring Chemical Plant and raffinate pits, vicinity properties, and from selected springs in the vicinity of the Weldon Spring site. The groundwater protection program is formally defined in two documents: the *Groundwater Protection Program Management Plan* (Ref. 13) and the *Environmental Monitoring Plan* (Ref. 42).

## 8.2 Referenced Standards

Two main criteria were used to develop the groundwater monitoring program: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Drinking Water* (Ref. 35), which are 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, Section 141.1, Subpart A.

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, based on the consumption of 730 liters/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 per year or 4% of the derived concentration guideline (DCG).

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

## TABLE 8-1 Referenced Federal and State Water Standards

| Parameter | | Level | Reference Standard | Parameter | | Level | Reference Standard |
|---|---|---|---|---|---|---|---|
| Radio-chemical | Uranium total[a] | 20 μg/l (13.6 pCi/l) | EPA | Metals | Cu[d] | 1.0 mg/l | MDWS |
| | Gross α (adjusted) | 15 pCi/l | MDWS | | Fe[d] | 300 μg/l | MDWS |
| | Ra-226[b] | 5 pCi/l | MDWS | | Pb | 50 μg/l | MDWS |
| | Ra-228[b] | 5 pCi/l | MDWS | | Mn[d] | 50 μg/l | MDWS |
| | Rn-222 | 300 pCi/l | EPA | | Hg | 2.0 μg/l | MDWS |
| Misc. | 2,4-DNT | 0.11 μg/l | MDWS | | Ni | 100 μg/l | MDWS |
| | TDS | 500 mg/l | MDWS | | Se | 10 μg/l | MDWS |
| Metals | Sb | 6.0 μg/l | MDWS | | Ag | 50 μg/l | MDWS |
| | As[c] | 50 μg/l | MDWS | | Zn[d] | 5.0 mg/l | MDWS |
| | Ba[c] | 1.0 mg/l | MDWS | Anions | $Cl^-$[d] | 250 mg/l | MDWS |
| | Be | 4.0 μg/l | MDWS | | $F^-$ | 2.2 mg/l | MDWS |
| | Cd[c] | 10 μg/l | MDWS | | $NO_3$[c] | 10 mg/l | MDWS |
| | Cr[c] | 50 μg/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.
EPA EPA Drinking Water Standards for Radionuclides.
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.

divide (Ref. 37). Backgrou[illegible]lues 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.

## 8.3 Weldon Spring Chemical Plant

### 8.3.1 Hydrogeology

The chemical plant and quarry are located in the same general geologic environment but are separated geographically. A generalized stratigraphic and hydrostratigraphic column is presented in Figure 8-1. Differences in specific geological features that impact groundwater mechanics necessitate separate monitoring programs for the chemical plant and quarry.

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

The aquifer of primary concern beneath the chemical plant, raffinate pits, and vicinity properties lies within the Burlington-Keokuk Limestone (the shallowest bedrock unit). 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.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Of the 72 monitoring wells, 17 are completed in the weathered zone, 35 are completed in both the weathered and unweathered zones, and 20 are completed in the unweathered zone. The wells in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. Where possible, monitoring wells within the boundaries of the chemical plant are located close to potential contaminant sources to assess migration into the

| SYSTEM | SERIES | STRATIGRAPHIC UNIT | TYPICAL THICKNESS (FT.) | LITHOLOGY | PHYSICAL CHARACTERISTICS | HYDROSTRATIGRAHIC UNIT |
|---|---|---|---|---|---|---|
| QUATERNARY | HOLOCENE | ALLUVIUM | 0 - 120 | | GRAVELLY, SILTY LOAM. | ALLUVIAL AQUIFER |
| | PLEISTOCENE | LOESS AND GLACIAL DRIFT | 10- 60 | VARIABLE | SILTY CLAY, GRAVELLY CLAY, SILTY LOAM, OR LOAM OVER RESIDUUM FROM WEATHERED BEDROCK. | (UNSATURATED) |
| MISSISSIPPIAN | MERAMECIAN | SALEM FORMATION (2) | 0 - 15 | | LIMESTONE, LIMEY DOLOMITE, FINELY TO COARSELY CRYSTALINE, MASSIVELY BEDDED, AND THIN BEDDED SHALE. | |
| | | WARSAW FORMATION (2) | 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 (3) | 40 - 55 | | QUARTZ ARENITE, FINE TO MEDIUM GRAINED, FRIABLE. | |
| | | LOWER PART OF SULPHUR SPRINGS GROUP UNDIFFERENTIATED | | | CALCAREOUS SILTSTONE, SANDSTONE, OOLITIC LIMESTONE, AND HARD CARBONACEOUS SHALE. | |
| ORDOVICIAN | CINCINNATIAN | MAQUOKETA SHALE (4) | 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 FORMATION | 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-0502 AND 0505. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMMELL (1987). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-89-252-GI (1989).

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

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

(4) THE MAQUOKETA SHALE IS NOT PRESENT IN THE WELDON SPRING AREA BASED ON HISTORICAL EVIDENCE.

# GENERALIZED STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

## FIGURE 8-1

| REPORT NO. | EXHIBIT NO. |
|---|---|
| DOE/OR/21548-512 | A/PI/047/0391 |

| ORIGINATOR | DRAWN BY | DATE |
|---|---|---|
| JR | SRS | 1/19/94 |

groundwater system. Additional wells are located outside the chemical plant boundary to detect and evaluate potential movement of contaminants off site (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 be impacted by previous chemical plant operations and discharge water containing one or more of the contaminants of concern (Figure 8-3).

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 and is beyond the contaminant plume area defined by the monitoring well network, indicates that discrete flow paths are present in the vicinity of the site. To address these complex hydrogeologic conditions, both springs and wells are included in the groundwater monitoring program.

### 8.3.2 Monitoring Program

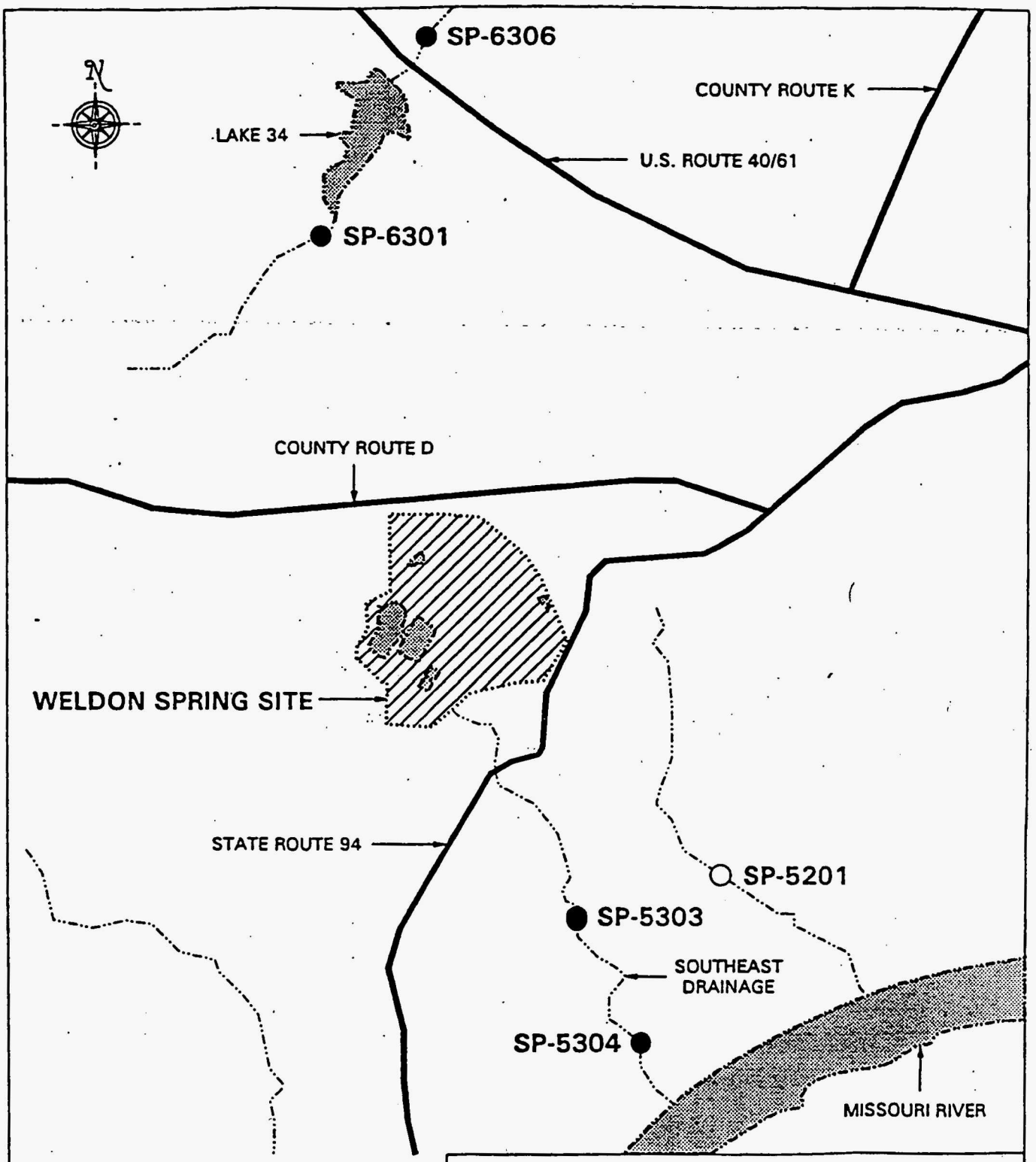
The 1994 groundwater monitoring program at the chemical plant and raffinate pits focused on contaminant monitoring and completing geochemical characterization of on-site groundwater. Total uranium, nitroaromatic compounds, sulfate, and nitrate were monitored quarterly, semiannually, or annually. Monitoring well locations were sampled annually, unless the following conditions applied to data collected during 1990-1993:

(1) Less than six samples have been collected for that location.

(2) Contaminant levels exceed water quality standards (10 mg/l for nitrate and 13.6 pCi/l for uranium).

(3) 2,4-Dinitrotoluene (DNT) or 2,6-DNT exceeded 0.11 $\mu$g/l or remaining nitroaromatic compounds exceeded 10 times their respective detections limits.

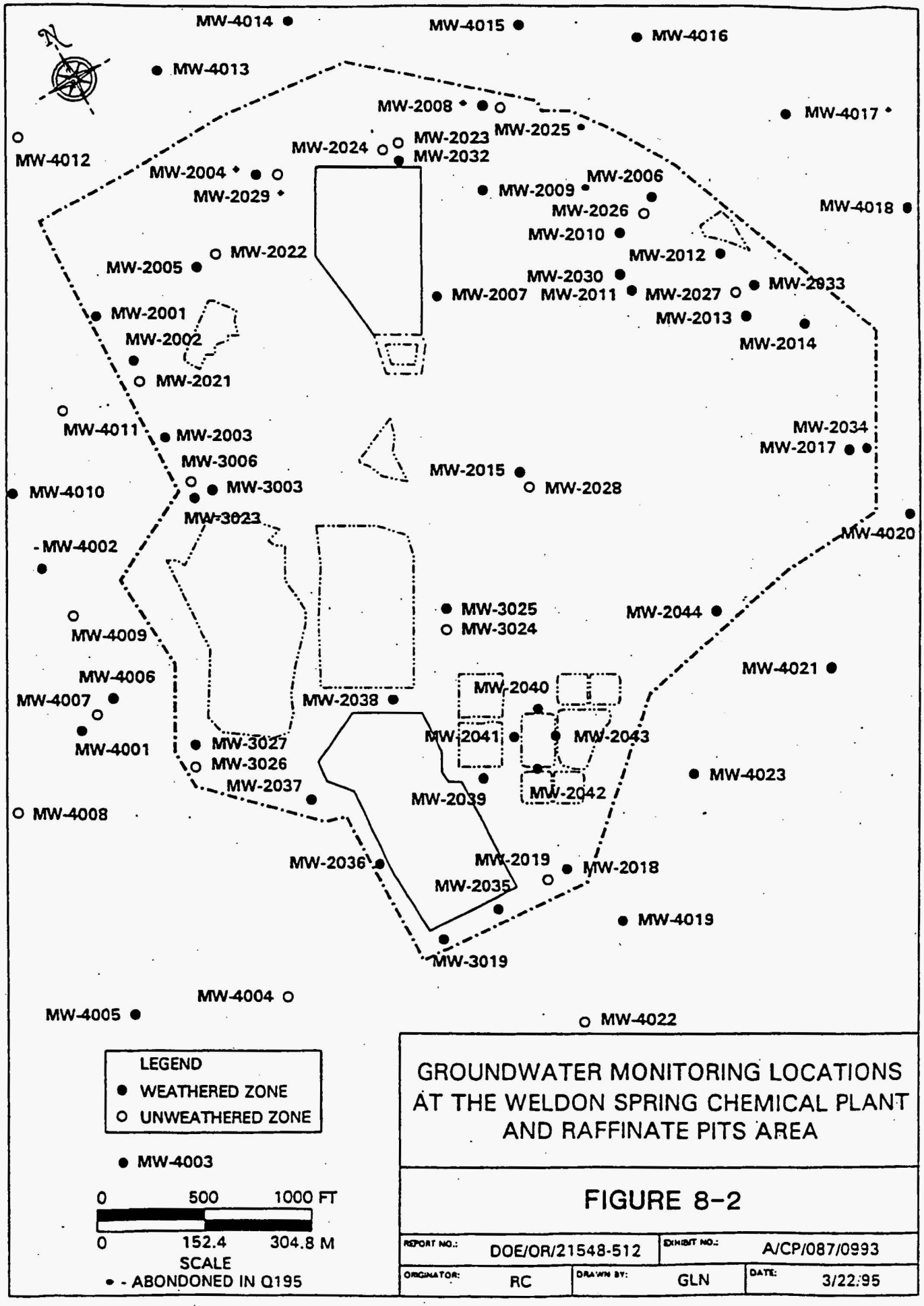
For those locations meeting Condition 1, samples were analyzed for all parameters quarterly; for those meeting Conditions 2 or 3, only total uranium, nitrate or nitroaromatic compounds were sampled semiannually. If an annually sampled well exceeded Condition 2 or




SPRING MONITORING LOCATIONS IN THE WELDON SPRING SITE AREA

FIGURE 8-3

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/VP/080/1193 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 11/30/94 |




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

## FIGURE 8-2

| | | | |
|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/CP/087/0993 |
| ORIGINATOR: | RC | DRAWN BY: | GLN |
| DATE: | 3/22/95 | | |

3 during the first sampling event, the location was sampled quarterly for that parameter for the remainder of the year. Monitoring wells around the raffinate pits and chemical plant buildings were sampled annually for Ra-226, Ra-228, Th-228, Th-230, Th-232, gross alpha, and gross beta. Geochemical analysis, which includes an extensive suite of naturally occurring water quality parameters, was also performed on groundwater samples to provide preoperational characterization data for evaluating the impacts of site remediation on the groundwater, to establish a baseline for the Chemical Plant Groundwater Operable Unit, and to gather sufficient data to support contaminant transport models.

Two springs were sampled quarterly, one semiannually, and one annually for total uranium. Burgermeister Spring was also monitored quarterly for nitrate, sulfate, and geochemical constituents. With the exception of Burgermeister Spring (SP-6301), springs are monitored at low flow to measure the groundwater component of spring discharge rather than surface water influences. Burgermeister Spring (SP-6301) was also sampled semiannually at high flow for uranium, nitrate, and sulfate to evaluate the differences between low flow and high flow.

### 8.3.3 Chemical Plant and Raffinate Pit Monitoring Results

**8.3.3.1 Groundwater Monitoring Wells.** In 1994, the measured concentrations for uranium, nitrate, sulfate, and nitroaromatic compounds (the primary contaminants of concern) 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 and typically reflected normal variation in the local aquifer system rather than significant changes in groundwater conditions.

During 1994, conditions appear to have changed in four shallow monitoring wells north of the raffinate pits (MW-2001, MW-2002, MW-2003, and MW-4011) and in one shallow well on the eastern edge of the site (MW-2034). MW-2001 through MW-2003 all showed decreases in nitrate, sulfate, and one or more mobile metals that are elevated in the raffinate pits (calcium, magnesium, strontium, lithium, and sodium). It is unclear whether the 1994 downturns represent a long-lived trend or are just part of the episodic variation at these locations. In contrast, MW-4011, which is located just west of these wells, displayed significant increases in

these same parameters during 1994. These relationships may indicate a minor shift in the location of the plume. Additional characterization, which will be conducted in 1995 as part of the Groundwater Operable Unit, will further define possible shifts in the location of the plume.

Data for all parameters analyzed during the 1994 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.

Radiochemical Parameters. Total uranium, which is measured in all monitoring wells, continues to impact groundwater near the raffinate pits. In 1994, groundwater from 21 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 four locations exceeded the proposed MCL of 20 $\mu$g/l (13.6 pCi/l or 0.5 Bq/l). New highs for uranium were recorded during 1994 at MW-2017 (13.4 pCi/l or 0.5 Bq/l) and MW-4014 (35.5 pCi/l or 1.31 Bq/l). The MW-4014 high, which was measured during the first part of the year, is thought to be a measurement error. A subsequent sample collected during the latter part of the year was below the limit of detection (0.667 pCi/l or 0.02 Bq/l) and was similar to previous values measured for this location. The high value caused the 1994 average concentration for this location to be above the proposed MCL. Although the MW-2017 high was within the expected range of variation, uranium values have steadily increased at this location during the last two years. Although the trend analysis conducted for the 1993 annual *Site Environmental Report* (Ref. 9) did not detect an upward trend at this location; the 1994 data indicate that such a trend is present.

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 water quality standards DCGs, with only one exception. These results can be found in Table 8-4. An above-background thorium level was recorded at MW-2044. This value is thought to be a measurement error.

Nitrate and Sulfate. Nitrate and sulfate were measured at all monitoring wells in the chemical plant area and exceeded the reference levels at some locations. Average nitrate levels exceeded the calculated background value (1.6 mg/l) at 24 locations and exceeded the drinking

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

| Location | Average | Location | Average | Location | Average |
|---|---|---|---|---|---|
| MW-2017 | 12.6 | MW-2019 | 3.15 | MW-2023 | 3.89 |
| MW-2030 | 13.23 | MW-2032 | 3.57 | MW-2034 | 2.95 |
| MW-3003 | 14.9 | MW-3023 | 8.85 | MW-3024 | 3.18 |
| MW-3025 | 2.91 | MW-3026 | 4.47 | MW-3027 | 9.7 |
| MW-4003 | 4.15 | MW-4009 | 2.91 | MW-4010 | 3.48 |
| MW-4011 | 9.64 | MW-4012 | 3.08 | MW-4014 | 17.92 |
| MW-4020 | 12.8 | MW-4021 | 3.82 | MW-4022 | 3.74 |

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

## Table 8-4 Radiological Isotope Results (pCi/l) at the Weldon Spring Chemical Plant

| Location | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | Gross Alpha | Gross Beta |
|---|---|---|---|---|---|---|---|
| MW-2044 | (0.281) | (0.002) | (0.242) | 8.35 | (0.324) | 3.74 | 2.77 |
| MW-3024 | 0.472 | (0.477) | (0.520) | (0.625) | (0.138) | (4.31) | 27.1 |
| MW-3025 | 0.613 | 1.19 | (0.248) | 0.956 | (0.144) | (13.0) | 31.0 |
| MW-3026 | 2.22 | (0.589) | (0.009) | 1.23 | (0.062) | 10.0 | 24.9 |
| MW-3027 | 0.644 | (0.511) | <0.717 | (0.435) | (0.119) | (0.002) | 0.010 |

Note 1: Results in parentheses were less than the detection limit.
Note 2: 1 pCi/l = 0.037 Bq/l.

water standard (10 mg/l) at 14 locations (Table 8-5). Average sulfate levels exceeded background (32 mg/l) at 27 locations; four of these were above the water quality standard (250 mg/l) (Table 8-6).

Trend analysis, which was conducted for the 1993 annual *Site Environmental Report* (Ref. 9) detected upward nitrate trends in three monitoring wells. Two of these wells, MW-2034 and MW-4011, continued to display these increases in 1994. Upward sulfate trends were detected in five monitoring wells, but only one, MW-4011, continues to display this trend.

MW-2034 has shown a steady increase in nitrate concentrations and a decrease in sulfate concentrations over the past 2 years. Nitrate levels have not exceeded the drinking water standards, but sulfate continues to exceed the secondary drinking water standard.

Nitroaromatic Compounds. Nitroaromatic compounds, which are not naturally occurring compounds, were detected in 31 monitoring wells (Table 8-7). New highs were recorded at MW-2002 for 2,6-DNT and at MW-2030 for 2,4,6-TNT. The high at MW-2002 was within the normal range of variation for this location; however, the increases at MW-2030 appear to be part of an increasing trend. Although new highs were not recorded, 2,6-DNT levels have also been elevated at this location. Levels rose from an average of 4.0 $\mu$g/l in 1993 to 15.0 $\mu$g/l in 1994.

Trend analysis conducted for the 1993 annual *Site Environmental Report* (Ref. 9) detected upward nitroaromatic trends at six monitoring wells: MW-2001 (TNT and 2,4-DNT), MW-2006 (2,4-DNT), MW-2008 (2,4-DNT), MW-2014 (TNT), MW-3023 (TNT), and MW-4015 (TNB). With the exception of MW-3023, which decreased slightly during 1994, all of these wells maintained 1993 nitroaromatic levels during 1994. With one exception, wells in which downward trends were detected at a number of locations have remained stable or continued to decrease during 1994. The only exception is MW-2013. Groundwater from this location displayed steep, decreasing trends for all nitroaromatic compounds until 1994. During 1994, increasing levels of TNB and 2,6-DNT were detected in groundwater from this well. In addition to the nitroaromatic compounds, sulfate, calcium, magnesium, and alkalinity also increased at this location. Although the source of this change is not known, construction activities in this area may have disturbed surface soils and modified infiltration pathways, thus exposing new nitroaromatic contaminated areas to groundwater leaching.

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

| Location | Average | Location | Average | Location | Average |
|---|---|---|---|---|---|
| MW-2001* | 37.25 | MW-2002* | 175 | MW-2003* | 228.5 |
| MW-2005* | 73 | MW-2006 | 5.37 | MW-2011 | 4.30 |
| MW-2014 | 2.13 | MW-2032* | 60 | MW-2034 | 4.62 |
| MW-3003* | 298.5 | MW-3023* | 228.5 | MW-3024* | 504 |
| MW-3025* | 436.5 | MW-3026* | 185.75 | MW-3027* | 63.53 |
| MW-4001* | 40.25 | MW-4002 | 3.52 | MW-4006 | 8.37 |
| MW-4011* | 130.5 | MW-4013* | 84 | MW-4014 | 5.4 |
| MW-4015 | 3.21 | MW-4018 | 2.3 | MW-4023 | 3.3 |

Note 1: Background Nitrate Concentrations equals 1.6 mg/l
* Exceeded the nitrate drinking water quality standard of 10 mg/l at least once during 1994.

## 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 | 135.5 | MW-2003 | 79.05 | MW-2006 | 32.05 |
| MW-2008 | 40.4 | MW-2009 | 98 | MW-2010 | 34.75 |
| MW-2012 | 61.35 | MW-2014 | 35.4 | MW-2015 | 126 |
| MW-2017* | 733 | MW-2028 | 123 | MW-2030 | 43.7 |
| MW-2032 | 52 | MW-2033 | 30.97 | MW-2034* | 288 |
| MW-2044 | 132.5 | MW-3003 | 91.3 | MW-3023* | 277 |
| MW-3024 | 81.13 | MW-3025 | 55.6 | MW-4001 | 54.8 |
| MW-4011 | 70.9 | MW-4012 | 37 | MW-4013 | 43 |
| MW-4020 | 112 | MW-4021* | 250 | MW-4023 | 69 |

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 1994.

TABLE 8-7 Annual Averages for Detectable Concentrations 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 | 0.068 | <0.090 | <0.030 | 0.12 | 0.055 | <0.030 |
| MW-2002 | <0.030 | <0.090 | <0.030 | 0.076 | 0.66 | <0.030 |
| MW-2003 | <0.030 | <0.090 | <0.030 | 0.118 | 0.315 | <0.030 |
| MW-2005 | (0.024) | <0.090 | <0.030 | 0.056 | 0.094 | <0.030 |
| MW-2006 | 9.5 | <0.090 | <0.030 | 0.165 | 1.45 | 0.039 |
| MW-2008 | 0.80 | <0.090 | <0.030 | 0.091 | 0.65 | <0.030 |
| MW-2009 | <0.030 | <0.090 | <0.030 | 0.069 | 0.19 | <0.030 |
| MW-2010 | 0.16 | <0.090 | 0.34 | 0.085 | 0.34 | <0.030 |
| MW-2011 | 0.36 | <0.090 | <0.030 | 0.12 | 1.5 | 0.032 |
| MW-2012 | 1.75 | <0.090 | 0.52 | 0.11 | 1.11 | <0.030 |
| MW-2013 | 4.75 | (0.068) | 0.48 | 0.245 | 4.45 | <0.030 |
| MW-2014 | 2.8 | <0.135 | (0.04) | 0.185 | 0.475 | <0.030 |
| MW-2030 | 8.83 | (0.06) | 22.3 | 0.213 | 12.93 | <0.030 |
| MW-2032 | 2.51 | <0.090 | 4.27 | 2.58 | 4.35 | <0.030 |
| MW-2033 | 4.67 | <0.090 | 0.89 | 0.45 | 1.87 | <0.030 |
| MW-2044 | <0.030 | <0.090 | <0.030 | (0.016) | <0.010 | <0.030 |
| MW-3003 | <0.030 | <0.090 | <0.030 | 0.067 | 0.12 | <0.030 |
| MW-3023 | <0.030 | <0.090 | <0.080 | 5.25 | 4.3 | <0.060 |
| MW-3024 | <0.030 | <0.090 | <0.030 | 0.135 | 0.42 | <0.030 |
| MW-3025 | <0.030 | <0.090 | <0.030 | 0.091 | 0.28 | <0.030 |
| MW-3026 | 0.133 | <0.090 | <0.030 | 0.076 | 0.067 | <0.030 |
| MW-3027 | 0.065 | <0.090 | <0.030 | 0.045 | 0.035 | <0.030 |
| MW-4001 | 66.5 | <0.090 | 1.8 | 0.9 | 3.7 | (0.027) |
| MW-4002 | 0.088 | <0.090 | 0.258 | (0.017) | 0.084 | <0.030 |
| MW-4006 | 15 | <0.090 | <0.030 | 0.115 | 2.8 | (0.017) |

TABLE 8-7 Annual Averages for Detectable Concentrations 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-4011 | <0.030 | <0.090 | <0.030 | <0.030 | 0.065 | <0.030 |
| MW-4013 | 38 | <0.090 | 0.047 | 0.075 | 0.70 | <0.030 |
| MW-4014 | 0.080 | <0.090 | <0.030 | (0.021) | 0.10 | <0.030 |
| MW-4015 | 1.21 | <0.090 | <0.030 | 0.126 | 0.85 | <0.030 |

Metals. Metals were analyzed quarterly, semiannually, or annually in all monitoring wells. Although a number of metals have been identified as potential contaminants of concern in the *Remedial Investigation For The Chemical Plant* (Ref. 3), only the following elements were detected at levels exceeding water quality standards; antimony (nine locations), beryllium (five locations), chromium (two locations), mercury (three locations), nickel (one location) and thallium (22 locations). Detection limits for antimony were higher than the water quality standard; therefore, it is not possible to determine the exact number of wells that may have exceeded this standard. The measured antimony values were close to the limit of detection; therefore, they are also subject to large errors and may be false positives.

The thallium and beryllium values that exceeded the water quality standards are believed to be measurement errors. These analytes were detected in the laboratory blanks at approximately the same levels as the samples. Similar problems were also observed for copper and lithium at various times during 1994.

Groundwater Overview. With few exceptions, contaminant levels remained within historic ranges at the monitoring wells sampled under the environmental monitoring program. Because contaminant levels have displayed only minor variability over the historic monitoring period, trend analysis is not conducted annually for the chemical plant monitoring wells. Uranium, sulfate, and nitrate contamination continues 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.

Contamination is primarily confined to groundwater in the shallow, weathered portion of the Burlington Keokuk limestone; however, contaminants have been observed in the deeper, unweathered portion of the aquifer in two retrofit wells (MW-3024 and MW-3026) near the raffinate pits. Conditions at shallow and deep private water wells monitored by the Missouri Department of Health remained unchanged during 1994 and continue to indicate vicinity domestic wells are not impacted by site-derived contaminants.

**8.3.3.2 Springs.** With the exception of uranium at SP-6306, the four springs included in the monitoring program remained within historic ranges for all contaminants of concern. The proposed uranium water quality standard was exceeded at all four springs (SP-5303, SP-5304, SP-6301, and SP-6306). Nitrate exceeded water quality standards at SP-6301, whereas sulfate was below these standards. Low levels of nitroaromatic compounds were detected at SP-6301.

Springs SP-5303 and SP-5304, both located within the Southeast Drainage, continue to display similar elevated uranium levels, but remained within historic ranges during 1994. No other parameters were measured at these locations.

The Southeast Drainage springs have not displayed above-background values for nitrate, sulfate, calcium, lithium, sodium, or strontium, which are all elevated in one or more of the raffinate pits. Thus, these heavily contaminated ponds are unlikely sources of uranium contamination in the Southeast Drainage. The source of uranium is likely residual uranium deposited in the drainage during chemical plant operations, although off-site discharge through NP-0001 and NP-0005 also contributes to this drainage. NP-0001 was effectively eliminated during the process sewer line removal in May 1994 (see Section 7.5.1.1).

During the first quarter, a new uranium high of 42.1 pCi/l (1.56 Bq/l) was measured for SP-6306, which lies below the outfall of Busch Lake 34. Uranium levels in samples collected at this location during second, third, and fourth quarters were within previous ranges and were below the MCL of 13.6 pCi/l (0.50 Bq/l). The cause of the high value, which was an isolated event, is not known.

Burgermeister Spring (SP-6301) results were within historic ranges for all contaminants of concern (uranium, nitrate, sulfate, and nitroaromatic compounds). Uranium values ranged from 0.3 pCi/l (0.01 Bq/l) to 96 pCi/l (3.55 Bq/l). The low value, which is a new extreme, may be an analytical error.

Over the past two years, the WSSRAP has attempted to collect low-flow and high-flow samples from Burgermeister Spring to evaluate the influx of contaminants from groundwater and surface water sources. Groundwater is the major discharge component during low flow, and surface water is the major component during high flow. Although flow rates from the spring respond to storm events and should be a good indicator of surface water input, alkalinity is perhaps the strongest fingerprint for these two water sources. Surface water alkalinity values are generally low (< 150 mg/l) having a mean value of 89.0 mg/l with a standard deviation of 38.6 mg/l. Groundwater alkalinity values in the local carbonate bedrock are typically higher (> 150 mg/l) with a mean value of 344.7 mg/l and a standard deviation of 92.1 mg/l. Using alkalinity as a tracer for surface and groundwater sources, recent data (from late 1991 to the present) continue to indicate that nitrate and uranium levels are typically highest when flow is dominated by groundwater.

## 8.4 Weldon Spring Quarry

### 8.4.1 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). The bedrock at the quarry has three distinct Ordovician formations: The Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone.

The sediment composing the alluvium along the Missouri River coarsens from clays, silts, sands, and gravels above the bedrock. The alluvium 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) composing 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 intermixed and interlayered clays, silts, and sands with some organics.

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

At the quarry, 15 monitoring wells are screened within either the Kimmswick-Decorah or Plattin Formations 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 were located south of the quarry within the Plattin Limestone to assess vertical contaminant migration.

There are also 36 monitoring wells screened in the alluvial material between the quarry and 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 alluvial 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 would provide an early warning of contaminant migration toward the county production well field if this were to occur. The county production wells are monitored to verify the quality of the municipal well field water supply.

Monitoring wells MW-1034 (Kimmswick-Decorah) and MW-1035 (alluvium) have been determined to be upgradient of the quarry for the assessment of groundwater quality in these materials and provide background data. In 1992, eight groundwater monitoring wells were installed 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 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 background well for the Plattin Formation is scheduled to be installed in

1995 as part of the Quarry Residual Operable Unit. A summary of background values used at the quarry is provided in Table 8-8. This table includes the average background values followed by the ranges of values based on two standard deviations about the mean or the average radiological error about the analytical value.

### 8.4.2 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 1994. The first program addresses sampling the Department of Energy wells monitoring the quarry area in order to monitor contaminant migration and the effects of quarry dewatering and bulk waste removal which began in mid-1993. The frequency of sampling for each location is based on the distance of the well from the source or migration pathway and the level of understanding of contaminant levels necessary to properly characterize the contaminantcondition. Monitoring wells on the quarry rim were sampled monthly for total uranium and nitroaromatic compounds, due to the changes in levels 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 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 water treatment plant were sampled quarterly and semiannually for selected parameters. This portion of the monitoring program was developed by representatives of the Department of Energy, several State and Federal regulatory agencies, and St. Charles County.

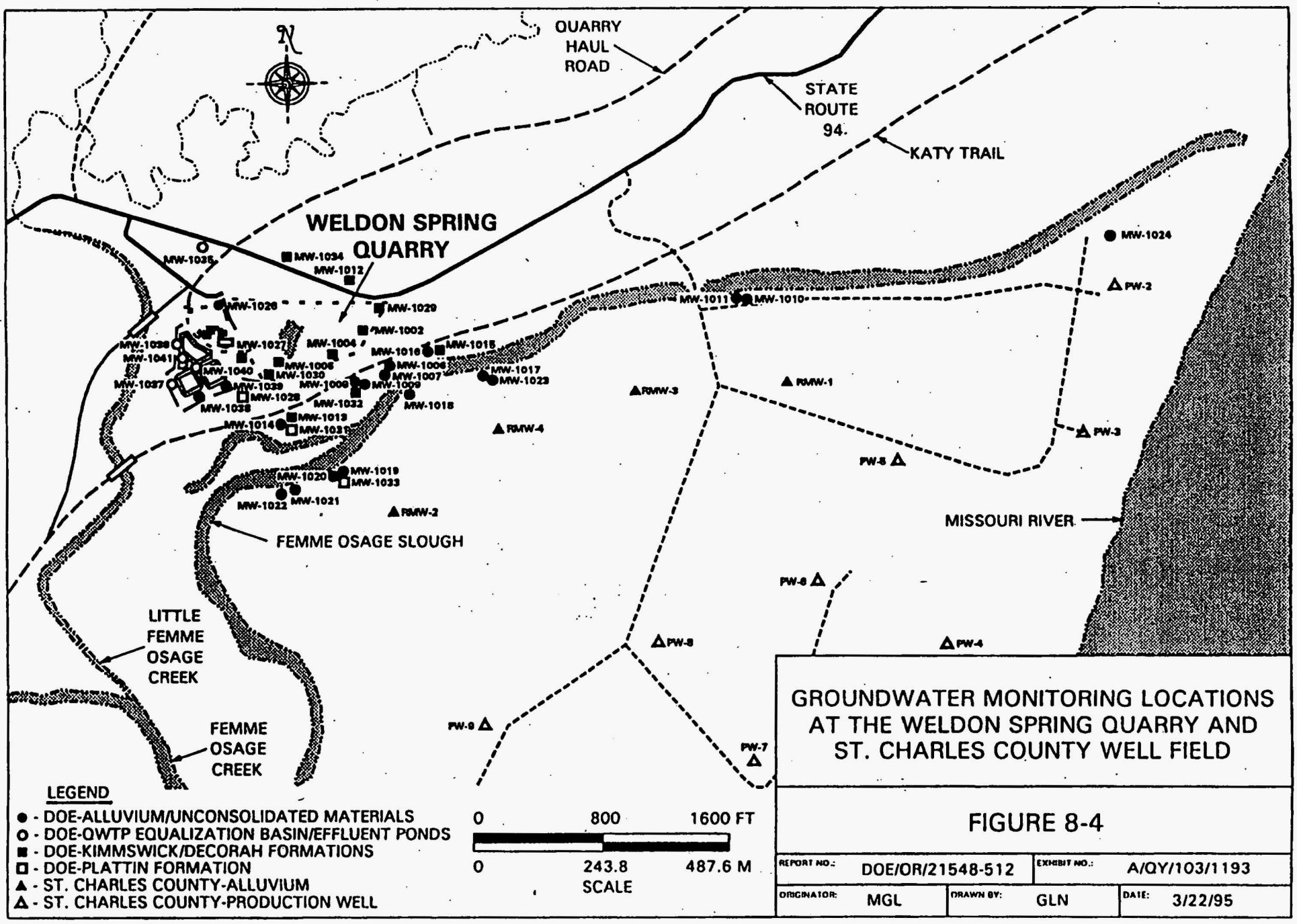
The third program monitors the equalization basin and the two effluent ponds at the quarry water treatment plant (Figure 8-4). Monitoring wells MW-1035 through MW-1037, MW-1040, and MW-1041 were sampled quarterly and annually for selected parameters. The monitoring program was developed to meet the requirements 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*

## TABLE 8-8 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 |
| 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) Dorst Bottom Wells (USGS and DOE)

* 95% Confidence Interval about the mean
** Average radiological error




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

## FIGURE 8-4

| | | | |
|---|---|---|---|
| REPORT NO.: DOE/OR/21548-512 | | EXHIBIT NO.: A/QY/103/1193 | |
| ORIGINATOR: MGL | DRAWN BY: GLN | DATE: 3/22/95 | |

*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 8.4.4.

The groundwater monitoring program at the quarry was dramatically impacted when the Missouri River flooded the St. Charles County well field in the spring. Heavy spring rains also caused flooding of the Femme Osage Slough. This heavy precipitation continued and resulted in the inundation of the well field; thus nine monitoring locations were unable to be sampled during the second bimonthly period. One of the county's production wells (MW-PW03) was flooded and was not sampled during the second and third quarters. The remaining production wells were sampled during this period. The results indicated no detectable levels of total uranium.

### 8.4.3 Weldon Spring Quarry Monitoring Results

**8.4.3.1 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 above background 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 8-9.

The proposed U.S. Environmental Protection Agency total uranium drinking water standard of 20 $\mu$g/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 DCG for total uranium in discharge water, 600 pCi/l, was exceeded at MW-1004, MW-1005, MW-1006, MW-1008, MW-1013, MW-1014, and MW-1032; however, these wells are not directly used as drinking water sources.

Gross alpha results also indicate that levels were above background (Table 8-8) in the bedrock downgradient from the quarry and alluvial material north of the Femme Osage Slough. These annual averages are summarized in Table 8-10.

## TABLE 8-9 Annual Averages for Total Uranium (pCi/l) Above Average Background at the Weldon Spring Quarry

| Location | Annual Average | Maximum | Minimum |
|---|---|---|---|
| MW-1002 | 3.46 | 6.05 | 2.20 |
| MW-1004 | 2801 | 3900 | 1870 |
| MW-1005 | 1896 | 2500 | 1280 |
| MW-1006 | 2912 | 3990 | 1540 |
| MW-1007 | 360.1 | 883.0 | 15.9 |
| MW-1008 | 2394 | 3080 | 1750 |
| MW-1010 | 2.9 | 11.1 | 0.2 |
| MW-1013 | 746.7 | 868.0 | 694.0 |
| MW-1014 | 857.6 | 953.0 | 700.0 |
| MW-1015 | 335.4 | 386.0 | 285.0 |
| MW-1016 | 172.0 | 198.0 | 147.0 |
| MW-1027 | 341.2 | 485.0 | 132.0 |
| MW-1030 | 128.9 | 308.0 | 40.0 |
| MW-1031 | 22.8 | 31.3 | 0.5 |
| MW-1032 | 642.3 | 875.0 | 1.7 |

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

TABLE 8-10 Annual Averages for Gross $\alpha$ (pCi/l) Above Average Background at the Weldon Spring Quarry

| Location | Annual Average | Maximum | Minimum |
|---|---|---|---|
| MW-1004 | 2461 | 2960 | 1630 |
| MW-1005 | 1523 | 1950 | 1120 |
| MW-1006 | 2320 | 2570 | 2040 |
| MW-1007 | 21 | 21 | (a) |
| MW-1008 | 1700 | 1700 | (a) |
| MW-1009 | 12.6 | 17.0 | 8.2 |
| MW-1013 | 595 | 595 | (a) |
| MW-1014 | 668 | 668 | (a) |
| MW-1031 | 23.9 | 23.9 | (a) |

(a) Only one result reported for location.
Note 1: 1 pCi/l = 0.037 Bq/l.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed in 1994 at all groundwater monitoring locations at the quarry. Elevated isotopic levels were observed at locations MW-1002, MW-1004, MW-1005, and MW-1006. It is suspected that the elevated isotopic values in these wells are the results of bulk waste removal activities. Operational data from the quarry pond has shown increased levels of isotopes of radium and thorium in the runoff from waste removal operations and groundwater collected in the pond, which is likely due to disturbance of bulk wastes in the quarry. This increase in the pond is likely representative of the increases occurring in the interstitial waters in the bulk wastes. Monitoring wells MW-1002, MW-1004, and MW-1005 are located in the bedrock rim, adjacent to the bulk wastes. Monitoring well MW-1006 is located in the alluvium downgradient of the quarry. It is screened directly above the bedrock and fracture flow may be occurring from the quarry and being monitored by this location. The annual averages from above background locations are summarized in Table 8-11.

Isotopic thorium data for many of the locations at the quarry, including the St. Charles County well field, were analyzed by an off-site contract laboratory which was experiencing analytical problems regarding isotopic thorium analyses. These values are artificially biased

TABLE 8-11 Annual Averages of Isotopic Radionuclides (pCi/l) Above Average Background at the Weldon Spring Quarry

| Location | Ra-228 | | Th-228 | | Th-230 | |
|---|---|---|---|---|---|---|
| | Annual Average | Maximum Minimum | Annual Average | Maximum Minimum | Annual Average | Maximum Minimum |
| MW-1002 | --- | --- | 1.27 ± 5.93 | 1.6 ± 1.3<br>0.21 ± 0.14 | 4.09 ± 4.10 | 17.7 ± 3.84*<br>0.03 ± 0.06 |
| MW-1004 | 0.96 ± 1.38 | 29.4 ± 3.29<br>(0.2) ± 0.34 | --- | --- | --- | --- |
| MW-1005 | --- | --- | --- | --- | 1.54 ± 1.25 | 4.22 ± 0.97<br>(0.2) ± 0.5 |
| MW-1006 | 7.80 ± 3.64 | 24.4 ± 3.10<br>(0.47) ± 0.47 | 1.33 ± 3.35 | 4.72 ± 2.87<br>0.43 ± 0.11 | --- | --- |

Note 1: Values reported in activity and radiological error.
Note 2: 1 pCi/l = 0.037 Bq/l.
* Poor chemical yield reported by laboratory resulting in data which were biased high.

values based on evidence of laboratory method blanks indicating isotopic thorium activity. This problem continued throughout most of 1994, and was identified in the quarterly environmental data summaries for 1994. Many of these locations were re-analyzed and the results were within historical ranges for each isotope. The problem regarding the analysis of isotopic thorium by the off-site laboratory was the use of an excessive amount of Th-229 as a tracer by the laboratory. Tracers are used to assess the chemical yield by the laboratory. Use of too much Th-229 can cause bleed over into the Th-228 and Th-230 peaks used by the laboratory to determine the activity of the isotopes. The positive Th-232 activity, as well as the positive Th-228 and Th-230 activity, is also likely the result of less than optimum sample preparation causing poor chemical yield. The values of activity, error, and minimum detectable activity (MDA) vary inversely with the chemical yield. This problem was corrected by changing the preparation technique to a method that should improve the counting efficiency and the resolution of the alpha spectra. Also, the procedure was examined regarding the amount of tracer (Th-229) which was added to the samples for the determination of chemical yield.

Nitroaromatic Compounds. In 1994, samples from all quarry monitoring wells were analyzed for nitroaromatic compounds. Fourteen locations yielded detectable concentrations of at least one of the six compounds analyzed during the 1994 sampling period. These monitoring

wells 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 8-12.

TABLE 8-12 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 | 429 | 0.59 | 86.3 | 0.17 | 17.2 | < 0.03 |
| MW-1004 | 8.60 | < 0.09 | 3.00 | 0.14 | 0.49 | < 0.03 |
| MW-1005 | < 0.03 | < 0.09 | < 0.03 | 0.07 | 0.02 | < 0.03 |
| MW-1006 | 108 | 0.13 | 10.9 | 0.33 | 1.96 | < 0.03 |
| MW-1007 | < 0.03 | < 0.09 | 0.02 | < 0.03 | 0.02 | < 0.03 |
| MW-1008 | 0.02 | < 0.09 | < 0.03 | < 0.03 | 0.01 | < 0.03 |
| MW-1009 | 0.02 | < 0.09 | < 0.03 | < 0.03 | < 0.01 | < 0.03 |
| MW-1013 | < 0.03 | < 0.09 | < 0.03 | 0.04 | 0.02 | < 0.03 |
| MW-1015 | 8.25 | 0.17 | 3.43 | 0.04 | 0.21 | < 0.03 |
| MW-1016 | 1.06 | < 0.09 | 0.13 | < 0.03 | 0.04 | < 0.03 |
| MW-1027 | 0.12 | < 0.09 | 4.31 | 0.77 | 1.79 | < 0.03 |
| MW-1029 | < 0.03 | < 0.09 | < 0.03 | < 0.03 | 0.01 | < 0.03 |
| MW-1030 | 0.02 | < 0.09 | 0.14 | 0.06 | 0.10 | < 0.03 |
| MW-1032 | < 0.03 | < 0.09 | 0.02 | 0.08 | 0.03 | < 0.03 |

The Missouri water quality standard for 2,4-DNT (0.11 μg/l) was exceeded at MW-1002, 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 in groundwater.

Sulfate. Groundwater analyses in 1994 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. Eleven 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. The annual averages for these wells are summarized in Table 8-14.

TABLE 8-13 Annual Averages for Sulfate (mg/l) Above Average Background at the Weldon Spring Quarry

| Location | Annual Average | Maximum | Minimum |
|---|---|---|---|
| MW-1005 | 266 | 420 | 205 |
| MW-1006 | 365 | 395 | 346 |
| MW-1007 | 56.2 | 144 | 3.80 |
| MW-1008 | 240 | 253 | 232 |
| MW-1009 | 187 | 199 | 176 |
| MW-1013 | 84.2 | 91.8 | 81.2 |
| MW-1014 | 83.6 | 85.8 | 81.5 |
| MW-1015 | 121 | 125 | 117 |
| MW-1016 | 124 | 134 | 115 |
| MW-1018 | 108 | 200 | 61.0 |
| MW-1032 | 202 | 256 | 110 |

**8.4.3.2 St. Charles County Wellfield.** Radiochemical Parameters. The St. Charles County production wells and the RMW-series monitoring wells were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta. A summary of the radiochemical annual averages is provided in Table 8-13. The annual averages for total uranium in the wells field remain at background. No production well exceeded the DCG of 24 pCi/l (4% of the DCG for discharge waters) for total uranium in drinking water systems, or the proposed groundwater standard of 20 $\mu$g/l (13.6 pCi/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 also sampled quarterly for gross alpha. The annual averages for these locations are within the statistical variation of background ranges for the Missouri River alluvium.

TABLE 8-14 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-228 | Th-230 | Th-232 |
|---|---|---|---|---|---|---|---|
| MW-1024 | 0.41 | 2.24 | 0.95 | 0.51 | 0.42 | 0.34 | 0.14 |
| MW-RMW1 | 1.90 | 2.92 | 1.00 | 1.02 | 0.23 | 0.44 | 0.21 |
| MW-RMW2 | 5.03 | 7.51 | 0.70 | 0.54 | 1.20 | 0.94 | 0.79 |
| MW-RMW3 | 2.22 | 2.56 | 0.71 | 0.52 | 0.61 | 0.67 | 0.38 |
| MW-RMW4 | 1.36 | 2.66 | 0.61 | 0.52 | 0.38 | 0.61 | 0.31 |
| MW-PW02 | 0.23 | 2.82 | 0.75 | 0.69 | 0.44 | 0.29 | 0.09 |
| MW-PW03 | 0.35 | 3.12 | 0.47 | 1.81 | 0.41 | 0.38 | 0.22 |
| MW-PW04 | 0.26 | 2.93 | 0.58 | 0.40 | 0.21 | 0.27 | 0.13 |
| MW-PW05 | 0.27 | 1.34 | 0.97 | 1..17 | 0.25 | 0.38 | 0.08 |
| MW-PW06 | 0.27 | 1.65 | 0.64 | 1.09 | 0.31 | 0.89 | 0.12 |
| MW-PW07 | 0.26 | 4.21 | 1.00 | 1.24 | 0.04 | 1.39 | 0.16 |
| MW-PW08 | 0.42 | 2.29 | 2.03 | 0.94 | 0.08 | 0.26 | 0.29 |
| MW-PW09 | 0.37 | 2.75 | 0.74 | 1.22 | 0.64 | 0.99 | 0.25 |
| MW-RAWW | 0.29 | 1.56 | 1.12 | 0.42 | 0.78 | 2.60 | 0.71 |
| MW-FINW | 3.24 | 0.58 | 0.50 | 0.33 | 0.41 | 1.93 | 0.41 |

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

The Missouri Drinking Water Standard of 5 pCi/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 15 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 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 remained within background ranges for 1994, except for MW-PW03 and MW-PW06, which were slightly above background. This is likely the result of Missouri River influences on the waters produced by these wells. The annual averages for the well field are summarized in Table 8-15. The secondary MCL for sulfate is 250 mg/l; this standard was not exceeded in the well field.

Metals. The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for arsenic and barium. The annual averages are summarized in Table 8-15. Except for MW-1024, MW-RMW-2, MW-RMW-3, and MW-RMW-4, which exceed background for arsenic, the concentrations for both of these metals in the well field area were within background ranges. The elevated arsenic values are likely the result of material conditions in the alluvial system. A source to the quarry bulk wastes cannot be determined from historical results.

### 8.4.4 Trend Analysis

Statistical tests for seasonal and time-dependent trends were performed on historical and current data from select groundwater wells dependent upon the parameters. Trending was performed only on total uranium, nitroaromatic, and sulfate data.

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

TABLE 8-15 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 | 17.0 | 15.7 | 226 |
| MW-RMW1 | 21.0 | 4.37 | 620 |
| MW-RMW2 | 14.7 | 35.6 | 298 |
| MW-RMW3 | 50.0 | 34.0 | 442 |
| MW-RMW4 | 18.4 | 36.4 | 250 |
| MW-PW02 | 64.6 | 1.36 | 368 |
| MW-PW03 | 77.9 | 1.45 | 286 |
| MW-PW04 | 68.0 | 0.63 | 290 |
| MW-PW05 | 41.2 | 1.03 | 432 |
| MW-PW06 | 73.4 | 1.75 | 354 |
| MW-PW07 | 58.0 | 2.60 | 514 |
| MW-PW08 | 41.8 | 3.80 | 518 |
| MW-PW09 | 34.1 | 4.80 | 514 |
| MW-RAWW | 53.0 | 1.95 | 426 |
| MW-FINW | 52.2 | 1.53 | 67.0 |

## Statistical Methods

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, which best accounts for the factors of nondetects and missing data. The trend slope estimation was performed using Sen's Nonparametric Slope Estimator method. Seasonality hypothesis testing was conducted using Minitab statistical software in which the Mann-Whitney U-Test method was selected for the determination of seasonality.

The outcome of the statistical analysis indicates the possible influence of seasonal behavior on groundwater quality. Trend analysis indicates the presence of a trend and its direction, upward or downward, and the slope is estimated in concentration units per year. A

95% confidence interval was calculated to indicate the variability in the values about this trend line. These values are to be interpreted as indicators and are not for the prediction of future concentrations, but to indicate areas that should be more closely monitored in the future.

Total Uranium Statistical Analysis

Based on the above criteria, 19 of the 36 DOE monitoring locations were selected for seasonality and trend analyses. The majority of the locations are situated north of the Femme Osage Slough. These monitoring wells, MW-1017, MW-1018, and MW-1023, are located south of the slough, across from the area of greatest total uranium impact. Monitoring wells MW-1034 and MW-1035 are background locations and statistical trending was performed at these locations to determine the regional trend of total uranium in the vicinity of the quarry. The results of the trend analyses are presented in Table 8-16.

Based on the results of the trend analysis on the uranium data, the only location which exhibited a statistically significant upward trend was monitoring well MW-1030 which is located on the quarry rim. This location has exhibited upward trends since 1993 as a result of flooded conditions in the St. Charles County Well Field. Total uranium levels showed dramatic increases during those periods when the static water level in the well was raised significantly when the flood waters were in contact with the bluff wall of the quarry. Trend directions were downward in several wells which had previously exhibited upward or stationary trends in 1992 and 1993. It is assumed that the overall decrease in total uranium levels is the result of the decreasing, and at times reversing, gradient from the bulk wastes toward the slough. No upward trends were determined to be evident south of the Femme Osage Slough. Seasonality was not indicated to be a factor for the trends in this area.

Nitroaromatic Compound Statistical Analysis

Trending analysis has been performed since 1992 for the nitroaromatic data at the quarry. Twelve of the 36 DOE monitoring locations were selected for trend analysis based on the previously outlined criteria. The summary of the nitroaromatic trend analysis is presented in Table 8-17. Nitrobenzene was not included in the statistical analysis due to levels consistently being below detection limits during sampling at the quarry.

## TABLE 8-16 Quarry Groundwater Total Uranium Trend Analysis Summary and Comparison for 1994

| Well ID | Location | Trend Direction | | | Slope (pCi/l/yr) | | | 95% Confidence Intervals (pCi/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1004 | Bedrock-rim | U | S | D | 435 | (b) | -743 | 238 - 685 | (b) | -1053 - -386 |
| MW-1005 | Bedrock-rim | U | S | S | 274 | (b) | (b) | 121 - 391 | (b) | (b) |
| MW-1006 | Alluvium-North of Slough | U | U | S | 407 | 253 | (b) | -215 - 557 | 84 - 422 | (b) |
| MW-1007 | Alluvium-North of Slough | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| MW-1008 | Alluvium-North of Slough | U | U | D | 910 | 632 | -695 | 711 - 1108 | 315 - 939 | -1115 - -352 |
| MW-1009 | Alluvium-North of Slough | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| MW-1013 | Bedrock-North of Slough | S | D | D | ((b) | -35 | -52 | (b) | -75 - -2 | -80 - -20 |
| MW-1014 | Alluvium-North of Slough | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| MW-1015 | Bedrock-North of Slough | U | S | D | 215 | (b) | -257 | 88 - 308 | (b) | -436 - -84 |
| MW-1016 | Alluvium-North of Slough | U | U | D | 132 | 53 | -139 | 58 - 224 | 25 - 93 | -218 - -15 |
| MW-1017 | Alluvium-South of Slough | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| MW-1018 | Alluvium-South of Slough | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| MW-1023 | Alluvium-South of Slough | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| MW-1027 | Bedrock-rim | S | S | D | (b) | (b) | -80 | (b) | (b) | -185 - -25 |
| MW-1030 | Bedrock-rim | (a) | U | U | (a) | 102 | 32 | (a) | 0.1 - 263 | 3 - 83 |
| MW-1031 | Bedrock-North of Slough | S | D | S | (b) | -5.4 | (b) | (b) | -11 - -0.9 | (b) |
| MW-1032 | Bedrock North of Slough | U | U | S | 846 | 348 | (b) | 36 - 1202 | 28 - 748 | (b) |

## TABLE 8-16 Quarry Groundwater Total Uranium Trend Analysis Summary and Comparison for 1994 (Continued)

| Well ID | Location | Trend Direction | | | Slope (pCi/l/yr) | | | 95% Confidence Intervals (pCi/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1034 | Bedrock-background | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| MW-1035 | Alluvium-background | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |

D Downward
S Stationary
U Upward
(a) Location not selected for trending
(b) Trend direction stationary, therefore no slope to data

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

## TABLE 8-17 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1994

| Well ID | Area | Compound | Trend | | | Slope (µg/l/yr) | | | 95% Confidence Intervals (µg/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1002 | Bedrock-rim | 2,4-DNT | S | U | U | (b) | 0.04 | 0.04 | (b) | 0.02, 0.07 | 0.01, 0.06 |
| | | 2,6-DNT | U | U | S | 2.7 | 5.3 | (b) | 1.8, 4.9 | 3.9, 8.2 | (b) |
| | | 1,3,5-TNB | U | U | S | 62 | 233 | (b) | 40, 110 | 146, 350 | (b) |
| | | 1,3-DNB | S | U | U | (b) | 0.1 | 0.15 | (b) | 0.04, 0.2 | 0.09, 0.17 |
| | | 2,4,6-TNT | U | U | U | 10 | 40 | 20 | 4.9, 17 | 26, 61 | 7.7, 50 |
| MW-1004 | Bedrock-rim | 2,4-DNT | U | U | D | 0.7 | 0.4 | -0.8 | 0.6, 0.9 | 0.1, 0.6 | -1.3, -0.4 |
| | | 2,6-DNT | U | S | D | 0.8 | (b) | -1.5 | 0.4, 1.2 | --- | -2.1, -0.9 |
| | | 1,3,5-TNB | U | U | D | 1.2 | 0.8 | -1.4 | 0.7, 1.8 | 0.4, 1.3 | -2.4, -0.3 |
| | | 1,3-DNB | D | D | (c) | 0.03 | 0.0 | (c) | -0.04, 0 | -0.03, 0.0 | (c) |
| | | 2,4,6-TNT | U | S | D | 0.8 | (b) | -2.5 | 0.4, 1.2 | --- | -4.9, -0.6 |
| MW-1005 | Bedrock-rim | 2,4-DNT | (a) | (a) | D | (a) | (a) | -0.03 | (a) | (a) | -0.04, -0.01 |
| | | 2,6-DNT | (a) | (a) | D | (a) | (a) | -0.013 | (a) | (a) | -0.02, -0.01 |
| | | 1,3,5-TNB | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| | | 1,3-DNB | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| | | 2,4,6-TNT | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |

TABLE 8-17 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1994 (Continued)

| Well ID | Area | Compound | Trend | | | Slope (µg/l/yr) | | | 95% Confidence Intervals (µg/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1006 | Alluvium-North of Slough | 2,4-DNT | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| | | 2,6-DNT | S | S | D | (b) | (b) | -0.99 | (b) | (b) | -1.5, -0.46 |
| | | 1,3,5-TNB | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| | | 1,3-DNB | D | D | (c) | 0.04 | -0.03 | (c) | -0.05, -0.01 | -0.04, 0.0 | (c) |
| | | 2,4,6-TNT | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| MW-1008 | Alluvium-North of Slough | 2,4-DNT | (a) | D | (c) | (a) | -0.02 | (c) | (a) | -0.02, 0.0 | (c) |
| | | 2,6-DNT | (a) | D | S | (a) | -0.04 | (b) | (a) | -0.05, -0.01 | (b) |
| | | 1,3,5-TNB | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| | | 1,3-DNB | (a) | D | (c) | (a) | -0.03 | (c) | (a) | -0.04, -0.01 | (c) |
| | | 2,4,6-TNT | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| MW-1013 | Bedrock-North of Slough | 2,4-DNT | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| | | 2,6-DNT | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| | | 1,3,5-TNB | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| | | 1,3-DNB | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| | | 2,4,6-TNT | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |

TABLE 8-17 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1994 (Continued)

| Well ID | Area | Compound | Trend | | | Slope (µg/l/yr) | | | 95% Confidence Intervals (µg/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1014 | Alluvium-North of Slough | 2,4-DNT | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| | | 2,6-DNT | (a) | (a) | S | (a) | (a) | (b) | (a) | (a) | (b) |
| | | 1,3,5-TNB | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| | | 1,3-DNB | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| | | 2,4,6-TNT | (a) | (a) | (c) | (a) | (a) | (c) | (a) | (a) | (c) |
| MW-1015 | Bedrock-North of Slough | 2,4-DNT | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| | | 2,6-DNT | S | S | D | (b) | (b) | -0.18 | (b) | (b) | -0.25, -0.06 |
| | | 1,3,5-TNB | U | S | D | 28 | (b) | -34 | 6.7, 100 | (b) | -58, -6 |
| | | 1,3-DNB | S | S | S | (b) | (b) | (b) | (b) | (b) | (b) |
| | | 2,4,6-TNT | S | S | D | (b) | (b) | -4.5 | (b) | (b) | -8, -0.4 |

TABLE 8-17 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1994 (Continued)

| Well ID | Area | Compound | Trend | | | Slope (µg/l/yr) | | | 95% Confidence Intervals (µg/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1016 | Alluvium-North of Slough | 2,4-DNT | D | (a) | (c) | 0.01 | (a) | (c) | -0.02, 0 | (a) | (c) |
| | | 2,6-DNT | S | (a) | D | (b) | (a) | -0.04 | (b) | (a) | -0.07, -0.01 |
| | | 1,3,5-TNB | U | (a) | D | 4.5 | (a) | -4.6 | -3.8, 20 | (a) | -9.0, -0.5 |
| | | 1,3-DNB | D | (a) | (c) | 0.01 | (a) | (c) | -0.02, 0 | (a) | (c) |
| | | 2,4,6-TNT | S | (a) | D | (b) | (a) | -0.7 | (b) | (a) | -1.5, -0.2 |
| MW-1027 | Bedrock-rim | 2,4-DNT | (a) | S | D | (a) | (b) | -2.7 | (a) | (b) | -3.8, -0.7 |
| | | 2,6-DNT | (a) | S | D | (a) | (b) | -1.1 | (a) | (b) | -1.8, -0.5 |
| | | 1,3,5-TNB | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| | | 1,3-DNB | (a) | S | (c) | (a) | (b) | (c) | (a) | (b) | (c) |
| | | 2,4,6-TNT | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| MW-1030 | Bedrock-rim | 2,4-DNT | (a) | U | S | (a) | 0.03 | (b) | (a) | 0.01, 0.07 | (b) |
| | | 2,6-DNT | (a) | U | U | (a) | 0.12 | 0.011 | (a) | 0.05, 0.38 | 0.0, 0.08 |
| | | 1,3,5-TNB | (a) | S | S | (a) | (b) | | (a) | (b) | (b) |
| | | 1,3-DNB | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| | | 2,4,6-TNT | (a) | U | S | (a) | 0.38 | (b) | (a) | 0.11, 1.04 | (b) |

TABLE 8-17 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1994 (Continued)

| Well ID | Area | Compound | Trend | | | Slope (µg/l/yr) | | | 95% Confidence Intervals (µg/l/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| MW-1032 | Bedrock-North of Slough | 2,4-DNT | (a) | U | S | (a) | 0.08 | (b) | (a) | -0.05, 0.21 | (b) |
| | | 2,6-DNT | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| | | 1,3,5-TNB | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |
| | | 1,3-DNB | (a) | S | (c) | (a) | (b) | (c) | (a) | (b) | (c) |
| | | 2,4,6-TNT | (a) | S | S | (a) | (b) | (b) | (a) | (b) | (b) |

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 year, therefore no trending performed.

# TABLE 8-18 Quarry Groundwater Sulfate Trend Analysis Summary for 1994

| Well ID | Area | Trend | Slope (mg/l/yr) | 95% Confidence Interval (mg/l/yr) |
|---|---|---|---|---|
| MW-1002 | Bedrock - quarrry rim | S | (a) | (a) |
| MW-1004 | Bedrock - quarry rim | D | -38 | -67, -8.5 |
| MW-1005 | Bedrock - quarry rim | S | (a) | (a) |
| MW-1006 | Alluvium - north of slough | S | (a) | (a) |
| MW-1007 | Alluvium - north of slough | S | (a) | (a) |
| MW-1008 | Alluvium - north of slough | S | (a) | (a) |
| MW-1009 | Alluvium - north of slough | D | -36 | -47, -17 |
| MW-1013 | Bedrock - north of slough | D | -9 | -11, -6 |
| MW-1014 | Alluvium - north of slough | D | -8 | -14, -1.6 |
| MW-1015 | Bedrock - north of slough | D | -71 | -90, -40 |
| MW-1016 | Alluvium - north of slough | D | -44 | -69, -17 |
| MW-1017 | Alluvium - south of slough | D | -1 | -3.4, -0.2 |
| MW-1018 | Alluvium - south of slough | S | (a) | (a) |
| MW-1019 | Alluvium - south of slough | S | (a) | (a) |
| MW-1020 | Alluvium - south of slough | S | (a) | (a) |
| MW-1021 | Alluvium - south of slough | S | (a) | (a) |
| MW-1022 | Alluvium - south of slough | S | (a) | (a) |
| MW-1023 | Alluvium - south of slough | S | (a) | (a) |
| MW-1027 | Bedrock - north of slough | D | -10 | -18, -1.4 |
| MW-1029 | Bedrock - quarry rim | D | -8 | -21, -4 |
| MW-1030 | Bedrock - quarry rim | S | (a) | (a) |
| MW-1031 | Bedrock - north of slough | S | (a) | (a) |
| MW-1032 | Bedrock - north of slough | S | (a) | (a) |
| MW-1033 | Bedrock - south of slough | D | -2.2 | -6, -0.3 |
| MW-1034 | Bedrock - background | S | (a) | (a) |
| MW-1035 | Alluvium - background | S | (a) | (a) |
| MW-RMW1 | Alluvium - south of slough | S | (a) | (a) |
| MW-RMW2 | Alluvium - south of slough | S | (a) | (a) |

TABLE 8-18 Quarry Groundwater Sulfate Trend Analysis Summary for 1994 (Continued)

| Well ID | Area | Trend | Slope (mg/l/yr) | 95% Confidence Interval (mg/l/yr) |
|---|---|---|---|---|
| MW-RMW3 | Alluvium - south of slough | S | (a) | (a) |
| MW-RMW4 | Alluvium - south of slough | S | (a) | (a) |

D Downward
S Stationary
(a) Trend direction stationary, therefore no slope to data.

Based on the results of the trending analysis, upward trends are present in the bedrock of the quarry rim at these locations (MW-1002 and MW-1003). As with total uranium, nitroaromatic trend directions were downward in most wells which have exhibited upward or stationary trends in 1992 and 1993. The reason for these decreases is assumed to be the result of the removal of a large portion of the nitroaromatic contaminated bulk wastes and the changes in gradient as the result of dewatering of the bulk wastes. No locations south of the slough were statistically trended due to historical data indicating no detectable concentrations of nitroaromatic compounds in this area. Seasonality was not indicated to be a factor for the trends in this area.

Sulfate Statistical Analysis

Sulfate data was selected for trending analysis in 1994 due to the coexistence of sulfate with total uranium in the groundwater at the quarry. Typically, sulfate has been used as a predictor of total uranium presence at the quarry because it is chemically conserved and at times precedes total uranium to an area. Twenty-six of the 36 DOE monitoring wells and the four St. Charles County monitoring wells (RMW-series) were selected for statistical analysis. The summary of the sulfate trend analysis is presented in Table 8-18.

Based on the results of the trending analysis, the sulfate levels at the quarry have shown stationary or downward trends. Downward trends were exhibited in the areas on the periphery of the total uranium plume. Those wells which are located in the central portion of the plume had stationary sulfate levels. The direction of the sulfate trend was not dependent upon the total

uranium level or the direction of the total uranium trend at that location. The locations south of the slough and background indicated stationary sulfate levels.

### 8.4.5 Geochemical Characterization

A select group of groundwater monitoring wells was selected for geochemical characterization. Wells were selected to provide a broad representation of the different geologic media present at the quarry, which include bedrock (MW-1002, MW-1005, MW-1013, MW-1028, MW-1031, MW-1032, MW-1033, and MW-1034), alluvium (MW-1014, MW-1018, MW-1019, MW-1021, MW-1022, MW-1038, and MW-1039), and Missouri River alluvium (MW-RMW1, MW-RMW2, MW-PW02, and MW-PW09). The geochemical characterization includes an extensive list of anions, cations, and metals that are not routinely monitored by the WSSRAP. The analyses are conducted as part of a two-year characterization of groundwater to evaluate groundwater quality, contaminant migration, and remediation alternatives. A summary of the analyses of the data and conclusions drawn from this multi-year investigation will be provided in the next site environmental report.

## 8.5 Waste Treatment Facilities

### 8.5.1 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 monitoring parameters 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 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 monitoring 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 monitoring 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).

Concentrations at the monitoring wells were compared with baseline 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 liners of the basins or storage area was initiated.

### 8.5.2 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 consists of a minimum of eight samples collected on a quarterly basis. A statistical summary of these baseline data can be found in Table 8-19. Beginning in 1995, and until closure of these facilities, monitoring data will be compared with the baseline data to identify significant changes in groundwater quality, which may be attributable to operation of these facilities.

Contaminant levels in these wells were below water quality standards for all parameters except mercury (MW-2037 and MW-2038), nitrate (MW-2037 - MW-2041), and selenium (MW-2041). Nitrate was above background in all wells, sulfate was above background in three wells (MW-2037, MW-2038, and MW-2041), and uranium was above background in one well (MW-2041). Nitroaromatics were detected at low levels in four wells (MW-2037, MW-2038, MW-2041, and MW-2043).

Contaminant levels remained relatively steady at most locations during the baseline monitoring period. However, for a few parameters, there were significant decreases during this 2-year period. Nitrate levels decreased at all five locations that exceeded the water quality criterion of 10 mg/l, and selenium and sulfate decreased at MW-2041. The cause of these decreases is not known, but they may be related to changes in groundwater flow resulting from local reduction in surface recharge to the groundwater beneath these facilities.

### 8.5.3 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 new monitoring wells, MW-1040 and MW-1041, were installed closer to the equalization basin to better monitor the waste storage unit. No baseline data were available in 1994 for comparison. Data from MW-1036 and MW-1037 were used as a comparison until sufficient data was available for comparison. Data from 1994 will be used as baseline since it was determined the groundwater beneath the basin was not impacted by waters stored in the equalization basin. Baseline metals, chloride and fluoride data were based on 1993 and 1994 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 each well were compared to baseline for each parameter at each well. Baseline for each well is summarized in Table 8-20 and the summary of detection monitoring results is given in Table 8-21.

The results of the comparison of the monitoring data to baseline indicated that wells MW-1036 and MW-1037 exceeded background for total uranium during 1994. Monitoring wells MW-1036 exhibited a level of 19.4 pCi/l for the second quarter and MW-1037 indicated a level of 6.30 pCi/l for the third quarter. Subsequent data for each well returned to within baseline for both locations. Periodic sampling of MW-1036, MW-1040, and MW-1041 have been performed to monitor any possible changes in the total uranium levels beneath the equalization basins. Results obtained using an on-site KPA indicates that levels in MW-1036 fluctuate, but no reason has been determined for these values. Total uranium levels for MW-1040 and MW-1041 remain within baseline for these sampling events.

## TABLE 8-19 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) | Mean | 0.97 | 1.05 | 1.13 | 1.63 | 1.31 | 1.43 | 1.32 | 1.28 | 2.23 |
| | Std Deviation | 0.43 | 0.35 | 0.23 | 1.38 | 0.37 | 0.90 | 1.01 | 0.71 | 3.19 |
| Barium (µg/l) | Mean | 92.40 | 269.75 | 106.71 | 238.19 | 191.25 | 795.56 | 202.38 | 521.22 | 296.78 |
| | Std Deviation | 4.85 | 20.95 | 47.60 | 108.41 | 16.26 | 55.50 | 48.15 | 22.89 | 15.89 |
| Cadmium (µg/l) | Mean | 1.96 | 2.01 | 2.05 | 2.05 | 2.53 | 1.87 | 1.86 | 1.87 | 1.84 |
| | Std Deviation | 0.65 | 0.63 | 0.54 | 0.54 | 1.49 | 0.72 | 0.78 | 0.64 | 0.65 |
| Chromium (µg/l) | Mean | 2.29 | 2.21 | 2.53 | 2.53 | 5.11 | 4.27 | 4.79 | 3.08 | 2.27 |
| | Std Deviation | 0.64 | 0.71 | 0.43 | 0.43 | 2.99 | 3.28 | 4.54 | 1.18 | 0.75 |
| Lead (µg/l) | Mean | 1.50 | 0.96 | 0.84 | 0.84 | 0.93 | 1.21 | 1.76 | 1.06 | 3.34 |
| | Std Deviation | 0.86 | 0.40 | 0.27 | 0.27 | 0.19 | 0.70 | 2.26 | 0.45 | 6.84 |
| Mercury (µg/l) | Mean | 0.06 | 0.06 | 2.14 | 1.55 | 0.07 | 0.06 | 0.24 | 0.07 | 0.07 |
| | Std Deviation | 0.02 | 0.02 | 0.42 | 0.94 | 0.03 | 0.02 | 0.12 | 0.02 | 0.03 |
| Selenium (µg/l) | Mean | 1.38 | 0.99 | 4.43 | 11.04 | 8.19 | 4.24 | 35.37 | 1.63 | 5.94 |
| | Std Deviation | 1.11 | 0.29 | 5.20 | 4.61 | 5.44 | 1.73 | 20.41 | 0.83 | 9.26 |
| Silver (µg/l) | Mean | 2.72 | 2.39 | 2.69 | 2.69 | 2.84 | 2.11 | 3.66 | 2.25 | 2.42 |
| | Std Deviation | 1.02 | 1.23 | 1.13 | 1.13 | 3.30 | 1.10 | 2.20 | 1.31 | 0.85 |
| Uranium (pCi/l) | Mean | 0.62 | 0.95 | 1.32 | 1.44 | 3.04 | 2.44 | 4.67 | 2.25 | 1.77 |
| | Std Deviation | 0.44 | 0.23 | 0.29 | 0.30 | 0.36 | 0.73 | 1.23 | 0.36 | 0.19 |

## TABLE 8-19 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Nitrate (mg/l) | Mean | 0.57 | 3.64 | 372.56 | 1115.33 | 59.84 | 254.30 | 1124.22 | 7.32 | 5.51 |
| | Std Deviation | 0.46 | 0.80 | 93.30 | 381.08 | 18.04 | 62.08 | 1006.64 | 2.02 | 0.83 |
| Sulfate (mg/l) | Mean | 2.43 | 4.30 | 150.22 | 95.71 | 38.93 | 13.03 | 87.58 | 20.28 | 15.02 |
| | Std Deviation | 0.98 | 0.36 | 9.00 | 12.24 | 5.23 | 4.96 | 36.12 | 6.42 | 1.92 |
| 1,3,5-TNB (µg/l) | Mean | 0.02 | 0.09 | 0.20 | 0.25 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | Std Deviation | 0.00 | 0.21 | 0.03 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| TNT (µg/l) | Mean | 0.02 | 0.09 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | Std Deviation | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,4-DNT (µg/l) | Mean | 0.02 | 0.03 | 0.63 | 1.74 | 0.02 | 0.02 | 0.02 | 0.02 | 0.06 |
| | Std Deviation | 0.00 | 0.05 | 0.05 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2,6-DNT (µg/l) | Mean | 0.01 | 0.02 | 0.14 | 0.33 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | Std Deviation | 0.00 | 0.05 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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

## TABLE 8-20 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 | 11.6 | 7.36 |
| U-234 (pCi/l) | 12.1 | (a) | 4.95 | 12.0 | 6.98 |
| U-238 (pCi/l) | 13.2 | (a) | 3.25 | 6.03 | 3.11 |
| Ra-226 (pCi/l) | 1.32 | 0.25 | 0.72 | 1.72 | 2.11 |
| Ra-228 (pCi/l) | 0.81 | 1.00 | 1.58 | 1.01 | 0.53 |
| Th-230 (pCi/l) | 1.23 | 2.94 | 0.48 | 0.78 | 1.48 |
| Th-232 (pCi/l) | 0.35 | 0.34 | 0.40 | 0.38 | 0.20 |
| Chloride (mg/l) | 6.82 | 102 | 11.8 | 10.9 | 3.49 |
| Fluoride (mg/l) | (a) | (a) | (a) | 0.14 | 0.21 |
| Nitrate (mg/l) | 0.37 | 0.32 | 0.82 | 0.22 | 0.22 |
| Sulfate (mg/l) | 70.0 | 82.0 | 55.5 | 109 | 44.3 |
| Arsenic (µg/l) | 6.09 | 4.71 | 5.50 | 7.09 | 7.09 |
| Barium (µg/l) | 315 | 351 | 752 | 360 | 567 |
| Cadmium (µg/l) | 3.18 | 3.61 | 3.44 | 4.44 | 3.71 |
| Chromium (µg/l) | 4.81 | 7.57 | 7.57 | 6.90 | 6.90 |
| Lead (µg/l) | 1.59 | 2.06 | 2.06 | 2.15 | 2.06 |
| Mercury (µg/l) | 0.18 | 0.20 | 0.17 | 0.16 | 0.16 |
| Selenium (µg/l) | 7.81 | 3.63 | 5.09 | 7.24 | 7.24 |
| Silver (µg/l) | 4.99 | 4.78 | 4.78 | 7.07 | 7.07 |

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

# TABLE 8-21 1994 Summary of the 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 | 0.29 | 9.22 | 2.40 | 6.66 | 4.57 |
| | max/min | 0.39/0.13 | 19.4/4.7 | 6.3/0.3 | 8.8/4.7 | 5.6/3.3 |
| U-234 (pCi/l) | average | 2.68 | no data | 1.89 | 3.39 | 3.31 |
| | max/min | 4.9/0.5 | no data | (a) | 5.4/1.2 | 3.4/3.2 |
| U-238 (pCi/l) | average | 2.78 | no data | 1.24 | 3.65 | 2.93 |
| | max/min | 5.2/0.3 | no data | (a) | 4.2/3.1 | 3.1/2.8 |
| Ra-226 (pCi/l) | average | 0.82 | < 0.30 | (0.10) | 0.78 | 0.93 |
| | max/min | (a) | (a) | (a) | (a) | (a) |
| Ra-228 (pCi/l) | average | < 0.77 | (0.10) | (0.60) | (0.35) | (0.50) |
| | max/min | (a) | (a) | (a) | (a) | (a) |
| Th-230 (pCi/l) | average | 0.67 | 1.50 | (0.20) | < 0.67 | (0.38) |
| | max/min | (a) | (a) | (a) | (a) | (a) |
| Th-232 (pCi/l) | average | (0.05) | < 0.40 | < 0.40 | < 0.54 | < 0.39 |
| | max/min | (a) | (a) | (a) | (a) | (a) |
| Chloride (mg/l) | average | 4.14 | 82.0 | 4.55 | 6.13 | 3.49 |
| | max/min | 5.0/2.9 | 86.6/72.0 | 7.4/2.5 | 8.1/4.7 | 5.0/1.3 |
| Fluoride (mg/l) | average | no data | no data | no data | 0.14 | 0.21 |
| | max/min | no data | no data | no data | (a) | (a) |
| Nitrate (mg/l) | average | < 0.30 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| | max/min | < DL | < DL | 0.16/0.03 | < DL | < DL |
| Sulfate (mg/l) | average | 37.8 | 83.6 | 177 | 80.1 | 44.1 |
| | max/min | 39.0/37.0 | 160/54.0 | 510/29.0 | 91.0/66.0 | 46.0/42.0 |
| Arsenic (µg/l) | average | 1.53 | 3.09 | 5.20 | < 2.50 | < 2.50 |
| | max/min | 2.1/1.0 | 4.2/1.0 | 7.4/3.5 | < DL | < DL |
| Barium (µg/l) | average | 247 | 282 | 394 | 242 | 380 |
| | max/min | 259/236 | 301/266 | 653/192 | 267/218 | 455/297 |
| Cadmium (µg/l) | average | < 2.0 | < 2.0 | < 2.0 | 2.40 | < 2.0 |
| | max/min | < DL | 2.3/1.1 | < DL | 3.1/2.0 | < DL |

TABLE 8-21 1994 Summary of the Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant (Continued)

| Parameter | | MW-1035 | MW-1036 | MW-1037 | MW-1040 | MW-1041 |
|---|---|---|---|---|---|---|
| Chromium (µg/l) | average | < 2.0 | < 2.5 | < 2.5 | < 3.0 | < 3.0 |
| | max/min | < DL | < DL | < DL | < DL | < DL |
| Lead (µg/l) | average | < 2.0 | < 1.0 | < 1.0 | < 1.0 | < 1.0 |
| | max/min | < DL | < DL | < DL | < DL | < DL |
| Mercury (µg/l) | average | < 0.18 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| | max/min | 0.13/0.05 | 0.13/0.05 | 0.12/0.05 | < DL | < DL |
| Selenium (µg/l) | average | < 3.0 | < 2.0 | 2.10 | < 2.5 | < 2.5 |
| | max/min | 3.6/0.8 | 2.4/1.0 | 3.7/1.0 | < DL | < DL |
| Silver (µg/l) | average | < 2.0 | < 2.0 | < 2.0 | < 3.0 | < 3.0 |
| | max/min | < DL | < DL | < DL | < DL | < DL |

(a) Location sampled once during 1994; therefore no maximum or minimum reported.
Note: 1 pCi/l = 0.037 Bq/l.

An investigation of possible sources for these excursions was initiated after review of the second quarter data. Review of the data from the equalization basin infiltration trench indicated that during May, the total uranium activity of the water in the trench rose from the prior levels of approximately 10 pCi/l or less to 17,900 pCi/l. The cause of the increased activity was due to siphoning from the equalization basin into the trench via the interceptor trench discharge line. By the end of June, the total uranium activity in the trench water had decreased to 20 pCi/l. It is possible that waters may have migrated from this trench into the groundwater beneath the basin. Data from upgradient bedrock monitoring well MW-1027 was reviewed to determine if an upgradient source to the wells existed. A comparison of the total uranium data for MW-1027 and MW-1036 since 1991 did not exhibit any similar trends in total uranium activity.

Monitoring wells MW-1036 and MW-1037 had levels which exceeded baseline for sulfate during 1994. Monitoring well MW-1036 had a level of 160 mg/l for sulfate in the second quarter and MW-1037 had levels of 126 mg/l and 510 mg/l for the first and second quarters, respectively. These levels are likely attributed to the flooding of the Femme Osage Creek area

during the spring of 1994. Similar levels were observed in these wells during the floods which occurred in 1993. Subsequent sulfate values have returned to within baseline for both wells.

The remainder of the monitoring parameters remained within baseline for each well. No detectable concentrations of nitroaromatic compounds, PCBs, PAH, or pesticides were reported for 1994.

## 8.6 Well Abandonment

In 1994, six piezometers, two groundwater monitoring wells, and two lysimeter groups were abandoned at the chemical plant. None of these structures were part of the active environmental monitoring program. Table 8-22 summarizes the monitoring structures and the reason for their abandonment.

All abandonment activities were conducted in accordance with procedure ES&H 4.4.4, Subsurface Monitoring Device Plugging and Abandonment. This procedure requires over-drilling of the well casing and construction material (grout, bentonite seal, and filter pack) and placing grout through the use of a tremie pipe to the ground surface. This process maintains the integrity of the associated aquifer by eliminating any conduit from the ground surface.

TABLE 8-22 Weldon Spring Chemical Plant Wells Abandoned during 1994

| Location | Reason for Abandonment |
|---|---|
| B-5 | Construction of Raffinate Pit Piping |
| B-6 | Construction of CSS Pilot Plant |
| B-18 | Construction of Raffinate Pit Piping |
| B-21 | Construction of Raffinate Pit #4 Toe Berm |
| B-22 | Construction of Raffinate Pit #3 Toe Berm |
| Unknown | Construction of CSS Pilot Plant |
| MW-3004 | Construction of Raffinate Pit Piping |
| MW-3015 | Construction of Raffinate Pit #3 Toe Berm |
| LY-3604 | Construction of Raffinate Pit #3 Toe Berm |

TABLE 8-22 Weldon Spring Chemical Plant Wells Abandoned during 1994 (Continued)

| Location | Reason for Abandonment |
|---|---|
| LY-3605 | Construction of Raffinate Pit #3 Toe Berm |
| LY-3606 | Construction of Raffinate Pit #3 Toe Berm |
| LY-3607 | Construction of Raffinate Pit #3 Toe Berm |
| LY-3608 | Construction of Raffinate Pit Piping |
| LY-3609 | Construction of Raffinate Pit Piping |
| LY-3610 | Construction of Raffinate Pit Piping |

## 8.7 Highlights

- 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 were within historic range.

- Monitoring results for groundwater and springs were generally within background ranges. Although some new highs and lows were recorded, they generally did not represent significant changes.

- Examination of the relationship between alkalinity and contaminant levels suggests that contaminant levels are typically higher when the groundwater component dominates flow at Burgermeister Spring.

- Flooding of the St. Charles County well field by the Missouri River inundated all groundwater monitoring locations in this area; nine of these wells were not sampled during the second quarter of 1994. Later sampling indicated that the St. Charles County production wells were not impacted by contaminants migrating from the bulk wastes in the quarry during the flooding.

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

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

- Data for 1994 indicate that bulk waste removal activities have caused some impact on the groundwater north of the slough. This impact is isolated and likely linked to fracture flow from the quarry.

- Trending analyses for total uranium and nitroaromatic data from the quarry area indicate downward trends overall at many locations that have exhibited stationary or upward trends in the recent past. Decreases, and at times reversal, of the groundwater flow gradient from the quarry are likely the results of dewatering activities associated with bulk waste removal.

- Two wells monitoring the quarry water treatment plant equalization basin showed total uranium activity greater than baseline. Subsequent monitoring has indicated that these are not continuing events and more frequent monitoring has been instituted to monitor the situation.

# 9 BIOLOGICAL MONITORING PROGRAM

## 9.1 Program Description

The biological monitoring program complies with the regulatory requirements included in the U.S. Department of Energy (DOE) Orders, the *National Environmental Policy Act* (NEPA), the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), and other appropriate Federal and State regulations. Many of the 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 NEPA and CERCLA biological monitoring program and may include the collection and analysis of water, soil, foodstuffs, and biota.

Activities for the biological monitoring program are selected from the results of pathway analysis. 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 presented.

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.

## 9.2 Applicable Standards

DOE Orders and U.S. Environmental Protection Agency (EPA) regulations provide the standards of compliance for the biological monitoring program. A surveillance level has been determined based upon DOE guidelines for established annual effective dose equivalents for humans consuming terrestrial foodstuffs.

DOE Order 5400.5 also 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 4. These calculations were based on the guideline 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).

The EPA has established Federal ambient water quality criteria for various pollutants, including a number of metal and nitroaromatic contaminants found at the Weldon Spring site. The EPA criteria are used in developing surveillance levels for fish and also serve as a guide in the surveillance of benthic invertebrates, waterfowl, and zooplankton.

## 9.3 Monitoring Results

The biological monitoring program was divided into two study units: aquatic and terrestrial. Studies were conducted as detailed in the *Environmental Monitoring Plan* (Ref. 42) with any deviations discussed below in the appropriate sections. General study locations are identified on Figure 1-4.

### 9.3.1 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the Weldon Spring site by aquatic pathways. Contaminated surface water bodies and 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 effects of contaminants on biota at on-site and off-site properties. The contaminants of concern for off-site surface water and sediments are uranium, arsenic, lead, and mercury. Biouptake studies conducted on fish were based on human consumption of game species.

**9.3.1.1 Fish.** In 1994, the Weldon Spring Site Remedial Action Project (WSSRAP) and the Missouri Department of Conservation (MDC), sampled fish from off-site properties, including Lakes 34, 35, and 36 at the Busch Memorial Conservation Area, and the

Femme Osage Slough within the Weldon Spring Conservation Area. Surface water sampling in previous years has revealed elevated levels of uranium in these water bodies. Lake 33 at the Busch Memorial Conservation Area, which has been shown to have no hydraulic connection to the site, was used as a background sampling location.

Samples consisted primarily of game species such as largemouth bass, crappie, sunfish, and catfish. Samples were prepared as fillets, and were analyzed for total uranium, arsenic, lead, and mercury. Average uranium and metals concentrations are presented in Table 9-1. Data below the analytical detection limit were used in calculations as half of the detection limit according to EPA guidance (Ref. 43) unless uncensored data were available. Subsequent to the 1994 metals analysis in fish tissues, it has been determined that elevated levels of arsenic, mercury, and lead in the Busch lakes are not attributable to former Weldon Spring Chemical Plant operations. No further sampling will be conducted to determine metals concentrations in fish or surface waters at the Busch Conservation Area (Ref. 50).

Uranium concentrations in edible portions of fish sampled from study locations in 1994 ranged from 0.0005 pCi/g ($1.85 \times 10^{-5}$ Bq/g) to 0.05 pCi/g (0.002 Bq/g). The highest uranium concentration was 0.1520 pCi/g (0.006 Bq/g) found in whole sunfish from Lake 35 at the Busch Memorial Conservation Area. Background levels ranged from undetectable to 0.0029 pCi/g ($1.1 \times 10^{-4}$ Bq/g). Total uranium concentrations in fish sampled in 1994 were within historic ranges and showed no increase in uranium accumulation in fish tissues.

**9.3.1.2 Benthic Invertebrates and Zooplankton.** Benthic invertebrates and zooplankton are routinely used as indicators of water quality and ecological stability in lakes and streams. Department of Energy Order 5400.1 specifies monitoring of benthics and organisms in the water column.

The 1994 Aquatic Surveillance Monitoring project (ASM) included surface water and sediment sampling as well as sampling of benthic invertebrates and zooplankton. Sample locations for the ASM project include Busch Lakes 33, 34, 35, and 36, Femme Osage Slough, and local streams and springs. Surface water from these locations was analyzed for total uranium, phosphorus, alkalinity, total suspended solids, chlorophyll A, and barium as well as for various water quality measurements such as temperature, pH, and dissolved oxygen. Sediment samples were analyzed for total uranium, arsenic, barium, chromium, cadmium, lead,

## TABLE 9-1 Average 1994 Uranium and Metal Concentrations in Fish

| Location | Sample Type | Total Uranium (pCi/g) | Arsenic (µg/g) | Lead (µg/g) | Mercury (µg/g) |
|---|---|---|---|---|---|
| Lake 33 (background) | Sunfish Whole | 0.0020 | 0.03 | 0.07 | <0.02 |
| | Bass Fillets | (0.000068) | 0.09 | 0.13 | 0.06 |
| | Catfish Fillets | <0.0003 | 0.03 | 0.68 | <0.02 |
| | Crappie Whole | 0.0029 | 0.10 | 0.84 | <0.02 |
| Lake 34 | Sunfish Cakes | 0.0173 | <1.0 | (0.09) | (0.02) |
| | Bass Fillets | 0.0007 | <1.0 | (0.16) | (0.11) |
| | Catfish Fillets | 0.00173 | <1.0 | (0.21) | (0.02) |
| Lake 35 | Sunfish Cakes | 0.0563 | 0.09 | 0.13 | 0.09 |
| | Sunfish Whole | 0.1520 | <0.02 | 0.09 | 0.04 |
| | Catfish Fillets | 0.0017 | <0.02 | 0.29 | 0.04 |
| | Bass Fillets | 0.0005 | 0.03 | 0.12 | 0.11 |
| | Crappie Cakes | 0.0095 | <0.02 | 0.26 | 0.07 |
| | Crappie Whole | 0.0269 | <0.02 | 0.28 | 0.05 |
| Lake 36 | Sunfish Fillets | 0.0195 | 0.02 | <0.02 | 0.05 |
| | Bass Fillets | 0.00265 | <0.02 | <0.02 | 0.13 |
| | Catfish Fillets | 0.00728 | <0.02 | <0.02 | 0.02 |
| | Crappie Fillets | 0.00496 | <0.02 | 0.04 | 0.12 |
| Femme Osage Slough | Sunfish Whole | 0.0097 | 0.06 | 0.09 | NS |
| | Sunfish Cakes | 0.0057 | <0.02 | 0.26 | NS |
| | Carp Fillets | 0.0035 | <0.02 | 0.83 | NS |
| | Crappie Cakes | 0.0018 | 0.06 | 0.09 | NS |

Note: 1 pCi/g = 0.037 pCi/g.
NS Not Sampled
( ) Data reported were below the detection limit.

# TABLE 9-2 Average 1994 Uranium Concentrations (pCi/g) in Benthic Invertebrates

| Location | Benthic Family | Uranium Concentration | Number of Samples |
|---|---|---|---|
| Lake 26 (Background) | Chironomids | 0.616 | 1 |
| | Other | 71.6* | 1 |
| Lake 33 (Background) | Other | 6.35 | 2 |
| Lake 34 | Corbicula | 6.05 | 1 |
| | Other | 3.92 | 1 |
| Lake 35 | Chironomids | 13.6 | 1 |
| | Other | 9.38 | 1 |
| Lake 36 | Chironomids | 4.77 | 1 |
| | Hexamae | 17.0 | 1 |
| Femme Osage Slough | Oligochaetes | 2.11 | 2 |
| Little Femme Osage Creek | Other | 0.575 | 1 |
| Dardenne Creek | Physadae | 5.47 | 1 |
| | Other | 12.21 | 2 |
| Burgermeister Spring | Other | 169.1* | 2 |
| SE Drainage | Other | 7.63 | 3 |
| Background Spring | Gammarids | 0.518 | 2 |

Note 1: 1 pCi/g = 0.037 pCi/g.
Note 2: "Other" are samples not represented by at least 75% of any one family.
* Two data point are being validated.

## TABLE 9-3 Average 1994 Surface Water Concentrations

| Location | Alkalinity (mg/l) | Barium (µg/l) | Chlorophylla (mg/l) | Phosphorus (mg/l) | TSS (mg/l) | Uranium (pCi/l) |
|---|---|---|---|---|---|---|
| Lake 26 | 57.50 | 31.20 | 0.002 | 0.03 | 8.94 | 0.36 |
| Lake 33 | 78.03 | 67.53 | 0.03 | 0.07 | 15.60 | 0.65 |
| Lake 34 | 104.67 | 76.89 | 0.01 | 0.04 | 6.97 | 11.36 |
| Lake 35 | 60.44 | 49.26 | 0.01 | 0.05 | 8.22 | 9.33 |
| Lake 36 | 66.84 | 69.68 | 0.01 | 0.04 | 9.64 | 35.10 |
| Burgermeister Spring | 198.00 | 117.43 | 0.0002 | 0.02 | 14.92 | 53.98 |
| Dardenne Creek | 131.38 | 259.75 | 0.01 | 0.13 | 36.08 | 3.03 |
| Femme Osage Slough | 148.51 | 154.01 | 0.02 | 0.13 | 47.24 | 13.49 |
| Little Femme Osage Creek | 233.33 | 152.33 | 0.003 | 0.13 | 97.00 | 6.57 |
| Southeast Drainage | 167.25 | 96.32 | 0.001 | 0.39 | 32.83 | 68.68 |
| Background Spring | 144.37 | 91.90 | 0.03 | 0.06 | 37.83 | 0.36 |

Note 1: 1 pCi/l = 0.037 Bq/l.
TSS Total Suspended Sediments

TABLE 9-4 Average 1994 Sediment Concentrations

| Location | Arsenic µg/g | Barium µg/g | Cadmium µg/g | Chromium µg/g | Lead µg/g | Mercury µg/g | Selenium µg/g | Silver µg/g | Zinc µg/g | Uranium pCi/g |
|---|---|---|---|---|---|---|---|---|---|---|
| Lake 26 | 5.80 | 148.63 | 0.62 | 25.67 | 19.51 | 0.20 | 9.49 | 0.84 | 44.55 | 2.41 |
| Lake 33 | 2.79 | 135.14 | 0.36 | 16.68 | 15.70 | 0.10 | 0.80 | 0.57 | 40.78 | 1.73 |
| Lake 34 | 6.28 | 182.03 | 1.53 | 12.10 | 19.99 | 0.12 | 1.15 | 0.66 | 43.83 | 9.52 |
| Lake 35 | 6.14 | 222.00 | 1.44 | 24.03 | 24.83 | 0.05 | 1.16 | 0.43 | 70.97 | 30.88 |
| Lake 36 | 6.75 | 140.35 | 1.56 | 17.54 | 22.25 | 0.08 | 0.80 | 0.38 | 62.86 | 53.33 |
| Burgermeister Spring | 4.93 | 87.72 | 0.55 | 16.33 | 18.73 | 0.05 | 0.42 | 0.62 | 42.38 | 27.18 |
| Dardenne Creek | 3.99 | 75.31 | 0.36 | 6.86 | 9.15 | 0.04 | 0.41 | 0.55 | 21.81 | 2.23 |
| Little Femme Osage Creek | 4.90 | 76.50 | 0.79 | 8.70 | 9.40 | 0.08 | 0.60 | 1.40 | 22.65 | 1.37 |
| Femme Osage Slough | 12.29 | 259.70 | 1.96 | 23.22 | 17.99 | 0.10 | 9.55 | 0.55 | 83.74 | 2.83 |
| Southeast Drainage | 8.37 | 132.65 | 0.54 | 14.55 | 19.48 | 0.07 | 0.48 | 0.92 | 62.03 | 19.03 |
| Background Spring | 12.68 | 86.97 | 0.34 | 11.93 | 24.58 | 0.05 | 0.32 | 0.56 | 22.95 | 0.96 |

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

mercury, selenium, silver, and zinc. Benthic invertebrate biomass samples were analyzed for total uranium. Average uranium concentrations in benthic invertebrates are shown in Table 9-2. Two data points (one from Lake 26 and one from Burgermeister Spring) are currently being validated. These data were over 10 times higher than any previous data from the same locations. Average results of surface water and sediment samples are shown in Tables 9-3 and 9-4, respectively. A final report to be issued in May 1995 will include additional data as well as a more detailed analysis of the results of the ASM project.

**9.3.1.3 Missouri River Vegetation.** Aquatic and terrestrial vegetation along the Missouri River was to be sampled for total uranium concentration. This monitoring is required under an agreement with the Missouri Department of Natural Resources to conduct preoperational and operational monitoring near the quarry water treatment plant discharge

structure. To date, vegetation has not re-established itself along this area of the river bank since the floods of 1993 and 1994 extinguished growth of existing vegetation. Therefore, no river vegetation was sampled.

### 9.3.2 Terrestrial Monitoring

The 1994 Environmental Monitoring Plan (Ref. 42) states that samples of agricultural products from the St. Charles County well field would be analyzed for Ra-226, Ra-228, and isotopic thorium. Because of the flooded condition of the wellfield in late 1993 and again in early 1994, no crops were planted for the 1994 growing season. Therefore, no crop samples were taken during 1994.

## 9.4 Highlights

- Uranium concentrations ranged from 0.0005 pCi/g ($1.85 \times 10^{-5}$ Bq/g) to 0.05 pCi/g (0.002 Bq/g) in edible portions of fish sampled in 1994. These results remained within historical limits.

# 10 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

## 10.1 Program Overview

The environmental quality assurance program includes management of the quality assurance/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.

### 10.1.1 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.

### 10.1.2 Environmental Quality Assurance Project Plan

Environmental compliance issues applicable to the WSSRAP are addressed in the WSSRAP *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 44) which outlines the specific U.S. Environmental Protection Agency/Quality Assurance Management Staff (EPA/QAMS) Quality Assurance requirements 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 provide a complete and accurate framework of information for assessing the amount and extent of hazardous constituents present at the site. The EQAPjP is also supported by standard operating procedures (SOPs), the *Environmental Safety and Health Plan* (Ref. 45), the *Environmental Monitoring Plan* (EMP) (Ref. 42), and sampling plans written for specific environmental tasks.

### 10.1.3 Environmental Data Administration Plan

The *Environmental Data Administration Plan* (EDAP) (Ref. 51) summarizes SOPs and data quality requirements for collecting and analyzing environmental data. The EDAP 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 EDAP details the specific requirements of the EQAPjP.

### 10.1.4 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* (QAP) (Ref. 22). All SOPs are reviewed at least annually and revised as appropriate.

### 10.1.5 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 an actual value. 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). In addition, all averages and summary calculations include the ratio of nondetect data to the total number of samples (e.g., 1:4) as required under the corrective action plan.

### 10.1.6 Audits

The environmental programs are audited by the Project Quality Department. Audits include self assessments, surveillances, and formal audits. They evaluate compliance with environmental programs and generate audit reports to track deficiencies and corrective actions. The WSSRAP is also audited routinely by external organizations including 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 audit reports, deficiencies, and corrective actions are tracked using the Site Wide Audit Tracking System (SWATS).

### 10.1.7 Subcontracted Off-Site Laboratories Programs

Subcontracted off-site laboratories that performed analyses used in 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 audits are performed annually 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.

## 10.2 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.

### 10.2.1 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).

### 10.2.2 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.

### 10.2.3 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.

# TABLE 10-1 QC Sample Description

| Type of Blank | 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. |
| Matrix Spike* (MS) | Monitors the 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) | Monitors the 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) | Monitors the 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.

### 10.2.4 Preservation and Security of Documents and Records

Requirements for preservation and security of documents and records are specified in DOE Order 5700.6C and ASME NQA-1 (1989). All documents pertinent to environmental monitoring are preserved and secured by the departments that produce them.

## 10.3 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.

### 10.3.1 Duplicate Analyses Results

Two kinds of duplicate analyses were performed in 1994; laboratory matrix duplicates and blind replicate duplicates. The laboratory matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring site. Replicate or blind duplicate analyses were performed using samples split by the WSSRAP into separate containers and identified by separate identification numbers. 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, laboratory matrix duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one for every 20 samples. Blind duplicate (replicate) samples were collected as specified in the EMP (Ref. 42). Typically, blind duplicate samples were analyzed for the more common parameters: uranium, nitroaromatic compounds, inorganic anions, and metals.

When laboratory and blind 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 for the parameters of sufficient data size to permit averaging. Both the laboratory matrix duplicates and the blind 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 relative percent differences calculated were within the 20% criterion as recommended in the CLP (Ref. 29 and 46). As a result duplicate samples analyses in 1994 were of acceptable quality.

### 10.3.2 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 effect a sample during collection (field/trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).

TABLE 10-2 Summary of Calculated Relative Percent Differences

| Parameter | Groundwater Duplicates(a) | | Surface Water Duplicates(b) | |
|---|---|---|---|---|
| | RPD%(c) | Count No.(e) | RPD%(c) | Count No.(e) |
| Alkalinity | 2.61 | 17 | 3.53 | 9 |
| Chloride | 1.34 | 11 | 4.89 | 36 |
| Fluoride | (d) | 0 | 7.81 | 21 |
| Nitrate-N | 3.69 | 5 | 2.97 | 22 |
| Sulfate | 1.82 | 16 | 4.50 | 35 |
| Uranium, Total | 4.98 | 11 | 8.16 | 46 |
| Barium | 4.20 | 12 | 5.19 | 15 |
| Calcium | 3.73 | 10 | 1.10 | 11 |
| Strontium | 4.03 | 9 | (d) | 0 |
| Mercury | (d) | 0 | 2.01 | 2 |
| Antimony | (d) | 0 | 1.50 | 4 |
| Beryllium | (d) | 0 | 3.30 | 2 |
| Lithium | 4.41 | 4 | 6.49 | 3 |
| Lead | (d) | 0 | 0.27 | 2 |
| Zinc | 4.13 | 3 | 3.80 | 4 |

(a) Groundwater samles include spring samples
(b) Surface water samples include NPDES samples
(c) RPD = Average Relative Percent Difference
(d) Average RPD could not be calculated for these parameters
(e) RPD sample population for each parameter

- Quality of water used to decontaminate sampling equipment and/or assess the ambient conditions (distilled water blanks).

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.

**10.3.2.1 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 1994, 14 trip blank samples were analyzed for volatile organic compounds. Low concentrations of acetone were found in five samples and one of the five samples also detected 2-Butanone. In all cases, the concentrations were just above the detection limit and did not exceed the CLP criterion. Toluene in one sample exceeded the CLP criterion; the compound was not found in the associated sample. In one other sample, 2-Hexanone was detected above the CLP criterion. The associated sample also detected the compound at the same concentration and is to be considered a suspect value.

**10.3.2.2 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.

The data is summarized in Table 10-3. This table presents the ratio of detects to total number of samples collected for each parameter having results above the detection limits.

**10.3.2.3 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.

The data is summarized in Table 10-4. This table presents the ratio of detects to total number of samples collected for each parameter having results above the detection limits.

**10.3.2.4 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

## 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 8 (0%) | N/A |
| Chloride | 0 out of 7 (0%) | N/A |
| Nitrate-N | 0 out of 6 (0%) | N/A |
| Sulfate | 0 out of 9 (0%) | N/A |
| Uranium, Total | 10 out of 21 (48%) | 1 of 10 (10%) <2 x DL |
| | | 4 of 10 (40%) >2 x DL |
| | | 1 of 10 (10%) <5 x DL |
| | | 4 of 10 (40%) >5 x DL |
| Arsenic | 0 out of 7 (0%) | N/A |
| Barium | 5 out of 20 (25%) | 2 of 5 (40%) <2 xDL |
| | | 3 of 5 (60%) >5 x DL |
| Beryllium | 0 out of 5 (0%) | N/A |
| Cadmium | 2 out of 6 (33%) | 1 of 2 (50%) <2 x DL |
| | | 1 of 2 (50%) >2 x DL |
| Chromium | 1 out of 7 (14%) | 1 of 1 (100%) <2 x DL |
| Lead | 0 out of 7 (0%) | N/A |
| Lithium | 1 out of 6 (17%) | 1 of 1 (100%) <5 x DL |
| Mercury | 0 out of 6 (0%) | N/A |
| Selenium | 0 out of 6 (0%) | N/A |
| Strontium | 0 out of 6 (0%) | N/A |
| Thallium | 0 out of 5 (0%) | N/A |

DL Detection limit; <2x = Less than two times; >5x = Greater than five times
N/A Not applicable

## TABLE 10-4 Summary of Equipment Blank Parameter Results

| | Number of Detects/Number of Analyses | Evaluation and Summary of Detects |
|---|---|---|
| Nitroaromatics | 0 out of 2 (0%) | N/A |
| Chloride | 0 out of 3 (0%) | N/A |
| Nitrate-N | 0 out of 3 (0%) | N/A |
| Sulfate | 0 out of 3 (0%) | N/A |
| Uranium, Total | 9 out of 15 (60%) | 1 of 9 (11%) <2 x DL |
| | | 3 of 9 (33%) >2 x DL |
| | | 5 of 9 (56%) >5 x DL |
| Arsenic | 0 out of 7 (0%) | N/A |
| Barium | 7 out of 14 (50%) | 2 of 7 (29%) <2 x DL |
| | | 1 of 7 (14%) >2 x DL |
| | | 4 of 7 (57%) >5 x DL |
| Beryllium | 0 out of 2 (0%) | N/A |
| Cadmium | 0 out of 6 (0%) | N/A |
| Chromium | 0 out of 7 (0%) | N/A |
| Lead | 1 out of 7 (14%) | 1 of 1 (100%) <2 x DL |
| Lithium | 1 out of 3 (33%) | 1 of 1 (100%) >2 x DL |
| Mercury | 0 out of 4 (0%) | N/A |
| Selenium | 0 out of 6 (0%) | N/A |
| Strontium | 1 out of 3 (33%) | 1 of 1 (100%) >5 x DL |
| Thallium | 0 out of 2 (0%) | N/A |

DL Detection limit; <2x = Less than two times; >5x = Greater than five times
N/A Not applicable

## TABLE 10-5 Summary of Distilled Water Blank Parameter Results

| Parameter | Number of Detects/Number of Analyses | Evaluation and Summary of Detects |
|---|---|---|
| Nitroaromatics | 0 out of 9 (0%) | N/A |
| Chloride | 0 out of 8 (0%) | N/A |
| Nitrate-N | 0 out of 7 (0%) | N/A |
| Sulfate | 0 out of 10 (0%) | N/A |
| Uranium, Total | 1 out of 9 (11%) | 1 of 1 (100%) <2 x DL |
| Arsenic | 1 out of 9 (11%) | 1 of 1 (100%) <2 x DL |
| Barium | 1 out of 9 (11%) | 1 of 1 (100%) >5 x DL |
| Beryllium | 0 out of 7 (0%) | N/A |
| Cadmium | 1 out of 8 (13%) | 1 of 1 (100%) <2 x DL |
| Chromium | 2 out of 9 (22%) | 2 of 2 (100%) <2 x DL |
| Lead | 2 out of 9 (22%) | 2 of 2 (100%) <2 x DL |
| Lithium | 1 out of 8 (13%) | 1 of 1 (100%) <2 x DL |
| Mercury | 0 out of 8 (0%) | N/A |
| Selenium | 1 out of 8 (13%) | 1 of 1 (100%) = DL |
| Strontium | 2 out of 8 (25%) | 1 of 2 (50%) >2 x DL |
| | | 1 of 2 (50%) >5 x DL |
| Thallium | 2 out of 7 (29%) | 1 of 2 (50%) <2 x DL |
| | | 1 of 2 (50%) >2 x DL |

DL = Detection limit; <2x = Less than two times; >5x = Greater than five times
N/A = Not applicable

TABLE 10-6 WSSRAP Validation Summary for Calendar Year 1994 (as of January 1995)

| Calendar Quarter 1994 | No. of Data Points Collected | No. of Data Points Selected for Validation | No. of Validated Data Points | Amount Completed |
|---|---|---|---|---|
| Quarter 1 | 15987 | 1519 | 1463 | 96.3% |
| Quarter 2 | 9868 | 669 | 654 | 97.8% |
| Quarter 3 | 18435 | 1583 | 1450 | 91.6% |
| Quarter 4 | 10302 | 947 | 0 | 0.0% |
| 1994 Total | 54592 | 4718 | 3567 | 75.6% |

samples also serve as laboratory blanks. Procedure ES&H 4.1.4 states that water blank samples shall be collected on a monthly basis. Generally, the water blanks were analyzed for contaminants of concern and were collected at the same time as field blanks.

In 1994, 11 water blanks were collected. Table 10-5 presents the ratio of detects to the total number of samples collected for each parameter that had results above the detection limit.

## 10.4 1994 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 information summarized below includes all WSSRAP data collected and is not limited to environmental monitoring data. 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 10-6 identifies the number of 1994 quarterly and total data points that were selected for data validation, and indicates the percentage of those selected that were completed. Data points presented in this table include all sample types.

Table 10-7 identifies validation qualifiers assigned to the selected data points as a result of data validation. To date, 69.9% of 1994 data validation has been completed. Data points presented in this table include water sample types only.

## TABLE 10-7 Annual Data Validation Qualifier Summary for Calendar Year 1994 (as of January 1995)

| | No. of Data Points | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Anions | Metals | Miscellaneous | Nitroaromatics | Pest/PCB | Radiochemical | Semi-VOA | VOA | Total |
| Accepted | 135 | 494 | 131 | 153 | 55 | 285 | 0 | 32 | 1,285 |
| Rejected | 25 | 65 | 15 | 49 | 0 | 69 | 0 | 1 | 224 |
| On Hold | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 |
| Not Validatable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pending | 52 | 128 | 26 | 78 | 74 | 159 | 96 | 33 | 646 |
| Total | 212 | 687 | 172 | 286 | 129 | 513 | 96 | 66 | 2,161 |
| | Percentages | | | | | | | | |
| Accepted | 63.7% | 71.9% | 76.2% | 53.5% | 42.6% | 55.6% | 0.0% | 48.5% | 59.5% |
| Rejected | 11.8% | 9.5% | 8.7% | 17.1% | 0.0% | 13.5% | 0.0% | 1.5% | 10.4% |
| On Hold | 0.0% | 0.0% | 0.0% | 2.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.3% |
| Not Validatable | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Pending | 24.5% | 18.6% | 15.1% | 27.3% | 57.4% | 31.0% | 100.0% | 50.0% | 29.9% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Table 10-8 identifies the average accuracy and precision for all sample types excluding environmental and waste management samples for anion, metal, 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 water sample types only.

TABLE 10-8 Laboratory Accuracy and Precision Summary for Calendar Year 1994 (as of January 1, 1995)

| Parameter | Laboratory Accuracy | | Laboratory Precision | |
|---|---|---|---|---|
| | Average (% Rec.)[a] | n[b] | Average (RPD)[c] | n[b] |
| ANIONS | | | | |
| Bromide | 96.7 | 9 | 1.7 | 9 |
| Fluoride | 98.8 | 25 | 1.1 | 17 |
| Chloride | 96.8 | 34 | 1.0 | 26 |
| Nitrate-N | 99.5 | 50 | 1.5 | 42 |
| Nitrite-N | 97.0 | 5 | 1.5 | 5 |
| Sulfate | 96.6 | 36 | 1.5 | 28 |
| METALS | | | | |
| Aluminum | 102.1 | 13 | 2.7 | 13 |
| Antimony | 97.7 | 15 | 8.3 | 15 |
| Arsenic | 98.9 | 37 | 3.5 | 28 |
| Barium | 99.1 | 37 | 1.9 | 31 |
| Beryllium | 95.6 | 15 | 2.1 | 15 |
| Cadmium | 101.8 | 25 | 3.0 | 21 |
| Calcium | 102.7 | 13 | 2.9 | 11 |
| Chromium | 101.9 | 35 | 3.3 | 31 |
| Cobalt | 102.2 | 11 | 2.4 | 11 |
| Copper | 100.3 | 22 | 2.2 | 18 |
| Iron | 103.0 | 24 | 3.8 | 20 |

## TABLE 10-8 Laboratory Accuracy and Precision Summary for Calendar Year 1994 (as of January 1, 1995) (Continued)

| Parameter | Laboratory Accuracy | | Laboratory Precision | |
|---|---|---|---|---|
| | Average (% Rec.)[a] | n[b] | Average (RPD)[c] | n[b] |
| Lead | 103.7 | 35 | 9.6 | 26 |
| Lithium | 103.6 | 20 | 1.0 | 20 |
| Magnesium | 103.1 | 14 | 2.2 | 11 |
| Manganese | 101.3 | 32 | 2.7 | 28 |
| Mercury | 106.6 | 32 | 2.9 | 28 |
| Molybdenum | 104.1 | 10 | 1.6 | 10 |
| Nickel | 102.8 | 17 | 1.8 | 17 |
| Potassium | 102.0 | 13 | 3.3 | 11 |
| Selenium | 97.7 | 37 | 5.2 | 32 |
| Silver | 98.4 | 27 | 2.6 | 16 |
| Sodium | 102.7 | 13 | 2.1 | 11 |
| Strontium | 106.1 | 13 | 0.9 | 11 |
| Thallium | 96.3 | 15 | 2.1 | 13 |
| Vanadium | 102.6 | 11 | 1.6 | 11 |
| Zinc | 102.5 | 22 | 2.3 | 18 |
| MISCELLANEOUS | | | | |
| Alkalinity | 92.1 | 24 | 11.3 | 12 |
| Biochemical Oxygen Demand | 103.8 | 6 | --- | 0 |
| Chemical Oxygen Demand | 103.1 | 20 | 1.3 | 8 |
| Total Suspended Solids | 99.9 | 20 | 17.0 | 8 |
| Cyanide, Amenable | 80.6 | 8 | 9.3 | 8 |
| Total Organic Carbon | 100.3 | 11 | 1.5 | 11 |
| Phenolics, Totals | 108.7 | 4 | 0.0 | 4 |
| Sulfide | 93.9 | 2 | --- | 0 |
| Phosphorus, Total | 98.5 | 18 | 1.7 | 18 |
| Silica, Dissolved | 103.1 | 8 | 2.2 | 8 |

## TABLE 10-8 Laboratory Accuracy and Precision Summary for Calendar Year 1994 (as of January 1, 1995) (Continued)

| Parameter | Laboratory Accuracy | | Laboratory Precision | |
|---|---|---|---|---|
| | Average (% Rec.)[a] | n[b] | Average (RPD)[c] | n[b] |
| NITROAROMATICS | | | | |
| 1,3,5-Trinitrobenzene | 78.7 | 25 | 5.8 | 9 |
| 1,3-Dinitrobenzene | 97.3 | 17 | NC | 0 |
| Nitrobenzene | 85.1 | 25 | 5.5 | 9 |
| 2,4,6-Trinitrotoluene | 112.0 | 41 | 6.2 | 21 |
| 2,4-Dinitrotoluene | 97.5 | 41 | 2.7 | 21 |
| 2,6-Dinitrotoluene | 96.3 | 17 | 0.0 | 1 |
| RADIOCHEMICAL | | | | |
| Uranium, Total | 103.7 | 66 | 7.2 | 52 |
| Th-228 | 101.3 | 15 | 2.6 | 20 |
| Th-230 | 117.2 | 24 | 9.4 | 20 |
| Th-232 | 110.2 | 43 | 6.0 | 40 |
| Ra-226 | 92.8 | 28 | 21.9 | 20 |
| Ra-228 | 96.6 | 28 | 8.8 | 20 |
| Gross Alpha | 91.5 | 41 | 5.7 | 17 |
| Gross Beta | 106.1 | 31 | 4.1 | 12 |
| Uranium-234 | 114.4 | 4 | 5.9 | 4 |
| Uranium-238 | 142.9 | 4 | 20.9 | 4 |
| PESTICIDES/PCBS | | | | |
| Aroclor-1016 | 56.0 | 2 | NC | 0 |
| Aroclor-1221 | 56.0 | 2 | NC | 0 |
| Aroclor-1232 | 56.0 | 2 | NC | 0 |
| Aroclor-1242 | 56.0 | 2 | NC | 0 |
| Aroclor-1248 | 56.0 | 4 | NC | 0 |
| Aroclor-1254 | 56.0 | 2 | NC | 0 |

TABLE 10-8 Laboratory Accuracy and Precision Summary for Calendar Year 1994 (as of January 1, 1995) (Continued)

| Parameter | Laboratory Accuracy | | Laboratory Precision | |
|---|---|---|---|---|
| | Average (% Rec.)[a] | n[b] | Average (RPD)[c] | n[b] |
| Aroclor-1260 | 56.0 | 2 | NC | 0 |

The accuracy values are based on the percent recoveries (% Rec) of the associated laboratory control samples.
The precision values are based on the relative percent differences (RPD) between associated duplicate laboratory control samples.
N Sample population
NC No average calculated since no samples collected.

## 10.5 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 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 10-9. This table provides information on the parameter, matrix type, laboratory name, DOE value, reported value, percent recovery, and performance criteria evaluation.

## TABLE 10-9 Summary of the DOE Interlaboratory Comparison Program

| Parameter (matrix) | Laboratory | DOE Value | Reported Value | Percent Recovery | Evaluation[a] |
|---|---|---|---|---|---|
| Uranium,234 (air) | Barringer | 0.197 | 0.191 | 97 % | A |
| Uranium,234 (air) | Barringer | 0.112 | 0.118 | 105 % | A |
| Uranium,238 (air) | Barringer | 0.203 | 0.186 | 92 % | A |
| Uranium,238 (air) | Barringer | 0.112 | 0.126 | 113 % | A |
| Uranium,total (air) | Barringer | 15.8 | 16.5 | 104 % | A |
| Uranium,total (air) | Barringer | 9.450 | 9.200 | 97 % | A |
| Uranium,total (air) | Barringer | 9.450 | 9.600 | 102 % | A |
| Uranium,234 (soil) | Barringer | 27.1 | 27.5 | 101 % | A |
| Uranium,234 (soil) | Barringer | 32.600 | 31.100 | 95 % | A |
| Uranium,238 (soil) | Barringer | 27.1 | 26.8 | 99 % | A |
| Uranium,238 (soil) | Barringer | 33.000 | 29.000 | 88 % | A |
| Uranium,total (soil) | Barringer | 2.13 | 2.38 | 112 % | W |
| Uranium,total (soil) | Barringer | 2.690 | 2.300 | 86 % | A |
| Uranium,total (soil) | Barringer | 2.690 | 2.500 | 93 % | A |
| Uranium,234 (water) | Barringer | 0.520 | 0.508 | 98 % | A |
| Uranium,234 (water) | Barringer | 1.110 | 1.100 | 99 % | A |
| Uranium,238 (water) | Barringer | 0.528 | 0.495 | 94 % | A |
| Uranium,238 (water) | Barringer | 1.110 | 1.000 | 90 % | A |
| Uranium,total (water) | Barringer | 0.0413 | 0.0395 | 96 % | A |
| Uranium,total (water) | Barringer | 0.089 | 0.081 | 91 % | A |
| Uranium,total (water) | Barringer | 0.089 | 0.079 | 89 % | A |
| Uranium,total (air) | Ecotek | 9.450 | 7.290 | 77 % | W |
| Uranium,234 (soil) | Ecotek | 21.1 | 24.6 | 91 % | A |
| Uranium,238 (soil) | Ecotek | 27.1 | 26.1 | 96 % | A |
| Uranium,total (soil) | Ecotek | 2.690 | 1.760 | 65 % | A |
| Uranium,total (water) | Ecotek | 0.089 | 0.085 | 96 % | A |
| Uranium,234 (air) | General | 0.197 | 0.227 | 115 % | A |
| Uranium,234 (air) | General | 0.112 | 0.140 | 125 % | A |
| Uranium,238 (air) | General | 0.203 | 0.214 | 105 % | A |

## TABLE 10-9 Summary of the DOE Interlaboratory Comparison Program (Continued)

| Parameter (matrix) | Laboratory | DOE Value | Reported Value | Percent Recovery | Evaluation[a] |
|---|---|---|---|---|---|
| Uranium,238 (air) | General | 0.112 | 0.130 | 116 % | A |
| Uranium,total (air) | General | 15.8 | 18.4 | 116 % | A |
| Uranium,total (air) | General | 9.450 | 9.110 | 96 % | A |
| Uranium,234 (soil) | General | 27.1 | 27.2 | 100 % | A |
| Uranium,234 (soil) | General | 32.600 | 24.600 | 76 % | A |
| Uranium,238 (soil) | General | 27.1 | 28.3 | 104 % | A |
| Uranium,238 (soil) | General | 33.000 | 27.500 | 83 % | A |
| Uranium,total (soil) | General | 2.13 | 2.36 | 111 % | W |
| Uranium,total (soil) | General | 2.690 | 1.890 | 70 % | A |
| Uranium,234 (water) | General | 0.520 | 0.619 | 119 % | W |
| Uranium,234 (water) | General | 1.110 | 1.230 | 111 % | W |
| Uranium,238 (water) | General | 0.528 | 0.561 | 106 % | A |
| Uranium,238 (water) | General | 1.110 | 1.190 | 107 % | A |
| Uranium,total (water) | General | 0.0413 | 0.0411 | 100 % | A |
| Uranium,total (water) | General | 0.089 | 0.120 | 135 % | N |
| Uranium,234 (air) | IEA | 0.197 | 0.198 | 101 % | A |
| Uranium,234 (air) | IEA | 0.112 | 0.106 | 95 % | A |
| Uranium,238 (air) | IEA | 0.203 | 0.213 | 105 % | A |
| Uranium,238 (air) | IEA | 0.112 | 0.107 | 96 % | A |
| Uranium,234 (soil) | IEA | 27.1 | 30.2 | 111 % | W |
| Uranium,234 (soil) | IEA | 32.600 | 25.800 | 79 % | A |
| Uranium,238 (soil) | IEA | 33.000 | 25.700 | 78 % | A |
| Uranium,234 (water) | IEA | 0.520 | 0.519 | 100 % | A |
| Uranium,234 (water) | IEA | 1.110 | 1.080 | 97 % | A |
| Uranium,238 (water) | IEA | 0.528 | 0.518 | 98 % | A |
| Uranium,238 (water) | IEA | 1.110 | 1.060 | 96 % | A |
| Uranium,234 (air) | Quanterra | 0.197 | 0.244 | 124 % | A |
| Uranium,238 (air) | Quanterra | 0.203 | 0.257 | 127 % | A |

## TABLE 10-9 Summary of the DOE Interlaboratory Comparison Program (Continued)

| Parameter (matrix) | Laboratory | DOE Value | Reported Value | Percent Recovery | Evaluation[a] |
|---|---|---|---|---|---|
| Uranium,total (air) | Quanterra | 15.8 | 17.3 | 109 % | A |
| Uranium,234 (soil) | Quanterra | 27.1 | 35.3 | 130 % | N |
| Uranium,238 (soil) | Quanterra | 27.1 | 38.5 | 142 % | W |
| Uranium,234 (soil) | Quanterra | 32.6 | 26.7 | 82% | A |
| Uranium,238 (soil) | Quanterra | 33.0 | 29.1 | 88% | A |
| Uranium,total (soil) | Quanterra | 2.690 | 1.330 | 49 % | A |
| Uranium,234 (water) | Quanterra | 1.11 | 1.23 | 111% | A |
| Uranium,238 (water) | Quanterra | 1.11 | 1.23 | 111% | A |
| Uranium,234 (water) | Quanterra | 0.520 | 0.112 | 22 % | N |
| Uranium,238 (water) | Quanterra | 0.528 | 0.128 | 24 % | N |
| Uranium,total (water) | Quanterra | 0.528 | 0.128 | 24 % | N |
| Uranium,total (water) | Quanterra | 0.089 | 0.079 | 89% | A |
| Uranium,234 (air) | Lockheed | 0.197 | 0.250 | 127 % | A |
| Uranium,234 (air) | Lockheed | 0.112 | 0.120 | 107 % | A |
| Uranium,238 (air) | Lockheed | 0.203 | 0.220 | 108 % | A |
| Uranium,238 (air) | Lockheed | 0.112 | 0.110 | 98 % | A |
| Uranium,total (air) | Lockheed | 9.450 | 7.740 | 82 % | A |
| Uranium,234 (soil) | Lockheed | 27.1 | 29.0 | 107 % | A |
| Uranium,234 (soil) | Lockheed | 32.600 | 26.000 | 80 % | A |
| Uranium,238 (soil) | Lockheed | 27.1 | 28.0 | 103 % | A |
| Uranium,238 (soil) | Lockheed | 33.000 | 22.600 | 69 % | W |
| Uranium,total (soil) | Lockheed | 2.690 | 1.790 | 67 % | A |
| Uranium,234 (water) | Lockheed | 0.520 | 0.620 | 119 % | A |
| Uranium,234 (water) | Lockheed | 1.110 | 1.120 | 101 % | A |
| Uranium,238 (water) | Lockheed | 0.528 | 0.540 | 102 % | A |
| Uranium,238 (water) | Lockheed | 1.110 | 1.050 | 95 % | A |
| Uranium,total (water) | Lockheed | 0.0413 | 0.0470 | 114 % | A |
| Uranium,total (water) | Lockheed | 0.089 | 0.085 | 96 % | A |

## TABLE 10-9 Summary of the DOE Interlaboratory Comparison Program (Continued)

| Parameter (matrix) | Laboratory | DOE Value | Reported Value | Percent Recovery | Evaluation[a] |
|---|---|---|---|---|---|
| Uranium,234 (air) | IT | 0.197 | 0.216 | 110 % | A |
| Uranium,238 (air) | IT | 0.203 | 0.204 | 100 % | A |
| Uranium,total (air) | IT | 9.450 | 8.390 | 89 % | A |
| Uranium,total (soil) | IT | 2.13 | 0.676 | 32 % | W |
| Uranium,total (soil) | IT | 2.690 | 0.934 | 35 % | W |
| Uranium,total (water) | IT | 0.0413 | 0.0417 | 101 % | A |
| Uranium,total (water) | IT | 0.089 | 0.089 | 100 % | A |
| Uranium,234 (air) | TMA/Eberline | 0.197 | 0.278 | 141 % | W |
| Uranium,234 (air) | TMA/Eberline | 0.112 | 0.100 | 89 % | A |
| Uranium,238 (air) | TMA/Eberline | 0.203 | 0.268 | 132 % | A |
| Uranium,238 (air) | TMA/Eberline | 0.112 | 0.100 | 89 % | A |
| Uranium,total (air) | TMA/Eberline | 15.8 | 21.0 | 133 % | W |
| Uranium,total (air) | TMA/Eberline | 9.450 | 8.860 | 94 % | A |
| Uranium,234 (soil) | TMA/Eberline | 27.1 | 24.0 | 89 % | A |
| Uranium,234 (soil) | TMA/Eberline | 32.600 | 25.100 | 77 % | A |
| Uranium,238 (soil) | TMA/Eberline | 27.1 | 24.5 | 90 % | A |
| Uranium,238 (soil) | TMA/Eberline | 33.000 | 23.000 | 70 % | A |
| Uranium,total (soil) | TMA/Eberline | 2.13 | 1.94 | 91 % | A |
| Uranium,total (soil) | TMA/Eberline | 2.690 | 2.500 | 93 % | A |
| Uranium,234 (water) | TMA/Eberline | 0.520 | 0.570 | 110 % | A |
| Uranium,234 (water) | TMA/Eberline | 1.110 | 1.010 | 91 % | A |
| Uranium,238 (water) | TMA/Eberline | 0.528 | 0.538 | 102 % | A |
| Uranium,238 (water) | TMA/Eberline | 1.110 | 1.000 | 90 % | A |
| Uranium,total (water) | TMA/Eberline | 0.0413 | 0.0433 | 105 % | A |
| Uranium,total (water) | TMA/Eberline | 0.089 | 0.091 | 102 % | A |
| Uranium,234 (water) | TMA/Eberline | 1.110 | 1.010 | 91 % | A |
| Uranium,238 (water) | TMA/Eberline | 0.528 | 0.538 | 102 % | A |
| Uranium,238 (water) | TMA/Eberline | 1.110 | 1.000 | 90 % | A |

## TABLE 10-9 Summary of the DOE Interlaboratory Comparison Program (Continued)

| Parameter (matrix) | Laboratory | DOE Value | Reported Value | Percent Recovery | Evaluation[a] |
|---|---|---|---|---|---|
| Uranium,total (water) | TMA/Eberline | 0.0413 | 0.0433 | 105 % | A |
| Uranium,total (water) | TMA/Eberline | 0.089 | 0.091 | 102 % | 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 radionculide control program are presented in Table 10-10. This table provides information on the parameter, matrix type, laboratory name, date analyzed, EPA value, reported value, percent recovery, and control limit evaluation. The results presented in Tables 10-9 and 10-10 indicated no major problems associated with subcontracted laboratories.

Results of the EPA organic and inorganic performance evaluation program are not presented in this section. However, this information is evaluated during the routine audit of each laboratory. Results of the 1994 performance evaluation samples have been reviewed, and no major problems with the results from these programs were observed.

TABLE 10-10 Summary of EPA - EMSL Intercomparison Radionuclide Control Program

| Parameter (matrix) | Laboratory (Date) | Value | Reported Value | Percent Recovery | EPA* Tag |
|---|---|---|---|---|---|
| Gross Alpha (air) | Quanterra 8/94 | 35.0 | 44.0 | 126 % | - |
| Gross Beta (air) | Quanterra 8/94 | 56.0 | 53.0 | 95 % | - |
| Gross Alpha (water) | Quanterra 1/94 | 15.0 | 9.0 | 60 % | - |
| Gross Alpha (water) | Quanterra 7/94 | 32.0 | 31.0 | 97 % | - |
| Gross Beta (water) | Quanterra 1/94 | 62.0 | 42.0 | 68 % | ↓ |
| Gross Beta (water) | Quanterra 7/94 | 10.0 | 12.33 | 123 % | - |
| Uranium,total (water) | Quanterra 2/94 | 10.1 | 9.80 | 97 % | - |
| Uranium,total (water) | Quanterra 6/94 | 52.6 | 51.07 | 97 % | - |
| Uranium,total (water) | Quanterra 9/94 | 35.0 | 31.77 | 91 % | - |
| Radium-226 (water) | Quanterra 2/94 | 19.9 | 26.57 | 134 % | ↑ |
| Radium-226 (water) | Quanterra 6/94 | 15.0 | 12.53 | 84 % | - |
| Radium-226 (water) | Quanterra 9/94 | 10.0 | 7.53 | 75 % | - |
| Radium-228 (water) | Quanterra 2/94 | 14.7 | 13.17 | 90 % | - |
| Radium-228 (water) | Quanterra 6/94 | 15.4 | 13.93 | 90 % | - |
| Radium-228 (water) | Quanterra 9/94 | 10.2 | 11.60 | 114 % | - |
| Gross Alpha (water) | Barringer 1/94 | 15.0 | 12.33 | 82 % | - |
| Gross Alpha (water) | Barringer 4/94 | 86.0 | 69.0 | 80 % | - |

TABLE 10-10 Summary of EPA - EMSL Intercomparison Radionuclide Control Program (Continued)

| Parameter (matrix) | Laboratory (Date) | Value | Reported Value | Percent Recovery | EPA* Tag |
|---|---|---|---|---|---|
| Gross Beta (water) | Barringer 1/94 | 62.0 | 54.7 | 88 % | - |
| Gross Beta (water) | Barringer 4/94 | 117.0 | 96.0 | 82 % | - |
| Radium-226 (water) | Barringer 2/94 | 19.9 | 19.27 | 97 % | - |
| Radium-226 (water) | Barringer 4/94 | 20.0 | 18.7 | 94 % | - |
| Radium-226 (water) | Barringer 6/94 | 15.0 | 18.40 | 123 % | - |
| Radium-226 (water) | Barringer 9/94 | 10.0 | 9.67 | 97 % | - |
| Radium-228 (water) | Barringer 2/94 | 14.7 | 13.60 | 93 % | - |
| Radium-228 (water) | Barringer 4/94 | 20.1 | 20.8 | 103 % | - |
| Radium-228 (water) | Barringer 6/94 | 15.4 | 15.57 | 101 % | - |
| Radium-228 (water) | Barringer 9/94 | 10.2 | 11.37 | 111 % | - |
| Uranium,total (water) | Barringer 2/94 | 10.1 | 8.10 | 80 % | - |
| Uranium,total (water) | Barringer 4/94 | 25.0 | 19.0 | 76 % | ↓ |
| Uranium,total (water) | Barringer 6/94 | 52.6 | 48.30 | 92 % | - |
| Uranium,total (water) | Barringer 9/94 | 35.0 | 28.27 | 81 % | ↓ |
| Gross Alpha (air) | Barringer 8/94 | 35.0 | 40.33 | 115 % | - |
| Gross Beta (air) | Barringer 8/94 | 56.0 | 63.33 | 113 % | - |
| Gross Alpha (water) | IEA 1/94 | 15.0 | 10.0 | 67 % | - |
| Gross Beta (water) | IEA 1/94 | 62.0 | 57.67 | 93 % | - |
| Gross Alpha (water) | IEA 7/94 | 32.0 | 22.0 | 69 % | - |
| Gross Beta (water) | IEA 7/94 | 10.0 | 9.67 | 97 % | - |
| Radium-226 (water) | IEA 2/94 | 19.9 | 18.63 | 94 % | - |
| Radium-228 (water) | IEA 2/94 | 14.7 | 11.00 | 75 % | - |
| Radium-226 (water) | IEA 6/94 | 15.0 | 14.0 | 93 % | - |
| Radium-228 (water) | IEA 6/94 | 15.4 | 14.20 | 92 % | - |
| Radium-226 (water) | IEA 9/94 | 10.0 | 9.23 | 92 % | - |
| Radium-228 (water) | IEA 9/94 | 10.2 | 12.53 | 123 % | - |
| Uranium,total (water) | IEA 2/94 | 10.1 | 9.57 | 95 % | - |

## TABLE 10-10 Summary of EPA - EMSL Intercomparison Radionuclide Control Program (Continued)

| Parameter (matrix) | Laboratory (Date) | Value | Reported Value | Percent Recovery | EPA* Tag |
|---|---|---|---|---|---|
| Uranium,total (water) | IEA 6/94 | 52.6 | 48.0 | 91 % | - |
| Uranium,total (water) | IEA 9/94 | 35.0 | 31.80 | 91 % | - |
| Gross Alpha (air) | IEA 8/94 | 35.0 | 37.0 | 106 % | - |
| Gross Beta (air) | IEA 8/94 | 56.0 | 58.0 | 104 % | - |
| Gross Alpha (water) | Lockheed 1/94 | 15.0 | 8.67 | 58% | - |
| Gross Beta (water) | Lockheed 1/94 | 62.0 | 60.67 | 98% | - |
| Uranium,total (water) | Lockheed 2/94 | 10.1 | 11.60 | 115% | - |
| Radium-226 (water) | Lockheed 2/94 | 19.9 | 18.37 | 92% | - |
| Radium-228 (water) | Lockheed 2/94 | 14.7 | 8.33 | 57% | - |
| Uranium,total (water) | Lockheed 6/94 | 52.6 | 52.37 | 99% | - |
| Radium-226 (water) | Lockheed 6/94 | 15.0 | 14.10 | 94% | - |
| Radium-228 (water) | Lockheed 6/94 | 15.4 | 14.83 | 96% | - |
| Gross Alpha (air) | Lockheed 8/94 | 35.0 | 47.67 | 136% | - |
| Gross Beta (air) | Lockheed 8/94 | 56.0 | 57.33 | 102% | - |
| Uranium,total (water) | Lockheed 9/94 | 35.0 | 36.10 | 103% | - |
| Radium-226 (water) | Lockheed 9/94 | 10.0 | 10.63 | 106% | - |
| Radium-228 (water) | Lockheed 9/94 | 10.2 | 9.17 | 90% | - |
| Gross Alpha (water) | Lockheed 10/94 | 57.0 | 53.0 | 93% | - |
| Gross Beta (water) | Lockheed 10/94 | 23.0 | 23.00 | 100% | - |
| Gross Alpha (water) | TMA/Eberline 1/94 | 15.0 | 12.3 | 82 % | - |
| Gross Beta (water) | TMA/Eberline 1/94 | 62.0 | 50.3 | 81 % | - |
| Uranium,total (water) | TMA/Eberline 2/94 | 10.1 | 7.5 | 74 % | - |
| Radium-226 (water) | TMA/Eberline 2/94 | 19.9 | 19.4 | 97 % | - |
| Radium-228 (water) | TMA/Eberline 2/94 | 14.7 | 13.5 | 92 % | - |
| Uranium,total (water) | TMA/Eberline 6/94 | 52.6 | 59.0 | 112 % | - |
| Radium-226 (water) | TMA/Eberline 6/94 | 15.0 | 16.5 | 110 % | - |
| Radium-228 (water) | TMA/Eberline 6/94 | 15.4 | 16.6 | 108 % | - |

## TABLE 10-10 Summary of EPA - EMSL Intercomparison Radionuclide Control Program (Continued)

| Parameter (matrix) | Laboratory (Date) | Value | Reported Value | Percent Recovery | EPA* Tag |
|---|---|---|---|---|---|
| Gross Alpha (water) | TMA/Eberline 7/94 | 30.0 | 27.0 | 90 % | - |
| Gross Beta (water) | TMA/Eberline 7/94 | 10.0 | 16.7 | 167 % | - |

* EPA control limits are based on three normalized standard deviations above and below the know value.
↑ Above the EPA control limit
↓ Below the EPA control limit
Note: EMSL = Environmental Measurements and Standards 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 Special Programs

The special programs described in this section were initiated to determine the effectiveness of engineering practices put in place as a result of remedial activities at the site. In addition, research activities were developed to support overall environmental monitoring.

### 11.1.1 Dam Safety Operations Program

Federal regulations require that embankments higher than 7.6 m (25 ft) and those that could pose a significant downstream hazard be regulated by a dam safety operations program. The Federal Energy Regulatory Commission has the overall responsibility for embankments owned by the Department of Energy and performs formal inspections annually. The Weldon Spring Site Remedial Action Project (WSSRAP) is responsible for the development and implementation of the dam safety operations program, maintenance of the embankments, and the performance of routine surveillance of the structures.

The WSSRAP has implemented the dam safety operations program that was developed in 1991 and formalized in 1992. This program outlines the training necessary to effectively survey and assess the embankments at both the chemical plant and quarry and requires mandatory surveys as outlined in procedure ES&H 4.2.3s. All regulatory and surveillance requirements, including documentation are also defined by this program. The *Dam Safety Operations Emergency Preparedness Plan* (Ref. 48) outlines actions to be taken in the event of possible or actual embankment failures.

In 1994, all embankments at the site were assessed in accordance with the requirements of these documents. General maintenance consisting of mowing weeds and grass, removing woody vegetation, and filling abandoned animal burrows was performed throughout the year.

During 1994, an approximately 52 m (170 ft) segment of the western berm of Raffinate Pit 4 failed. The failure occurred adjacent to an area that had exhibited similar failure, and was repaired in early 1980. The failure did not result in a release of materials from the raffinate pit. A design for removal of poor fill material and replacement of the berm at a lesser slope was performed.

A toe berm system was designed and constructed along the northern and northeastern portions of Raffinate Pit 3 to provide a greater factor of safety for the existing over-steepened slopes in this area. This toe berm system was installed due to the results of a slope stability investigation performed in 1993 to determine the soundness of the structure.

## 11.2 Special Studies

The special studies described in this subsection are short-term or one-time studies that support regulatory requirements not specifically covered by DOE 5400.1 or which were not planned in the *Environmental Monitoring Plan* (Ref. 42).

### 11.2.1 Comparison of Filtered and Unfiltered Groundwater Samples

Comparison of Filtered and Unfiltered Samples

During 1994, a study was conducted to evaluate the impact of filtering groundwater samples on water quality data. Historically, the WSSRAP has passed groundwater samples through a 0.45 $\mu$m filter prior to preserving the sample for shipping and analysis. In keeping with recent U.S. Environmental Protection Agency (EPA) recommendations for collecting unfiltered samples (Ref. 52) and the need to collect unfiltered data for risk assessment calculations, the WSSRAP has moved to unfiltered groundwater samples in 1995.

The impact of sediments suspended during pumping on water chemistry analyses is a major concern in unfiltered samples. In particular, acids used to preserve samples for metals

analyses are known to leach some metals from the sediments, thus increasing the measured levels for these metals. To minimize the amount of suspended material in the samples, micropurging and slow pumping rates were used to collect unfiltered samples from the monitoring wells.

A study of filtered and unfiltered samples collected at selected monitoring wells was conducted to determine the comparability of historic filtered data with unfiltered data and to evaluate the effectiveness of the micropurge-slow pump rate technique in minimizing sediment impacts on water chemistry. The relative percent difference between the filtered and unfiltered sample was calculated for each parameter at each monitoring well. If sample pair concentrations were less than the EPA Contract Laboratory Program (CLP) Contract Required Detection Limit (CRDL) or less than five times the detection limit for non-CLP parameters, they were deleted from the calculations. The fraction of samples for each parameter having relative percent differences (RPDs) less than 10%, between 10% and 20%, and greater than 20% are given in Table 11-1. Twenty percent is the typical tolerance allowed for duplicate samples analyzed under CLP protocols. The absolute value of the maximum RPD is also listed.

As shown in Table 11-1, only a limited number of parameters have RPDs exceeding 20%. Most notable among these are aluminum and iron followed by lead, chromium, manganese, and zinc. For these and most other parameters, concentrations are highest in the unfiltered sample. Anions and selenium are exceptions to this rule. All uranium RPDs are less than 10%.

The high RPDs for aluminum, iron, lead chromium, manganese, and zinc are expected as these elements are common in soils and sediments; however, none of these parameters have RPDs in excess of 50%. The results of this evaluation indicate that omitting filtration should not substantially change contaminant concentrations when samples are collected with micropurging and slow pumping techniques. Thus for most parameters, previous filtered data should be comparable to unfiltered data. These results cannot be extrapolated to bailed wells, because bailing usually disturbs a well, and causes suspension of sediments.

## TABLE 11-1 Relative Percent Differences (RPDs) for Filtered/Unfiltered Sample Pairs

| Parameter | Number of Pairs Evaluated[a]/ Number of Pairs Measured | RPD[b] | | | Maximum RPD Absolute Value |
|---|---|---|---|---|---|
| | | <10% | 10% - 20% | > 20% | |
| 1,3,5-TNB | 2/24 | 1 | 1 | 0 | 10.6 |
| 1,3-DNB | 0/24 | 0 | 0 | 0 | - |
| TNT | 5/24 | 5 | 0 | 0 | - |
| 2,4-DNT | 3/24 | 2 | 1 | 0 | 15.0 |
| 2,6-DNT | 5/24 | 5 | 0 | 0 | - |
| Gross Alpha | 4/4 | 4 | 0 | 0 | - |
| Gross Beta | 5/5 | 5 | 1 | (1) | (24.6) |
| Radium-226 | 6/6 | 6 | 0 | 0 | - |
| Radium-228 | 6/6 | 6 | 0 | 0 | - |
| Thorium-228 | 6/6 | 6 | 0 | 0 | - |
| Thorium-230 | 6/6 | 6 | 0 | 0 | - |
| Thorium-232 | 6/6 | 6 | 0 | 0 | - |
| Uranium, total | 7/16 | 7 | 0 | 0 | - |
| Chlorine | 15/15 | 14 | 1 | 0 | 14.0 |
| Fluoride | 8/8 | 8 | 0 | 0 | - |
| Nitrate | 17/17 | 14 | (2) | (1) | (31.5) |
| Sulfate | 19/19 | 19 | 0 | 0 | - |
| Alkalinity | 19/19 | 19 | 0 | 0 | - |
| Phosphorus,total | 9/9 | 5 | 3 | (1) | (30.6) |
| Potassium | 3/10 | 2 | 1 | 0 | 10.5 |
| Silicon Dioxide | 9/9 | 9 | 0 | 0 | - |
| Sodium | 9/10 | 9 | 0 | 0 | - |
| Aluminum | 6/10 | 0 | 0 | 6 | 49.7 |
| Antimony | 0/10 | 0 | 0 | 0 | - |
| Arsenic | 3/16 | 3 | 0 | 0 | - |
| Barium | 13/16 | 11 | 2 | 0 | 11.0 |
| Beryllium | 0/10 | 0 | 0 | 0 | - |

## TABLE 11-1 Relative Percent Differences (RPDs) for Filtered/Unfiltered Sample Pairs (Continued)

| Parameter | Number of Pairs Evaluated[a]/ Number of Pairs Measured | RPD[b] | | | Maximum RPD Absolute Value |
|---|---|---|---|---|---|
| | | <10% | 10% - 20% | > 20% | |
| Cadmium | 0/16 | 0 | 0 | 0 | - |
| Calcium | 10/10 | 10 | 0 | 0 | - |
| Chromium | 4/16 | 1 | 1 | 2 | 37.9 |
| Cobalt | 0/10 | 0 | 0 | 0 | - |
| Copper | 2/10 | 0 | 1 | 1 | 30.5 |
| Iron | 10/10 | 3 | 1 | 6 | 45.6 |
| Lead | 5/16 | 1 | 0 | 4 | 47.3 |
| Lithium | 10/10 | 10 | 0 | 0 | - |
| Magnesium | 16/16 | 16 | 0 | 0 | - |
| Manganese | 10/10 | 7 | 1 | 2 | 37.9 |
| Mercury | 1/16 | 0 | 1 | 0 | 16.7 |
| Molybdenum | 10/10 | 9 | 1 | 0 | 14.2 |
| Nickel | 1/10 | 1 | 0 | 0 | - |
| Selenium | 2/16 | 0 | (2) | 0 | - |
| Silver | 0/16 | 0 | 0 | 0 | - |
| Strontium | 10/10 | 10 | 0 | 0 | - |
| Thallium | 0/10 | 0 | 0 | 0 | - |
| Vanadium | 1/10 | 0 | 0 | 1 | 23.8 |
| Zinc | 5/10 | 1 | 2 | 2 | 45.9 |

(a) Only pairs exceeding the EPA contract required detection limit or 5 times the detection limit were evaluated.

(b) Unless enclosed in parentheses, tabulated values indicate number of sample pairs where unfiltered concentrations were greater than filtered concentrations. Values in parentheses indicate number of pairs where filtered concentrations were greater than unfiltered concentrations.

### 11.2.2 Evaluation of Retrofit Well Data

In the fall of 1993, three open-hole wells that extended from the weathered zone into the unweathered zone were retrofitted as cased and screened wells to isolate specific parts of the aquifer and to prevent contaminant migration from shallow to deeper levels in the aquifer. MW-2020, a relatively shallow well, was converted to a well (MW-2044) screened totally within the weathered-zone. MW-3008 and MW-3009, both deep wells, were converted to unweathered-zone wells (MW-3024 and MW-3026, respectively). Shallow wells, screened within the weathered zone, were installed next to these wells (MW-3025 and MW-3027, respectively).

With the exception of MW-2044, the new wells have been monitored quarterly since retrofitting. Although scheduled for quarterly sampling, monitoring at MW-2044 was hampered by problems arising from the retrofitting process. Following installation of the casing and well screen, water in this well displayed high pH levels and significantly altered water chemistry. Conditions finally restabilized during the summer of 1994, as indicated by the return of pH and water chemistry to preretrofit levels. Thus, limited samples are available from this location.

The retrofit wells were compared with their predecessor wells to evaluate the effect of limiting the intake (or screen) interval on water chemistry. For this comparison, the average concentration in samples collected during 1.5 years prior to retrofitting was subtracted from the average concentration in samples collected since retrofitting. Propagation of errors was used to calculate the error in the difference between the two averages. Differences were considered significant at the 95% confidence level, if the absolute value of the difference was greater than two times the calculated error. For the 3000 series wells, the new shallow and deep wells were compared with the predecessor well as well as with each other.

Water chemistry in MW-2044 was generally unchanged after retrofitting. The only significant differences appear to be higher nitrate levels and lower chloride levels in MW-2044 than in MW-2020.

No significant differences were found between MW-3008 (predecessor well) and MW-3024 (the deep well); however, MW-3025 (the shallow well) had lower calcium, lithium, sodium, mercury, chloride, and sulfate and higher alkalinity and barium than MW-3008. The higher alkalinity value in MW-3025 is typical of shallow wells near the overburden-bedrock

interface. Comparison of MW-3024 and MW-3025 showed that 2,4-DNT, calcium, sodium, mercury, and sulfate were higher, while barium and manganese were lower in MW-3024. Uranium values were at similar low levels in all wells, average values ranged from 2.85 pCi/l to 3.82 pCi/L.

The similarity of MW-3024 to MW-3008, which had high levels of nitrate and other raffinate-sourced species (calcium, magnesium, sodium, lithium, strontium, sulfate), indicates that seepage from these contaminated ponds appears to be reaching the unweathered zone of the aquifer in this area. This result was not expected. Unweathered-zone wells, even those near the raffinate pits, have not displayed these signatures. It is unlikely that the levels in MW-3024 reflect residual contamination from the open-hole well, because flow rates through this well (as inferred from water level recovery after pumping) are sufficiently high that natural flushing should have removed, or at least decreased, contaminant levels. Similarly, seepage from shallow levels resulting from well-construction problems also appears unlikely.

Comparison of MW-3026 and MW-3027 with the predecessor well, MW-3009, shows few significant differences. Magnesium is higher in MW-3027 and 2,4-DNT is higher in both new wells. Alkalinity is higher in the shallow well, MW-3027, than in either MW-3009 or MW-3026, the deep well. The lack of significant differences between the new or retrofit wells and MW-3009 results from the extreme variability of the water chemistry in this well. Prior to retrofitting, the working hypothesis for the variability in MW-3009 was mixing of water from a contaminated, most likely shallow source with uncontaminated water from a deeper source. Results from the new/retrofit wells support the mixing hypothesis, but not the spatial location of the sources. Comparison of MW-3026 with MW-3027 shows that barium, calcium, magnesium, potassium, sodium, strontium, zinc, chloride, nitrate, and sulfate are all significantly higher in MW-3026, the deeper well. These elements are all elevated in Raffinate Pit 4, which is adjacent to the wells. Uranium results are mixed and difficult to compare because of an apparent decreasing trend in MW-3026 and a high outlier in the MW-3027 dataset. The highest uranium value recorded in MW-3026 is 11.0 pCi/l.

In contrast to MW-3024, MW-3026 has a low flow rate, thus natural flushing of residual contamination resulting from vertical contaminant transport to the deeper parts of the aquifer in predecessor, open-hole, well would occur more slowly. Residual contamination is an unlikely explanation for the strong raffinate pit signatures in MW-3026, however. Water sampled in the

shallow well has significantly lower levels of these constituents, and thus could not have been the source. Seepage from the base of Raffinate Pit 4 appears to be the most reasonable source, but additional monitoring is required to resolve this issue.

### 11.2.3 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 NPDES outfalls (NP-0002, NP-0003 and NP-0005), the data for the years 1987 through 1994 have been reviewed and corrected, where required, for several factors. Data for 1993 and 1994 were used as the basis for the correction factors because totalizing flow meters were installed at the outfalls and actual flow measurements were used to determine the mass of uranium migrating off site.

Correction factors were calculated for watershed areas, precipitation, and runoff coefficients. Watershed areas required a correction factor because it was determined that areas that contributed to flow at Outfalls NP-0002 and NP-0003 were not considered during earlier years. Precipitation required a correction factor because there were some years where an average precipitation was used instead of the actual precipitation for that year. Runoff coefficients required a correction factor because published estimates were used for some years before the actual runoff was measured. The base watershed areas and the base runoff coefficients were taken from the 1993 and 1994 data.

The runoff coefficients were calculated by dividing the total volume flowing off site at the outfall (as measured by totalizing flow meters) by the total volume of precipitation falling on the watershed draining to that outfall for the particular year. The base coefficients were determined by averaging the coefficients for 1993 and 1994 for each outfall. The correction factor was then determined by dividing the runoff coefficient used in the original calculations into the base runoff coefficient.

The correction factor for the watershed areas was determined by dividing the watershed area used in the original calculations into the base watershed.

The correction factor for precipitation was determined by dividing the precipitation used in the original calculations into the actual precipitation for that year.

A final correction factor for the mass of uranium at each outfall was determined by multiplying the three correction factors together.

The corrected mass was then calculated by multiplying the original calculated mass by the correction factor for that outfall for that year.

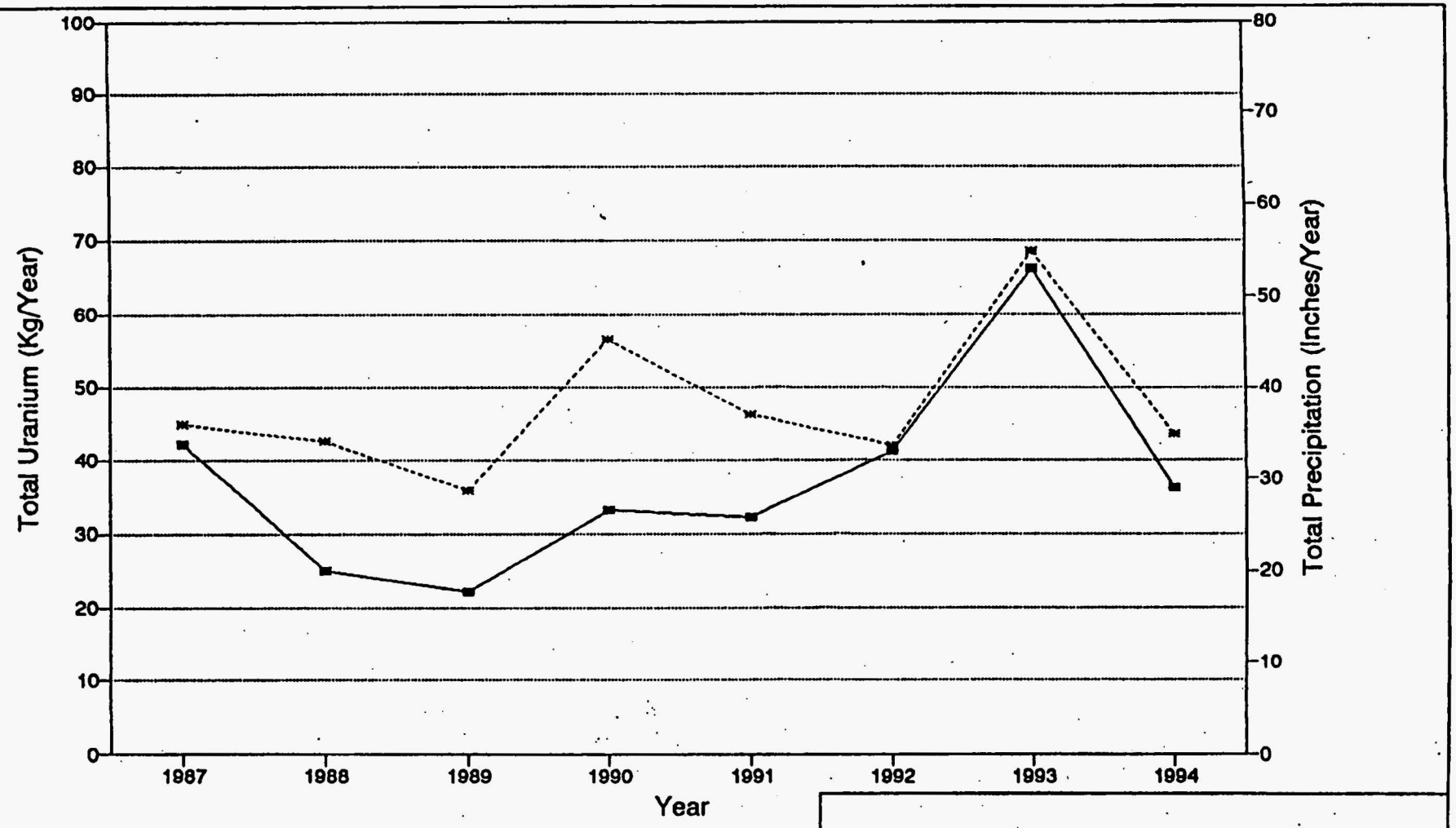
The annual precipitation and corrected total annual mass of uranium for the years 1987 through 1994 are plotted in Figure 11-1, Figure 11-2 and Figure 11-3. The mass, precipitation, and mass per inch of precipitation is also show in Table 11-2.

Storm Water Outfall NP-0002

Figure 11-1 is for Outfall NP-0002. This outfall is downstream of Frog Pond and drains the eastern section of the chemical plant where most of the building dismantlement took place. The figure indicates that the uranium migrating off site initially decreased, then increased with the beginning of building dismantlement. Uranium migration decreased in 1994 when corrective measures were taken and building dismantlement was finally complete. The figure also indicates that the uranium mass is proportional to the precipitation. The mass migrating off site per inch of precipitation was calcuated and can be seen to initially decrease and then somewhat increase with the beginning of building dismantlement in 1992 (Table 11-2). With the completion of building dismantlement in 1994, the mass per inch of precipitation decreased slightly. It also appears from the data of individual storm events that uranium concentration in storm water is as dependent on volume of stormwater, length of precipitation event, and time between precipitation events as it is on activities that have taken place on site.

Storm Water Outfall NP-0003

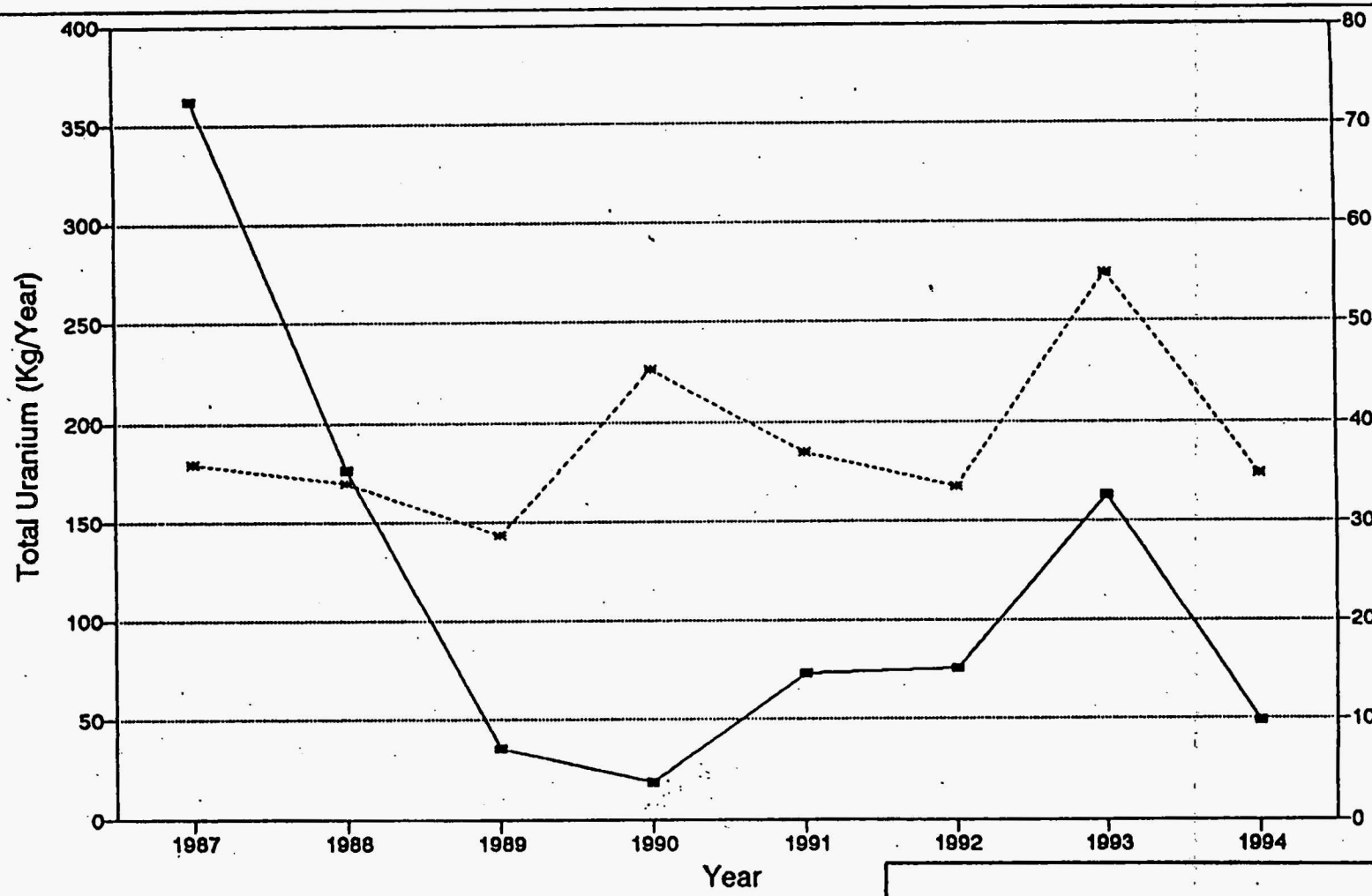
Figure 11-2 indicates that uranium migrating off site sharply decreased between 1987 and 1989 at Outfall NP-0003. This was a result of the construction of the Ash Pond diversion channel, which was started during November of 1988 and completed in April of 1989. The diversion channel diverted much of Outfall NP-0003 flow around the highly contaminated Ash Pond area preventing it from flowing through the pond as it had in the past. The only flow from Ash Pond now is storm water runoff from precipitation falling directly on the pond. The annual uranium mass at Outfall NP-0003 is highly dependant on the flow from Ash Pond. During the




TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0002

FIGURE 11-1

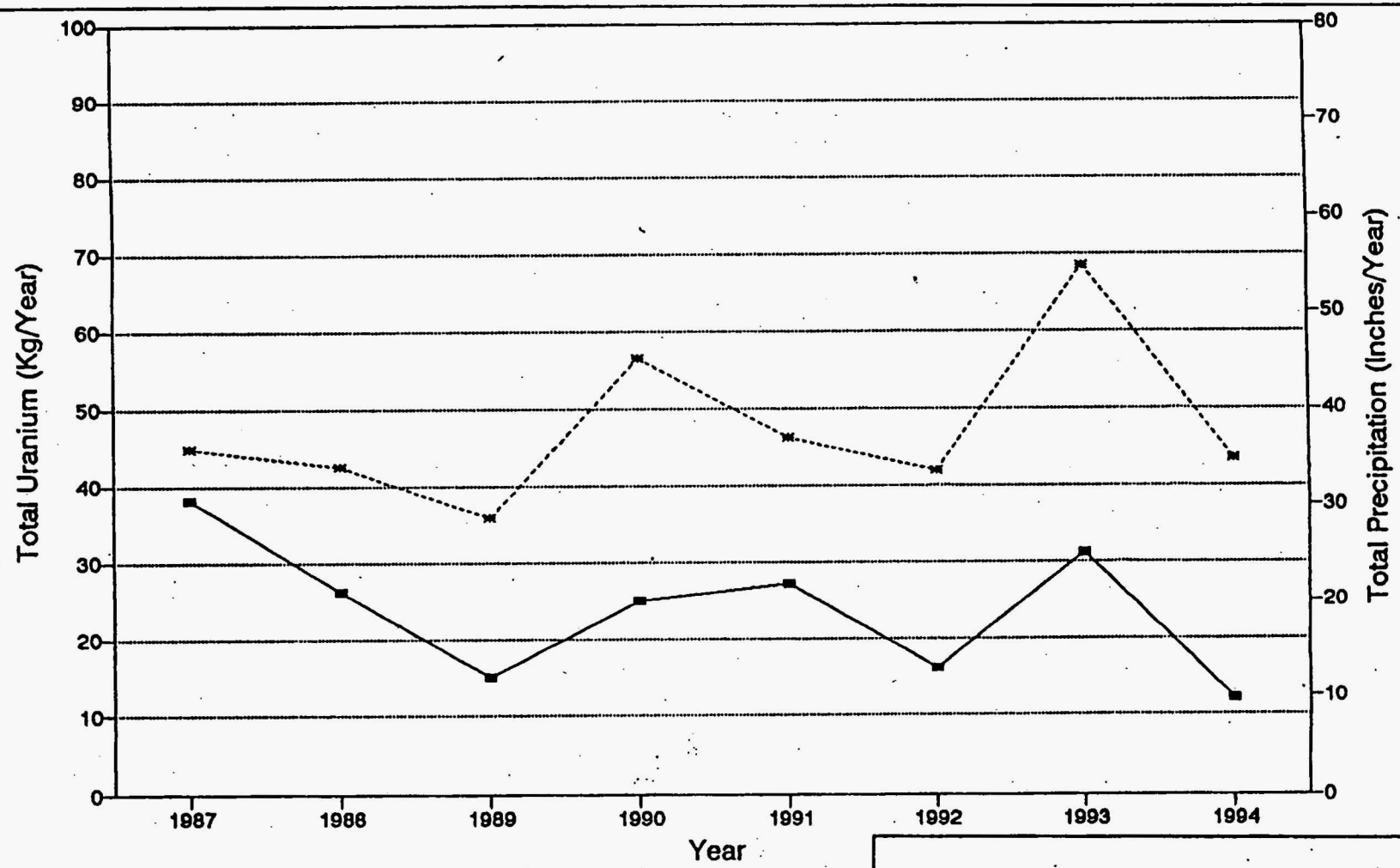
| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/PI/026/0395 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 3/3/95 |




TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0003

FIGURE 11-2

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/PI/027/0395 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 3/3/95 |




TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0005

FIGURE 11-3

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/PI/028/0395 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 3/3/95 |

TABLE 11-2 Mass of Uranium Discharged from NPDES Storm Water Outfalls

| Year | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|
| Precipitation (PPT) (inches) | 35.8 | 33.9 | 28.5 | 45.1 | 36.9 | 33.4 | 54.7 | 34.7 |
| Outfall NP-0002 (kg) | 42 | 25 | 22 | 33 | 32 | 41 | 66 | 36 |
| Mass/Inch of PPT (kg/in) | 1.17 | 0.74 | 0.77 | 0.73 | 0.87 | 1.23 | 1.21 | 1.03 |
| Outfall NP-0003 (kg) | 362 | 176 | 35 | 17.7 | 73 | 75 | 163 | 49 |
| Mass/Inch of PPT (kg/in) | 10.11 | 5.19 | 1.23 | 0.39 | 1.98 | 2.25 | 2.98 | 1.41 |
| Outfall NP-0005 (kg) | 38 | 26 | 15 | 25 | 27 | 16 | 31 | 12 |
| Mass/Inch of PPT (kg/in) | 1.06 | 0.77 | 0.53 | 0.55 | 0.73 | 0.48 | 0.57 | 0.34 |

summer and other dry periods there may be little or no flow from the pond which results in the diversion channel flow, from the much less contaminated areas of the site, making up the bulk of the flow. This causes lower uranium concentrations at the outfall.

During winter, when the Ash Pond soils have become saturated and precipitation may be higher, flows from Ash Pond increase and concentrations at the outfall are higher. There has been little soil disturbance or other activity in the NP-0003 watershed. The graph shows that since the diversion channel was constructed, the mass migrating off site has been proportional to precipitation. The mass per inch of rain has also remained fairly steady (Table 11-2).

The mass during 1990 for NP-0003 was exceptionally low. Although precipitation was fairly high, the randomly collected samples may have been collected when Ash Pond was not discharging. In 1993, when precipitation was very high and massive flooding of the Missouri and Mississippi Rivers occurred, it can be observed that the mass per inch of precipitation increased slightly, but still remained in the range of the years previous. The mass per inch of precipitation decreased slightly during 1994 because: precipitation was less than normal; Ash Pond discharged very little; and because a soil cover was placed over the south dump area of the pond and the pond itself during the middle of the year, which decreased the concentration of uranium in the Ash Pond water. The covers were placed because Ash Pond is being used as a storage area. The storage of materials makes Ash Pond a managed area and the DOE requires that the water flowing from a managed area have uranium concentrations less than 600 pCi/l. If the concentration is higher than 600 pCi/l, the water is retained and treated.

In summary, precipitation has had the greatest effect on the mass of uranium migrating off site at NP-0003, and the Ash Pond diversion channel and the capping of areas of the pond have helped reduce uranium migration.

Storm Water Outfall NP-0005

Outfall NP-0005, the Southeast Drainage outfall, indicates that the annual mass of uranium migrating off site has been proportional with precipitation (Figure 11-3). 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 that settles sediments from the water flowing off the treatment plant area. The storm water from the treatment plant site is generally less than 10 pCi/l for uranium. The other major source for the outfall is a watershed that drains the highly contaminated Building 301 area. This area has been partially capped in an effort to decrease the concentration of uranium in storm water leaving the area. The concentration of uranium in storm water from the individual sampling events is highly dependant on precipitation rates, periods between precipitation, and the ratio of flow from the sedimentation basin and the Building 301 area. Although concentrations from the 301 area have been high, Table 11-2 indicates that the mass of uranium per inch of precipitation has remained fairly steady and even decreased somewhat.

In conclusion, it appears that although site activities can cause increases in off site migration of uranium, the major factors are total precipitation and precipitation rates. Mitigation measures have also been effective in reducing the migration of uranium off site and maintaining the migration at steady levels.

### 11.2.4 Biodenitrification Study

A full scale system that biologically destroys nitrates from contaminated water was successfully implemented last spring and summer at the Weldon Spring Site. Cleanup at the chemical plant necessitates the treatment of chemically and radiologically contaminated water from four raffinate pits and a number of small impoundments. The current water treatment plant at the site is capable of removing site contaminants with the exception of nitrates and other anions.

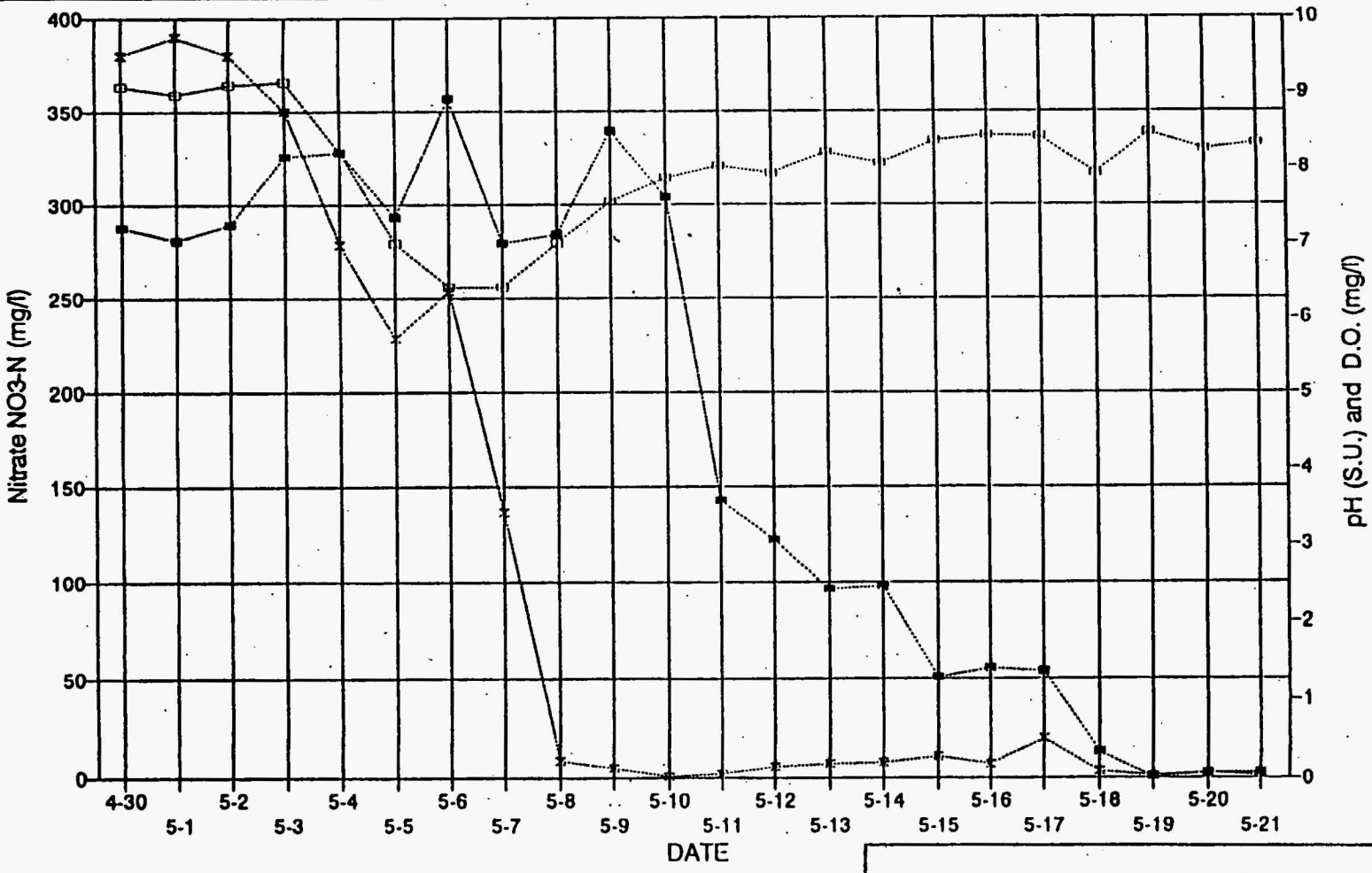
Unusually high precipitation in 1993 caused water levels in raffinate pit 3 to increase to a level threatening to overtop the berm and raising the possibility of having to transfer water from raffinate pit 3 to pit 4. This transfer was not considered to be a desirable option since raffinate pit 3 water contains high levels of nitrates which are not found in raffinate pit 4. The existing wastewater treatment facility was not capable of treating water high in nitrates, therefore other alternatives to reduce the water level in raffinate pit 3 had to identified.

Biodenitrification in the raffinate pits was identified as a potential alternative to reduce the nitrate concentrations. The biological process converts nitrates to nitrogen and carbon dioxide, therefore reducing the nitrates to a low level. Once the nitrate levels are reduced, this water can be transferred to raffinate pit 4 for final treatment in the site water treatment facility.

Bench and pilot scale studies were conducted first to evaluate the feasibility of the process and to support the full scale design and application. These studies demonstrated that when nutrients were provided to the water, the microorganisms that exist in the water consumed the nitrates and that the water could therefore be successfully biologically denitrified.

Full scale operations were initiated in June to denitrify 8,650,000 gallons of water from raffinate pits 1, 2, and 3. The water from raffinate pit 3 was pumped to raffinate pits 1 and 2, where the water was processed. Pre-batch data was collected and provided a baseline for calculating the appropriate amount of calcium acetate and phosphate needed to denitrify the water. The calcium acetate solution and phosphate solution were fed to the pits over a 24-hour period to ensure adequate nutrient dispersion.

Once the treatment was started, the pits were monitored daily for nitrates, pH, dissolved oxygen, temperature, total organic carbon, and sulfates. Treatment times for each batch varied from 3 to 15 days per batch depending on operating conditions. Nitrate levels were reduced from 400 mg/l to less than 20 mg/l, although typically less than 10 mg/l (Figure 11-4). The discharge level for nitrates set by the State of Missouri is less than 20 mg/l.




SUMMARY OF
PROCESS MONITORING RESULTS

FIGURE 11-4

| | | | | | |
|---|---|---|---|---|---|
| REPORT NO.: | DOE/OR/21548-512 | EXHIBIT NO.: | A/PI/057/0495 | | |
| ORIGINATOR: | MGL | DRAWN BY: | GLN | DATE: | 4/17/95 |

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**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*
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
40 CFR 264,
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,
10 CSR 25.7

## 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 4.9.3, *Data Review Procedures for Surface Water, Groundwater, and Soils*
MGT-6a, *Surveillances and Walkthroughs*
SQP-24a, *Administration and Conducted of Self Assessment*

# 13 GLOSSARY, ACRONYMS, AND ABBREVIATIONS

## 13.1 Technical Terms

**ABSORBED DOSE**: The amount of energy absorbed in any material from incident radiation. Measured in rads, where 1 rad equals 100 ergs of energy absorbed in 1 gram of matter.

**ACTIVITY**: A measure of the rate at which radioactive material is undergoing radioactive decay; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The unit of activity is the curie (Ci) (see also BECQUEREL and CURIE).

**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 = $2.703 \times 10^{-11}$ 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.

**COMMITTED EFFECTIVE DOSE EQUIVALENT**: The total dose equivalent averaged throughout a tissue in the 50 years after intake of a radionuclide into the body.

**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 ($3.7 \times 10^{10}$ dps), which is equal to the decay rate of one gram of radium-226.

**DAUGHTER**: An element that results immediately from the disintegration of a radioactive element.

**DECAY PRODUCTS**: Isotopes that are formed by the radioactive decay of some other isotope. In the case of radium-226, for example, there are 10 successive decay products, ending in the stable isotope lead-206.

**DERIVED CONCENTRATION GUIDE**: Concentrations of radionuclides in water and air that could be continuously consumed or inhaled and not exceed an effective dose equivalent of 100 mrem/year.

**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**: Total radiation delivered to a specific part of the body, or to the body as a whole; also called dose equivalent.

**DOSE RATE**: Dose or dose equivalent per unit of time (e.g., millirem per year) as it is being delivered to the body.

**DOSIMETER**: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

**EFFECTIVE DOSE EQUIVALENT**: The proportion of the stochastic risk resulting from irradiation of a tissue to the total risk when the whole body is irradiated uniformly. A term used to express the amount of effective radiation when modifying factors have been considered, it is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rem (Roentgen Equivalent Man).

**ERG**: 1 ERG = $2.8 \times 10^{-14}$ KWH

**EXPOSURE PATHWAY**: The route by which a contaminant or health hazard may enter and move through the environment or an individual.

**EXPOSURE RADIATION**: The amount of ionization produced in air by X-rays or gamma rays, measured in Roentgens (R).

**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 into another form. Half-lives of different isotopes vary from millionths of a second or less 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 mass numbers.

**LLD**: Lower limit of detection.

**MDA**: Minimum detectable amount.

**NATURAL URANIUM**: A naturally occurring radioactive element that consists of 99.2830% uranium-238, 0.7110% uranium-235 and 0.0054% uranium-234 by weight.

**NUCLIDE**: A general term referring to isotopes of the chemical elements, both stable and unstable.

**PERCHED LENSE**: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

**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 radiowaves 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 the effective 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 express the effective 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 radon-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 Ra-222 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 exposure period.

**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/2 | detection limit |
| DNT | dinitrotoluene |
| DOE | U.S. Department of Energy |
| DOT | U.S. Department of Transportation |
| DQO | data quality objectives |
| 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 |
| mSv | millisievert |
| 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 |
| TAB | trinitrobenzene |
| TND | dinitrotoluene |
| TNT | trinitrotoluene |
| tpy | tons per year |
| TSA | temporary storage area |
| TSCA | Toxic Substance 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 |
| $\mu$Ci | microcurie |
| $\mu$g/l | micrograms per liter |

# APPENDIX A
## Unpublished Documents

Bruce

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

November 21, 1994

Mr. M. D. Jewett, Chief
Regulatory Branch, Operations
Division
U. S. Department of the Army
Kansas City District, Corps of Engineers
700 Federal Building
Kansas City, Missouri 64106-2896

Dear Mr. Jewett:

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP) SECTION 404, NATIONWIDE PERMIT NO. 26

REFERENCE: March 11, 1994 letter from M. D. Jewett to J. Powers

Pursuant to the contingent approval described in the referenced letter, I am submitting the signed Mitigation Agreement between the Missouri Department of Conservation and the U. S. Department of Energy.

It is my understanding that the Missouri Department of Conservation (MDOC) and DOE have authority to proceed with the project described in the permit. The MDOC and DOE plan to proceed with the project in accordance with conditions described in the subject permit.

Additionally, the WSSRAP Site Environmental Report will be sent to you annually to satisfy monitoring requirements.

If you have any questions, please contact myself or Bruce Ballew.

Sincerely,

S H McCracken

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/o enclosure:
Larry Cavin, COE
Chad Remley, Soil Conservation Service
Roy Grimes, MDOC
Martha Windsor/Geri Kountzman, MDNR
Mary Picel, ANL
Jim Powers, MK-Ferguson

WALTER ANGELS
ILEN N
JULIE R.

# TELECON

DATE AND TIME 12/1/94 0930

PERSON RECEIVING THE CALL CHAD REMLEY, SCS, USCOE

CALLER BRUCE BALLEW, WESTRAD

ADDRESS KANSAS CITY, MO

PHONE NUMBER (816) 426-5500

CONCERN OR QUESTION I CALLED CHAD TO VERIFY THAT THE NOV. 21 1994 LETTER WE SENT WAS SUFFICIENT TO ~~CLOSE~~ ALLOW AN UNCONDITIONAL NATIONWIDE PERMIT NO. 26. HE HAD NOT REVIEWED THE PACKAGE IN DETAIL. HOWEVER, HE DID NOT FORSEE ANY PROBLEMS. HE PLANS TO ATTEND TO THIS THIS WEEK OR EARLY NEXT WEEK. HE WILL SEND A LETTER ISSUEING THE UNCONDITIONAL PERMIT. THE TWO YEAR CLOCK DOES NOT START UNTIL WE RECEIVE THE UNCONDITIONAL PERMIT LETTER.

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED CALL CHAD NEXT WEEK TO CHECK ON LETTER/REVIEW STATUS.

SIGNED Ron Ballew

# AGREEMENT

THIS AGREEMENT made and entered into, by and among the Missouri Department of Conservation, hereinafter referred to as the "MDC" and the United States Department of Energy, hereinafter referred to as the "DOE."

WITNESSETH:

The DOE desires to meet its obligations to effect no net loss of wetland areas as a result of its remediation efforts being undertaken at the Weldon Spring Site Remedial Action Project (WSSRAP) in St. Charles County, Missouri.

The MDC desires to create seasonal herbaceous wetlands on the Busch Conservation Area in St. Charles County, Missouri adjacent to WSSRAP.

The Parties desire to accomplish the creation of the wetlands as soon as possible during the Fall/Winter 1993 so as to make construction equipment available for post flood activities in the Spring/Summer of 1994.

NOW THEREFORE, in consideration of the covenants and promises contained herein due to be faithfully kept and performed by the parties hereto and each of them, it is agreed as follows:

1. The MDC will prepare a plan for the proposed wetlands creation project included in Attachment A.

2. DOE representatives will have an opportunity to review the plans and specifications and the MDC will execute the wetlands creation in accordance with the plan set forth in Attachment A.

3. The MDC will be responsible for all construction efforts associated with the development of the proposed wetlands area including but not limited

to use of State of Missouri personnel and equipment.

4. The MDC will have the right to make any necessary changes to the specifications to the proposed wetland areas except that no such changes will effect DOE's obligation of funds under this Agreement. MDC should notify DOE of any changes to the wetland creation effort which adversely impact the construction schedule or which may result in a change of the scope of the project.

5. Pursuant to a Cooperative Agreement (Attachment B), the DOE will tender to the State of Missouri a check in the amount of $30,000. The MDC agrees that these funds shall be used for the sole purpose of developing wetlands as specified in Attachment A.

6. The MDC agrees to manage the wetlands in accordance with the Wetlands Project Plan (Attachment C).

IN WITNESS WHEREOF, the parties have entered into this agreement on the last date written below.

Executed by the DOE the 2[illegible] day of [illegible], 1994.

Executed by the MDC the 9th day of February, 1994.

REPORT OF TELECON

TO: Distribution INCOMING: _____

FROM: Ken Warbritton OUTGOING: X

DATE: December 1, 1994

TIME: 1:00 PM

CONVERSATION WITH:

Roy Grimes PHONE: 441-4554

OF: Missouri Dept. of Conservation

AND: Ken Warbritton PHONE: x2933

OF: PMC

SUBJECT: MDC Coordination Issues - Multiple

SUMMARY OF CONVERSATION:

I discussed the following topics with Roy:

-PMC Surveyors are preparing to set survey monuments near off-site monitoring stations and vicinity properties. They plan to set the pre-cast concrete monuments (with brass caps) approximately 18 inches below grade. Roy indicated this was OK with MDC. This work will commence within the next week.

-ES&H requested the number of full and part-time personnel employed at the local MDC office. Roy indicated approximately 25 permanent personnel and part-time personnel varying from 2 to 10 people.

(Continued on attached sheet)

ACTION OR FOLLOW-UP/RECOMMENDATIONS:

Schedule meetings and relay information to Roy.

CC: D. Dobkowski, G. Wantowa, M. Lutz
K. Boyd, W. Anderson, B. Billow
EDC File - MDC Coord.

BY: Kenneth R Warbritton

National Environmental Policy Act

N
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A

# SECRETARIAL POLICY on the NATIONAL ENVIRONMENTAL POLICY ACT

U.S. Department of Energy

June 1994

**The Secretary of Energy**
Washington, DC 20585

June 13, 1994

MEMORANDUM FOR SECRETARIAL OFFICERS AND HEADS OF FIELD ELEMENTS

FROM: HAZEL R. O'LEARY

SUBJECT: NATIONAL ENVIRONMENTAL POLICY ACT POLICY STATEMENT

Full compliance with the letter and spirit of the National Environmental Policy Act (NEPA), our national charter for protection of the environment, is an essential priority for the Department of Energy, consistent with our core values. We are fully committed to pursuing excellence in all areas of environment, safety, and health, including NEPA activities. The Department's openness initiative underscores the need for public access to information and involvement in our actions. The NEPA process is a valuable planning tool and an opportunity to improve the quality of the Department's decisions and build public trust.

An internal process improvement team and further analysis by the offices of the Assistant Secretary for Environment, Safety and Health and the General Counsel have shown that we must improve our NEPA process. We must approach NEPA as a team--ensuring quality and improving efficiency and thereby making NEPA work better and cost less. Accordingly, with the attached Policy Statement, I am directing a number of actions to streamline the NEPA process, minimize the cost and time for document preparation and review, emphasize teamwork, and make the process more useful to decision makers and the public. Importantly, the Policy Statement requires continuing evaluation of the outcomes of these reforms and allows for additional changes where necessary. I look forward to full participation within the Department, including our contractors, in implementing these important new policies.

ATTACHMENT

# SECRETARIAL POLICY STATEMENT

# ON THE NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA process is a valuable planning tool and provides an opportunity to improve the Department of Energy decisions and build public trust. Reviews of the Department's NEPA program have shown that the Department must change the way it conducts its business to avoid unnecessary delays and reap the full benefits of the NEPA process. The Department must conduct the process as a team effort to make NEPA work better and cost less. The following new policies will streamline the NEPA process, minimize the cost and time for document preparation and review, emphasize teamwork, and make the process more useful to decision makers and the public. Except where specifically indicated otherwise, these policies are immediately effective.

## I. Delegations of Authority

A. To facilitate early integration of the NEPA process with project planning and decision making, reduce document review times, and foster ownership of NEPA documents, the Heads of Field Organizations listed in Attachment 1 will receive full authority for environmental assessments, findings of no significant impact, and associated floodplain and wetland action documentation requirements relating to their proposed actions. Under certain conditions, Heads of Field Organizations may redelegate these authorities to Heads of subsidiary Field Organizations. For actions not within the purview of a Field Organization, the Secretarial Officers listed in Attachment 1 will receive full authority for the preparation of such documents relating to their actions.

1. The Assistant Secretary for Environment, Safety and Health will grant this delegation upon receipt of a valid request. Heads of Field Organizations should redelegate such authorities to Heads of subsidiary Field Organizations upon receipt of a request. Requests for delegation should confirm that: (i) a NEPA Compliance Officer has been designated, (ii) internal scoping procedures and public participation and quality assurance plans have been prepared, and (iii), in the case of Field Organizations, adequate Department of Energy legal resources are available.

2. Secretarial Officers and Heads of Field Organizations should submit requests for delegation as soon as practicable; the Assistant Secretary for Environment, Safety and Health will delegate authorities within two weeks of receiving a valid request. Each Secretarial Officer and Head of a Field Organization listed in Attachment 1 is required to submit a valid request no later than December 15, 1994, so that the delegation process can be completed by December 31, 1994.

B. To reduce document review times and foster ownership of NEPA documents, Secretarial Officers will approve implementation plans for environmental impact statements for their respective proposed actions, after soliciting comments from the Office of Environment, Safety and Health, in consultation with the Office of the General Counsel. Preparers are reminded that implementation plans are intended to be brief (normally about 20 pages) and to simply establish a road map for the environmental review to follow.

C. Each Secretarial Officer and Head of a Field Organization will submit an annual NEPA planning summary to the Assistant Secretary for Environment, Safety and Health by January 31 of each year and will make the summaries available to the public.

1. The annual NEPA planning summaries will describe briefly the status of ongoing NEPA compliance activities and any environmental assessments expected to be required in the next 12 months or environmental impact statements expected to be required in the next 24 months and, if available, the schedule for completion of each NEPA review identified (see Attachment 2).

2. Every three years starting with the first year, Field Organizations will include in the annual NEPA planning summary an evaluation of whether a site-wide environmental impact statement would facilitate future NEPA compliance efforts.

3. The Office of Environment, Safety and Health will review the summaries in consultation with the Office of General Counsel and comment as appropriate.

D. To maintain the quality of NEPA reviews, the Office of Environment, Safety and Health will provide additional guidance and training to Secretarial Offices and Field Organizations on matters such as the following:

1. Preparation of adequate statements of work to effectively direct the efforts of NEPA contractors;

2. Improving public participation in the NEPA process (to be provided with the assistance of the Public Affairs Office); and

3. Application of the Office of Environment, Safety and Health's "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements."

E. The Assistant Secretary for Environment, Safety and Health is authorized to direct a Secretarial Officer or Head of a Field Organization to prepare an environmental assessment or environmental impact statement.

F. Where multiple Field Organizations or Program Offices would be involved in a proposed action for which an environmental assessment is to be prepared, all involved Offices should consult regarding the assignment of

responsibility for preparing and approving the environmental assessment. The Assistant Secretary for Environment, Safety and Health will resolve NEPA issues where several Offices are unable to reach agreement.

II. Process Changes

A. The NEPA process should be a team effort. To establish team leadership and ownership of the NEPA process and thereby improve its management, the cognizant Secretarial Officer or Head of a Field Organization will designate a Department of Energy member of the team working on any project requiring NEPA review as the NEPA Document Manager, to manage the document preparation process and keep it on schedule. Among the responsibilities of the NEPA Document Manager are to:

1. Consider innovative measures to reduce NEPA process time;

2. Consider requesting variances from Department of Energy NEPA regulations (10 CFR Part 1021) as necessary to meet timing requirements or for other reasons that are permitted under section 1021.343 of the regulations; and

3. Elevate internal disputes for prompt decision.

The Project Manager or NEPA Compliance Officer may serve this function as appropriate; in any case, the NEPA Document Manager should work closely with these other individuals.

B. To expedite approval of innovative procedures, where appropriate, the Assistant Secretary for Environment, Safety and Health is delegated authority to grant variances from provisions of Department of Energy NEPA regulations, as provided in 10 CFR 1021.343.

C. The NEPA Document Manager will conduct an early internal scoping process for the environmental assessment or environmental impact statement being prepared. The scoping process should involve a team representing all necessary departmental elements. For an environmental impact statement, this internal scoping process should precede the public scoping process that begins with publication of a notice of intent.

1. The internal scoping process will include the adoption of a proposed schedule for the preparation of the NEPA document and a public participation plan tailored to the project in question.

2. For each environmental impact statement, the schedule established during the internal scoping process will, absent extraordinary circumstances, provide for completion of a final environmental impact statement within 15 months of the issuance of the Notice of Intent.

3. The NEPA Document Manager will maintain a tracking system to monitor compliance with the schedule. The annual NEPA planning summaries

will identify NEPA reviews that are behind schedule and the reasons for any delays.

D. To eliminate multiple cycles of revisions, internal reviews of draft environmental assessments and environmental impact statements will be concurrent, rather than sequential.

1. As a general matter, documents will be revised only after all reviewing offices have submitted their comments and agreement has been reached as to what changes are necessary.

2. Absent extraordinary circumstances, any subsequent reviews that may occur will be limited to addressing any new material, confirming that previous comments have been adequately addressed, and obtaining management-level concurrence.

E. To facilitate meeting the environmental objectives of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and respond to concerns of regulators, consistent with the procedures of most other Federal agencies, the Department of Energy hereafter will rely on the CERCLA process for review of actions to be taken under CERCLA and will address NEPA values and public involvement procedures as provided below.

1. NEPA reviews will be undertaken for siting, construction, and operation of treatment, storage, and disposal facilities that, in addition to supporting CERCLA actions, also serve waste management or other purposes.

2. Department of Energy CERCLA documents will incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socioeconomic impacts, to the extent practicable.

3. The Department of Energy will take steps to ensure opportunities for early public involvement in the CERCLA process and will make CERCLA documents available to the public as early as possible.

4. Notwithstanding the above, the Department of Energy may choose, after consultation with stakeholders and as a matter of policy, to integrate the NEPA and CERCLA processes for specific proposed actions.

5. For proposed corrective actions under the Resource Conservation and Recovery Act at sites that are listed on the National Priorities List under CERCLA, project managers should consult with the Environmental Management NEPA Compliance Officer, who will involve the Offices of Environment, Safety and Health and General Counsel as necessary to make determinations about how to proceed under NEPA.

III. NEPA Contract Reform

A. All future contracts for the preparation of environmental assessments and environmental impact statements will contain incentives to encourage superior performance in document quality and timeliness.

B. To improve the quality and timeliness of documents, all contractors preparing NEPA documents will be subject to performance appraisals.

1. Procurement solicitations will include an evaluation criterion for the bidder's past performance of comparable assignments. Measures will include any existing evaluations of NEPA support performance.

2. At the conclusion of the preparation of each environmental assessment and environmental impact statement, the NEPA Document Manager will evaluate the contractor's performance for timeliness, quality, cost-effectiveness, responsiveness, and application of the Office of Environment, Safety and Health's "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements." The evaluations will be provided to the contractor with an opportunity for rebuttal and made available to Secretarial Offices and Field Organizations for consideration in assigning future work to a contractor.

3. Management and Operating Contractors and National Laboratories will be subject to the same NEPA evaluation process as other contractors.

C. Consistent with the contract reform effort that is underway Department-wide, a quality improvement team comprised of Headquarters and Field project, procurement, NEPA, and legal personnel will be formed to develop innovative contracting mechanisms and incentives suited particularly to NEPA document preparation contracts. The quality improvement team will develop recommendations on the most effective use of different contracting mechanisms, such as fixed price contracts, award fees, indefinite quantity/indefinite delivery contracts, and task order contracts. The team also will recommend specific methods of evaluating a potential contractor's past performance. Finally, the team should consider proposing Department of Energy organizations to participate in pilot projects to test contracting mechanisms and methods of evaluation and to monitor performance of the resulting contracts through appropriate metrics. The team will report its findings and recommendations no later than October 1, 1994.

IV. Additional Reforms for High Priority Projects

A. Department of Energy personnel rather than contractors will be used, to the maximum extent practicable, to prepare environmental assessments and environmental impact statements that have short preparation time requirements or present unusually controversial or sensitive issues.

Where resource limitations do not permit Department of Energy personnel to carry out the entire task, contractors might be used for limited analytical or drafting assignments.

B. When necessary or helpful in meeting important departmental objectives, the NEPA Document Manager may form a special team, comprised of relevant Field Organization and Secretarial Office personnel and representatives from the Offices of Environment, Safety and Health and General Counsel, to carry out the NEPA process from start to finish. This will ensure that all relevant programmatic, policy, and legal considerations are taken into account from the beginning and that the only necessary review function is obtaining senior management approval.

C. The NEPA Document Manager is encouraged to consider whether a specific project offers opportunities for innovation in the NEPA process. For example:

1. Using a toll-free number for submission of comments in order to reduce the number of public scoping meetings.

2. Providing the NEPA document on-line as an option for interested parties to provide comments.

D. The cognizant Secretarial Officer and the Assistant Secretary for Environment, Safety and Health will consult to determine whether delegation of approval authority for a specific environmental impact statement to the Secretarial Officer or the Head of a Field Organization would be appropriate to expedite the review and approval process.

V. Enhanced Public Involvement

A. NEPA Document Managers will take appropriate action to encourage and facilitate public participation throughout the NEPA process, taking into account Office of Environment, Safety and Health guidance on improving public participation.

B. Whenever possible, the Department of Energy will provide enhanced opportunities for public involvement in the environmental assessment process, which ordinarily will include at a minimum:

1. Early public notice of the Department of Energy's intent to prepare an environmental assessment (concurrent with state/tribal notification); and

2. Opportunity for interested parties, on request, to review environmental assessments (concurrent with state/tribal review) prior to Department of Energy approval.

## VI. Continuing Improvement

A. One year from now a quality improvement team will be formed to measure the outcome of the NEPA initiatives put forth in this policy statement and to consider what additional reforms are necessary; this team will report its findings and recommendations within 90 days of its formation.

B. The Office of Environment, Safety and Health will solicit comments from the NEPA Document Manager, the NEPA Compliance Officer, and team members after completing each environmental impact statement and environmental assessment on lessons learned in the process and will circulate a quarterly summary to all NEPA Compliance Officers and NEPA Document Managers. The Office of Environment, Safety and Health also will revise its "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements", as appropriate, to reflect the lessons learned and will improve Department-wide NEPA policy, directives, guidance, and training accordingly.

C. The Office of Environment, Safety and Health will provide NEPA training in order to develop a more knowledgeable and experienced group of Headquarters and Field personnel capable of carrying out NEPA compliance activities.

D. The Office of Environment, Safety and Health will consider establishing a NEPA certification program to formally recognize the expertise of personnel who have achieved a specified combination of training and practical experience.

E. The Office of Environment, Safety and Health and the Office of General Counsel will monitor the progress of and advise the Secretary on the Department's NEPA compliance program. Metrics will include the cost and time required for NEPA document preparation, the influence of NEPA review on decision making, the evaluations of contractor performance, Environmental Protection Agency ratings of Department of Energy environmental impact statements, public reactions, and litigation experience. Within two years, Secretarial Offices and Field Organizations, with assistance from the Offices of Environment, Safety and Health and General Counsel, will reduce the median process time for environmental impact statements (from notice of intent to final environmental impact statement) to 15 months with no decline in quality. Meeting this objective will, of course, require adjustments to the schedules for environmental impact statements now in preparation.

F. In carrying out and improving their NEPA compliance process, Heads of Departmental Elements should make effective use of NEPA Compliance Officers for advice, assistance, training, and coordination.

* * * * * *

*This policy statement establishes internal management procedures and, as such, must be followed by Department of Energy personnel. It is not intended to create rights or obligations or any cause of action on the part of any other person.*

## ATTACHMENT 1

### SECRETARIAL OFFICERS *

Assistant Secretaries:
- Defense Programs
- Energy Efficiency and Renewable Energy
- Environmental Management
- Fossil Energy
- Field Management (Associate Deputy Secretary)

Directors:
- Civilian Radioactive Waste Management
- Energy Research
- Laboratory Management
- Nonproliferation and National Security
- Nuclear Energy

Administrators:
- Bonneville Power Administration
- Western Power Administration
- Alaska Power Administration
- Southeastern Power Administration
- Southwestern Power Administration

### HEADS OF FIELD ORGANIZATIONS *

Operations Office Managers:
- Albuquerque, Chicago, Idaho, Nevada, Oakland, Oak Ridge, Richland, and Savannah River Operations Offices

Managers:
- Golden Field, Ohio Field, and Rocky Flats Offices

Directors:
- Morgantown Energy Technology Center
- Pittsburgh Energy Technology Center
- Bartlesville Project Office
- Metairie Site Office
- Naval Petroleum and Oil Shale Reserves (in Colorado, Utah, and Wyoming)
- Naval Petroleum Reserves in California
- Yucca Mountain Project Office

Project Manager of Strategic Petroleum Reserve Project Office

* For purposes of applying this policy: Secretarial Officers are heads of departmental elements that report to the Office of the Secretary. Heads of Field Organizations are heads of field departmental elements that report to a Secretarial Officer (or, in the case of Bartlesville Project Office, Metairie Site Office, Naval Petroleum and Oil Shale Reserves, Naval Petroleum Reserves, and the Strategic Petroleum Reserve Project Office, to a Deputy Assistant Secretary). The above list excludes Secretarial Officers and Heads of Field Organizations that generally do not sponsor proposed actions that are subject to NEPA review.

ATTACHMENT 2

ILLUSTRATION OF CONTENT OF ANNUAL NEPA PLANNING SUMMARY FOR AN ENVIRONMENTAL IMPACT STATEMENT OR ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL IMPACT STATEMENTS:

Appleton Windplant and Wind Farms, Appleton County, Washington

Description: The proposed action would include placement and operation of an estimated 420 wind turbines, collection lines, transmission lines, access roads, turbines and transformer pads, and various other associated facilities. These wind energy projects are proposed for development in Stayman County (Central Washington).

Schedule:
NOI: April 1994
Public Scoping Meetings: May 1994
Implementation Plan: July 1994
Draft EIS: December 1994
Final EIS: June 1995
ROD: July 1995

ENVIRONMENTAL ASSESSMENTS:

Wastewater Flow Collection and Treatment System, Mississippi River Plant, Jackson, Mississippi

Description: To construct and operate a collection and treatment system for contaminated wastewaters and groundwaters at the Department of Energy-operated Mississippi River Plant. The system would consist of collection conduits, a flow splitter box, an equalization basin, sedimentation basins, sludge handling and storage facilities, and associated chemical storage and feed equipment.

Schedule: No schedule yet set. In preliminary stages of consideration.

Note: Schedule information should be provided to the extent available.

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

# *Report of Telecon*

To: Melissa Lutz
From: Launa Danielson

Incoming: ___ Outgoing: X WP#: ___
Date: 1/10/95 Time: 10 am

Conversation With:

Dr. Robert Shoewe Phone: 441-0050
of: Francis Howell High School
and: Launa Danielson Phone: 441-8086 ext. 2703
of: PMC

Subject: Number of students and faculty at Francis Howell High School

Summary of Conversation:

Dr. Shoewe reported the following numbers for the high school:

Students: 2,175

Faculty/Staff: 150

Action of Follow-Up/Recommendations:

Route info. to M. Lutz for inclusion in the annual site environmental report

cc:

By: Launa L Danielson

ENG-6a.3 Rev.2 10-92

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

# *Report of Telecon*

To: Melissa Lutz
From: Launa Danielson

Incoming: ___ Outgoing: X WP#: ____
Date: 1/9/95 Time: 3:15 pm

Conversation With:
Gary Peel
of: Highway Maintenance Dept.
and: Launa Danielson
of: PMC

Phone: 441-8471
Phone: 441-8086 x2703

Subject: Number of employees at the highway maintenance dept.

Summary of Conversation:

There are 10 full time employees at the state highway department maintenance shop adjacent to the Weldon Spring Site.

Action of Follow-Up/Recommendations:

Route info. to M. Lutz for inclusion in the annual site environmenta report.

cc:

By: Launa L. Danielson

DOE-F 1325.8
(5-89)

35583

United States Government

Department of Energy

# memorandum

Oak Ridge Operations

DATE: November 1, 1993

REPLY TO ATTN OF: EW-94:

SUBJECT: **UPDATE ON WETLAND MITIGATION FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)**

TO: Jim Wagoner, Director, Off-Site Program Division, EM-421

REFERENCE: Memo from Steve McCracken to Jim Wagoner, dated October 1, 1993, subject Wetlands Mitigation for the WSSRAP

The referenced memorandum provides the background on this action. This memorandum is an update on this activity. The WSSRAP is no longer preparing a categorical exclusion (CX) or an environmental assessment (EA) for this specific action. EM-22, with concurrence from EH-251 and the Oak Ridge NEPA Compliance Officer (Patty Phillips), has determined that no further NEPA review is required for this action. Specifically, from a NEPA standpoint, this action has been adequately addressed. The rationale for this determination is described in more detail in the attached memorandum from EM-22 to Steve McCracken.

A wetland management plan is being prepared that will describe how the wetland will be managed during the five (5) year period that we are required to monitor it. This plan is being prepared with significant input from the Missouri Department of Natural Resources (MDNR), Missouri Department of Conservation (MDOC), and the U. S. Army Corps of Engineers (COE).

Two 404 permits will be required. One for the elimination, being prepared by the WSSRAP, and one for the creation, being prepared by the MDOC. These must be approved before construction may begin. All of the elements required for the 404 permit have been completed. We are now assembling these elements into a cohesive package for review by the COE.

An agreement has been drafted by DOE-Oak Ridge Legal Counsel. This agreement will be between the DOE and the MDOC. We are currently working with the MDOC to review and finalize the language in the agreement.

We are still aiming for an early November completion date.

If you have any questions please contact Karen Reed or Bruce Ballew at (314) 441-8978.

Jerry S. Van Fossen
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

Attachment:
As stated

cc w/attachment:
Bob Boettner, EM-421
Dane Bartlett, CC-10
Patty Phillips, SE-31
Jim Powers, PMC
Mary Picel, ANL

RECEIVED
NOV 0 1 1993
M-K FERGUSON, CO.
WSSRAP CONTRACT 3589

DOE F 1325.8
(8-89)
EFG (07-90)

United States Government | Department of Energy

35583

# memorandum

DATE: OCT 8 1993

REPLY TO ATTN OF: EM-22 (Clay:3-7905)

SUBJECT: Wetlands Replacement as part of the Remediation of the Chemical Plant Area of the Weldon Spring Site

TO: Stephen H. McCracken, Project Manager
Weldon Spring Site Office

On September 30, 1993, a conference call was held to discuss the need for additional NEPA review and floodplain/wetlands documentation for the creation of wetlands as part of the remedial action of the Chemical Plant Area of the Weldon Spring Site. The individuals involved in the conference call were as follows: Bruce Ballew of your office together with support personnel from Argonne National Laboratory; Jennifer Clay of my office; and, Dennis Hosaflook and Carolyn Osborne of the Office of NEPA Oversight. The position taken by my office and supported by your staff was that the creation of wetlands was part of the proposed action and DOE's mitigation commitment as described in the *RI/FS-EIS for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (November 1992)* and subsequent joint CERCLA/NEPA Record of Decision (ROD). This position was also supported by Patricia Phillips, the NEPA Compliance Officer for the Oak Ridge Operations Office. Our mitigation commitment involved replacing wetlands that would be destroyed by the remediation and to do so in consultation with the appropriate state agencies and the Corps of Engineers. A final decision on this matter was deferred until further consultation could take place with the Office of NEPA Oversight.

On October 6, 1993, Patricia Phillips and I met with Carol Borgstrom, Director of the Office of NEPA Oversight, to further discuss the need for additional NEPA review to support the creation of the replacement wetlands. Based on our discussions, Ms. Borgstrom agreed that the proposed action is adequately evaluated in the RI/FS-EIS and no additional NEPA documentation is required. Subsequent to that conversation, Jennifer Clay communicated with Dean Monroe, Office of the General Counsel, and Dennis Hosaflook on October 7, 1993, and confirmed that no additional Federal Register notices or formal assessments are required to satisfy the floodplain and wetlands environmental review requirements of 10 CFR 1022 for this proposed action.

Two actions that must be completed prior to start-up of the project involve completing the EIS process. Specifically, the NEPA ROD which consists of the Decision Summary of the CERCLA ROD must be published in the Federal Register. Jennifer Clay is available to provide guidance on preparing this notice. Second, the mitigation action plan (MAP) that DOE committed to prepare and implement (largely due to the impacts to wetland areas) must be delivered to Headquarters and submitted to the Assistant Secretary for Environment, Safety and Health for review. Your consultation meetings held with the Missouri Department of Conservation, the Corps of Engineers, and other agencies should be referred to in the MAP and records of this consultation maintained in the project file.

If you have any questions, please call me on (202) 586-0338 or Jennifer Clay on (513) 648-3106.

Michael Kleinrock
Director
Office of Environmental Oversight

014290
10/15/93

35583

cc:
Randal S. Scott, EM-20
James Wagoner, EM-421
Patricia Phillips, OR
Carolyn Osborne, EH-251
Dennis Hosaflook, EH-251

# APPENDIX B
## Assumptions and Scenarios for Dose Calculations

A. Dose from the chemical plant/raffinate pits to a maximally exposed individual.

1. Inhalation :

a. Airborne Particulates: Statistical analysis of gross alpha results indicated that five monitoring stations around the Weldon Spring Chemical Plant were different than background levels. One station is located at the WSSRAP administration building (AP-2005), and four are located around the chemical/raffinate pits perimeter (AP-2001, AP-2002, AP-3004, and AP-2013). Station AP-2002 was used to evaluate the dose from the chemical plant and raffinate pits perimeter to a hypothetical maximally exposed individual. This monitoring station was used because it is the closest to the Busch Memorial Conservation Area. The net concentration at the Busch Memorial Conservation Area was 5.0E-16 $\mu$Ci/ml or 5.0E-4 pCi/$m^3$ and was assumed to be natural uranium. A combined exposure time of 119.5 hours for boating and fishing (see ingestion pathway below) was also used in the dose estimate.

CEDE(inhalation) = net airborne particulate concentration x exposure time x breathing rate x dose conversion factor (DCF[1])

= 5.0E-4 pCi/$m^3$ x 119.5 hr x 0.96 $m^3$/hr x 1.32E-1 mrem/pCi

= 0.008 mrem (0.00008 mSv)

b. Radon Gas: No contribution to the estimated EDE for the hypothetical individual was calculated for radon gas. Based on the statistical analysis of the data collected, there is no reason to suspect at the 95% confidence level that the measured results from any of the monitoring locations were greater than background.

2. External Gamma Pathway: No contribution to the estimated EDE for the hypothetical individual was calculated for external gamma radiation. Based on the statistical analysis of the data collected, there is no reason to suspect at the 95% confidence level that the

measured results from any of the monitoring locations around the chemical plant/ raffinate pit areas were greater than background.

3. Ingestion Pathway: Lakes that receive effluent from the chemical plant/raffinate pits are used in order to determine the estimated effective dose equivalent to a maximally exposed individual via ingestion of fish, water, and sediment obtained from these lakes.

   Fishing at the Busch Conservation Area averages 2.5 hours per visit (Ref. 32). Assume that the maximally exposed individual visited the lakes for the purpose of fishing 25 times during the year. The ratio of fish caught to hours spent fishing is estimated at 0.40, while the ratio of fish kept is estimated at 0.5. Therefore, on an annual basis, the maximally exposed individual would keep 12.5 fish from the lakes. Assuming that the edible portion of fish has an average mass of 200 g, a fish consumption rate of 2,500 g/year is assumed.

   Boating at the Busch Memorial Conservation Area requires more hours per visit than any other activity; therefore, boating was assumed to be the activity in which the maximally exposed individual participated for the water and sediment ingestion scenarios. Assume the average time spent by the maximally exposed individual per boating trip is 5.7 hours, and the hypothetical individual visits the area for the purpose of boating 10 times in a year. Assume 5% of the time is devoted to swimming during each visit. Thus, 2.85 hours is spent swimming in the lakes.

   a. Fish: Assume a 2,500 g/year fresh water fish consumption rate from Lake 36 at the Busch Memorial Conservation Area and a 0.009 pCi/g (0.0003 Bq/g) average total uranium content in fish of all lakes receiving runoff from the Weldon Spring site.

   b. Water: Assume a 0.05 l/hour swimming ingestion rate for the 2.85 hours for a total annual consumption of 0.14 liters. The water is assumed to have a total uranium concentration of 67.5 pCi uranium/l, as detected in Lake 36, which has the highest uranium concentration (in water) of all lakes receiving runoff from the site.

c. Sediment: Assume a 200 mg/day ingestion rate for the 2.85 hours for a total of 24 mg of sediment. The sediment is assumed to have a total uranium concentration of 91.1 pCi uranium/g sediment, as detected in Lake 36, which has the highest uranium concentration (in sediment) of all lakes receiving runoff from the site.

CEDE (ingestion) = annual fish consumption x uranium concentration x uranium DCF[1] + annual water consumption x uranium concentration x uranium DCF[1] + annual sediment ingestion x uranium concentration x uranium DCF[1]

= 2,500 g/year x 0.009 pCi/g x 2.83E-4 mrem/pCi + 0.14 l/year x 67.5 pCi/l x 2.83E-4 mrem/pCi + 0.024 g/year x 91.1 pCi/g x 2.83E-4 mrem/pCi

= 0.010 mrem (0.0001 mSv)

The total estimated committed effective dose equivalent to the maximally exposed individual at the chemical plant/raffinate pits area is 0.018 mrem (0.00018 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: Results of gross alpha measurements at the quarry indicated five stations with results statistically greater than background averages for 1994. The highest annual average net concentration, 1.57E-3 pCi/$m^3$, was measured at station AP-1009, located on the northeast portion of the quarry perimeter. This concentration was used in evaluating dose to the maximally

exposed individual, and was assumed to be natural uranium. A breathing rate of 1.25 $m^3$/hr was assumed.

CEDE (air particulates) = Net Airborne Particulate Concentration x Exposure Time x Breathing Rate x Dose Conversion Factor

= 1.57E-3 pCi/$m^3$ x 5 hr x 1.25 $m^3$/hr x 0.132 mrem/pCi
= 0.0013 mrem (0.000013 mSv)

b. Thoron and Radon Gas: Concentrations of thoron and radon at the southeastern perimeter of the quarry were estimated using concentrations measured at station RD-1002, located along the eastern portion of the quarry perimeter. Because of the significant release of thoron and radon during excavation activities at the quarry during 1994, elevated measurements were reported, especially during the first quarter. An estimation was made to discriminate thoron (Rn-220) from radon (Rn-222). For the first and second quarters, this estimation was made using a correction factor obtained from a thoron response graph (Refer to Figure B-1). During third and fourth quarters, actual thoron data was provided by modified "M-type" alpha-track detectors, and thoron concentrations for this period were calculated using Pearson's method (Ref. 49).

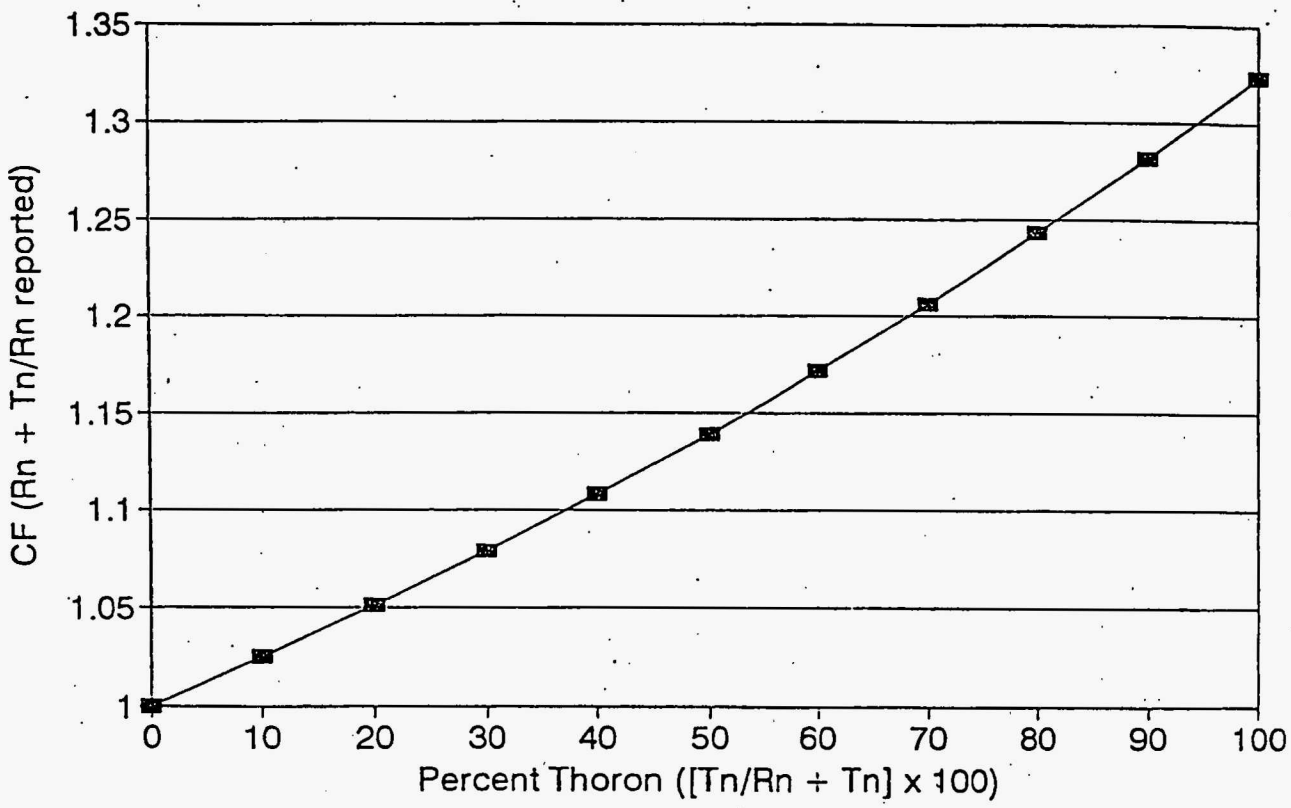
The estimated radon and thoron concentrations measured at station RD-1002 are listed in the following table.

TABLE B-1: Estimated Thoron and Radon Concentrations at Station RD-1002

| | 1st Qtr Concentration (pCi/l) | 2nd Qtr Concentration (pCi/l) | 3rd Qtr Concentration (pCi/l) | 4th Qtr Concentration (pCi/l) | 1994 Average Concentration (pCi/l) |
|---|---|---|---|---|---|
| Radon | 1.2 | 0.5 | 0.6 | 0.4 | 0.7 |
| Thoron | 10.5 | 4.6 | 3.4 | 3.7 | 5.6 |

Thoron and radon concentrations are often expressed in units of working levels (WL), where 1 WL (at 100% equilibrium) is equal to 100 pCi/l for radon and 7.43 pCi/l for

# ALPHA-TRACK THORON RESPONSE
## TYPE RADTRAK




ALPHA-TRACK THORON RESPONSE

TYPE RADTRAK

FIGURE B-1

| REPORT NO.: DOE/OR/21548-512 | | EXHIBIT NO.: A/PI/061/0495 |
|---|---|---|
| ORIGINATOR: EKA | DRAWN BY: LGB | DATE: 4/26/95 |

thoron. Exposures to radon and thoron are often expressed in terms of working level months (WLM), corresponding to an exposure of 1 WL during the reference working period of 1 month (i.e. 2000 working hours per 12 months, or 170 hours per month). An exposure time of 5 hours per year is assumed (Section 4.4.2), as well as a daughter equilibrium ratio of 10% (Ref. 53). The committed effective dose equivalent is calculated as follows:

CEDE (thoron) = net thoron concentration x exposure time x daughter equilibrium ratio x dose conversion factor x working month dose conversion factor

= 5.4 pCi/l x 5 hrs x 0.1 x 1 WL/7.43 pCi/l x 0.33 rem/WLM x 1 working month/170 hrs x 1000 mrem/rem

CEDE (thoron) = 0.705 mrem (0.00705 mSv)

CEDE (radon) = net radon concentration x exposure time x daughter equilibrium ratio x dose conversion factor x working month dose conversion factor

= 0.5 pCi/l x 5 hrs x 0.1 x 1 WL/100 pCi/l x 1.0 rem/WLM x 1 working month/170 hrs x 1000 mrem/rem

CEDE (radon) = 0.0147 mrem (0.000147 mSv)

CEDE(inhalation)= CEDE (air particulates) + CEDE (thoron) + CEDE (radon)

= 0.721 mrem (0.00721 mSv)

2. External Pathway: Two environmental TLD monitoring stations located along the quarry perimeter were statistically found to be at greater than background levels. These stations, TD-1003 and TD-1004, provided total annual gross measurements of approximately 75 mrem and 70 mrem, respectively. The higher result was used in the dose estimate to the maximally exposed individual who hikes 5 hours/year around the quarry perimeter. An average background gamma radiation dose equivalent of 57.2 mrem was estimated for the year.

CEDE (external) = (gross TLD result - background TLD result) x exposure time

= (75 - 57.2) mrem/y x 5 hrs x 1 y/8,760 hrs

CEDE (external) = 0.0102 mrem (0.000102 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.

CEDE (total) = CEDE (inhalation) + CEDE (external)

= 0.721 mrem + 0.0102 mrem

= 0.731 mrem (0.00731 mSv)

The total estimated committed effective dose equivalent to a maximally exposed individual at the quarry is therefore 0.731 mrem (0.00731 mSv).

C. Dose from the Vicinity Properties to a Maximally exposed Individual

1. Inhalation Pathway:

a. Airborne Radioactive Particulates:

The Femme Osage Slough, located adjacent to the Weldon Spring Quarry, is the only portion of the vicinity properties which would likely be frequented by members of the public. Statistical analysis of gross alpha results at station AP-1010, which is the air particulate monitoring location closest to the slough, indicated an annual average concentration higher than background levels. The annual average net concentration at AP-1010 was 8.6E-16 $\mu$Ci/ml, or 8.6E-4 pCi/$m^3$, and was assumed to be natural uranium. As with the fishing scenario for Busch Conservation Area (see part A of this Appendix), assume that the maximally exposed individual visited the slough for the purpose of fishing 25

times per year, 2.5 hours per visit. Therefore, the individual fishes at the slough 62.5 hours per year.

CEDE (inhalation, air particulates) = net airborne particulate concentration x exposure time x breathing rate x dose conversion factor (DCF[1])

= 8.6E-4 pCi/$m^3$ x 62.5 hr x 0.96 $m^3$/hr x 0.132 mrem/pCi

= 0.007 mrem (0.00007 mSv)

b. Radon Gas: Not applicable since radon concentrations measured at the slough were indistinguishable from background levels.

CEDE (inhalation) = 0.007 mrem (0.00007 mSv)

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 collected from the slough of 0.005 pCi/g.

CEDE (ingestion) = fish consumption rate x uranium concentration x dose conversion factor (DCF[1])

= 6.5 g/day x 365 d/yr x 0.005 pCi/g x 2.83E-4 mrem/pCi

= 0.0034 mrem (0.000034 mSv)

CEDE (total) = CEDE (inhalation) + CEDE (ingestion)

= 0.007 mrem + 0.0034 mrem

= 0.010 mrem (0.00010 mSv)

The total estimated committed effective dose equivalent for the maximally exposed individual at the Femme Osage Slough is therefore 0.010 mrem (0.00010 mSv).

D. Collective Population Dose Estimate

**Exposure Points** - 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 addressed only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area. Three of the lakes on this property receive runoff from the site and are used by the general public for fishing and boating purposes. None of these bodies of water are used as drinking water sources.

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, is not included in the collective population dose estimate.

The only area where there was reason to suspect that radon environmental monitoring results could be different than background concentrations was at the quarry perimeter. The only potential receptors near the quarry perimeter are people using the Katy Trail,

a recreational hiking and biking trail located on state-owned land south of the quarry. Track etch detectors placed at the trail indicate that there was no reason to suspect at the 95% confidence level that concentrations exceeded background. Although the 1994 average NESHAPs concentration at station AP-4011 (located near the Katy Trail) was not distinguishable from background levels, the gross alpha results at AP-1010 were statistically significant and were used in the dose estimates. Therefore, a collective population dose was estimated for users of the Katy Trail. An estimated 72,000 people use the trail each year (Ref. 30).

The scenario for the Katy Trail is based on an exposure due to inhalation of airborne particulates as individuals traverse the portion of the trail near the quarry. This portion is 260 m in length, and at a walking speed of 3.2 km/hr (2 mi/hr) results in an exposure time of approximately 5 minutes.

The only area where there was reason to suspect that a significant amount of the general population could consume fish, water, and sediments from waters that receive runoff from the site was at the Busch Memorial Conservation Area. The only potential receptors in that area are the people who actually use the Busch Memorial Conservation property for recreational purposes. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the Weldon Spring site and are utilized for fishing and boating activities. The Missouri Department of Conservation recently 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.

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 one, two, and three.

Although data from five radon track etch stations at the perimeter of the raffinate pits were found to be statistically greater than background, it is not realistic to calculate a population dose based on the concentrations that were measured. At all off-site monitoring stations in the vicinity of the chemical plant/raffinate pits there was no reason to suspect at the 95% confidence level that any of the stations were greater than background. As a result, no radon dose was calculated for the population that frequents the Busch Memorial Conservation Area.

Population Dose Estimate for Users of the Katy Trail

1. Population dose estimate due to inhalation of radioactive air particulates at the Katy Trail:

   a. Assume a population of 72,000 persons visits the Katy Trail for the purpose of hiking and each person spends 5 minutes while walking along the portion of the trail near the quarry.

   b. Assume a net airborne concentration of 8.6E-4 pCi/$m^3$.

   CEDE (inhalation) = net airborne concentration x exposure time x breathing rate x dose conversion factor ($DCF^1$) x population

   = 8.6E-4 pCi/$m^3$ x 0.083 hr x 1.25 $m^3$/hr x 1.32E-1 mrem/pCi/l x 1 rem/1,000 mrem x 72,000 persons

   = 0.0008 person-rem (8E-6 person-Sv)

   Population Dose Estimate (Katy Trail) = 0.0008 person-rem (8E-6 person-Sv)

Population Dose Estimate for Users of the Busch Memorial Conservation Area

1. Population dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area.

a. 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.

b. Using the total uranium fish content of 0.009 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 is:

Population Dose Estimate (fish ingestion)

= consumption rate x total uranium concentration in fish x exposure time x dose conversion factor[1] x persons

= 0.55 g/day x 0.009 pCi/g x 365 day x 2.83E-4 mrem/pCi x 80,000 persons x 1 rem/1,000 mrem

= 0.041 person-rem (0.00041 person-Sv)

2. Population dose estimate due to incidental ingestion of water at the Busch Conservation lakes:

a. 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).

b. Using the total uranium surface water content of 67.5 pCi/l obtained from Lake 36 and an ingestion rate of 0.05 l/hour (Ref. 23) the estimated population dose is

1 Uranium dose conversion factor (DCF) was the greater of the two DCFs reported for each uranium isotope (U-234 and U-238) in Table 2.2 of Eckerman et al. (Ref. 21)

Population Dose Estimate (water ingestion)

= ingestion rate x total uranium concentration in surface water x exposure time x dose conversation factor[1] x persons

= 0.05 l/hr x 67.5 pCi/l x 0.285 hr x 2.83E-4 mrem/pCi x 5,985 persons x 1 rem/1,000 mrem

= 0.0016 person-rem (0.000016 person-Sv)

3. Population dose estimate due to ingestion of sediments at the Busch lakes:

   a. 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).

   b. Using the total uranium sediment content of 91.1 pCi/g obtained from Lake 34 and an ingestion rate of 200 mg/day, the estimated population dose is:

Population Dose Estimate (sediment ingestion)

= ingestion rate x total uranium concentration in sediment x exposure time x dose conversion factor[1] x persons

= 200 mg/day x 91.1 pCi/g x 0.285 hr/person x 2.83E-4 mrem/pCi x 5,985 persons x 1 g/1,000 mg x 1 day/24 hr x 1 rem/1,000 mrem

= 0.0004 person-rem (4E-6 person-Sv)

4. Population dose estimate due to inhalation of airborne particulates:

   a. Assume a population of 5,985 persons visit the area for the purpose of boating and each person spends 5.7 hours per visit.

b. Assume a population of 160,000 persons visit the area for the purpose of fishing and each person spends 2.5 hours fishing.

c. Assume an airborne concentration of 5.0E-4 pCi/$m^3$ (measured at AP-2002).

Population Dose Estimate (inhalation)

= net airborne concentration x exposure time for boating x breathing rate x dose conversion factor ($DCF^1$) x boating population + net airborne concentration x exposure time for fishing x breathing rate x dose conversion factor ($DCF^1$) x fishing population.

= 5.0E-4 pCi/$m^3$ x 5.7 hr x 0.96 $m^3$/hr x 1.32E-1 mrem/pCi x 1 rem/1,000 mrem x 5985 person + 5.0E-4 pCi/$m^3$ x 2.5 hour x 0.96 $m^3$/hr x 1.32 E-1mrem/pCi x 1 rem/1000 mrem x 160,000 person

= 0.028 person-rem (0.00028 person-Sv)

Population Dose Estimate (Busch) = Population Dose Estimate (ingestion) + Population Dose Estimate (inhalation)

= 0.043 person-rem + 0.028 person-rem
= 0.071 person-rem (0.00071 person-Sv)

Population Dose Estimate (total) = Population Dose Estimate (Katy Trail) + Population Dose Estimate (Busch)

= 0.072 person-rem (0.00072 person-Sv)

The total estimated population dose for all potential exposure pathways for calendar year 1994 is 0.072 person-rem (0.00072 person-Sv).

E. U-238, U-235, and U-234 Release Estimates

During 1994, the only critical receptor location that had an average total uranium concentration statistically above background was station AP-2001. The above background uranium measurements resulted from building dismantlement and demolition activities conducted during the year. The Clean Air Act Assessment Package - 1988 (CAP88-PC) computer model was used to determine the annual airborne uranium release rate in curies resulting from these activities. Because the WSSRAP meteorological station was not fully operational for the entire year, missing data was obtained from the St. Louis/Lambert Field International Airport for the months of January through August. A Pasquill-Gifford stability class of "D" was assumed (neutral stability conditions). The source area representing the active work area during 1994 was estimated to be 4,800,000 $ft^2$ (146,300 $m^2$). A natural uranium activity ratio was assumed (49.1% U-234, 2.3% U-234, and 48.6% U-238). Station AP-2001 is located approximately 200 m NNE of the source area of interest. The average net concentration at this location was 1.91E-10 $\mu Ci/m^3$. A series of model runs was made to determine what release rate (Ci/y) would result in a total uranium concentration of 1.91E-10 $\mu Ci/m^3$ at a distance of 200 m NNE of the source area. The model computed the following release rates for the three naturally occurring uranium isotopes:

| | |
|---|---|
| U-238: | 1.80E-04 Ci/y |
| U-235: | 8.51E-06 Ci/y |
| U-234: | 1.82E-04 Ci/y |

F. Radon-220 and Radon-222 Release Estimates

To estimate the airborne Rn-220 (thoron) and Rn-222 (radon) releases from the Weldon Spring site during 1994, the above background alpha-track monitoring results were incorporated into a series of four box models. Only quarry stations were considered in this estimate, because perimeter monitoring stations at the chemical plant area indicated results that were indistinguishable from background measurements. The box-model approach provides conservative results and is used in place of Gaussian dispersion modeling, which is generally inappropriate for estimates at close-in receptors.

Quarry alpha-track monitors RD-1002, RD-1003, RD-1004, RD-1006, and RD-1009 measured average integrated radon levels above background during 1994. Average net radon and thoron concentrations measured or estimated at these stations (see Table B-2 of this Appendix) were incorporated into box models corresponding to four ranges of wind directions: NE, ENE, and E (Station RD-1002); ESE, SE, SSE, S, and SSW (Stations RD-1003 and RD-1004); SW, WSW, and W (Station RD-1006); and WNW, NW, NNW, N, and NNE (Station RD-1009). These ranges of wind direction encompass the sector in which each monitoring station is located. Yearly meteorological data were used to calculate the frequencies at which the wind blew in each direction.

Thoron concentrations were measured only at stations RD-1002 and RD-1006 during 1994. The remaining monitoring locations were assumed to have the same proportions of radon and thoron as RD-1006, where estimates indicated approximately 25% Rn-220 and 75% Rn-222. The only predominantly downwind station, RD-1002, indicated a radon/thoron ratio of approximately 90% Rn-220/10% Rn-222 for the year. The following table provides an overview of the parameters and assumptions used in the modeling scheme:

As explained in the previous section, meteorological data from the St. Louis/Lambert Field Airport was used for the months of January through August, while on-site data was available for the remainder of the year. These data were combined and averaged to obtain wind directions and corresponding wind speeds, which were organized in a STAR summary format. A release height of 6 m was assumed for all box models. The release height was estimated based on the approximate vertical distance from the source area to the quarry rim, where the monitoring stations are located. The box length for each model was selected according to the approximate width of the source area perpendicular to the direction of each monitoring station from the source.

The following equation is used to estimate radon and thoron release rates from the quarry for each model:

$$\text{Release Rate (Ci/y)} = \text{Box Length (m)} \times \text{Release Height (m)} \times \text{Wind Speed (m/s)} \times \text{Net Radon or Thoron Concentration (pCi/l)} \times 10^{-12}\ \text{Ci/pCi} \times 1{,}000\ \text{l/m}^3 \times 3.16\text{E}7\ \text{seconds/year} \times \text{Directional Frequency}$$

TABLE B-2 Parameters and Assumptions Used in Box Modeling Scheme

| Box Model | Range of Wind Directions (wind blowing toward) | Monitoring Stations | Average Wind Speed (m/s) | Directional Frequency | Box Length (m) | Rn-220 Net Concentration (pCi/l) | Rn-222 Net Concentration (pCi/l) |
|---|---|---|---|---|---|---|---|
| 1 | NE,ENE,E | RD-1002 | 3.9 | 0.159 | 119 | 5.4 | 0.5 |
| 2 | ESE,SE, SSE,S,SSW | RD-1003, RD-1004 | 5.2 | 0.300 | 219 | 0.06 | 0.17 |
| 3 | SW,WSW,W | RD-1006 | 4.8 | 0.145 | 229 | 0.03 | 0.09 |
| 4 | WNW,NW, NNW,N,NNE | RD-1009 | 5.7 | 0.396 | 274 | 0.03 | 0.09 |

Rn-220 Calculations:

Box 1:

Release Rate = 119 m x 6 m x 3.9 m/s x 5.4 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.159

= 76 Ci/y

Box 2:

Release Rate = 219 m x 6 m x 5.2 m/s x 0.06 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.300

= 3.9 Ci/y

Box 3:

Release Rate = 229 m x 6 m x 4.8 m/s x 0.03 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.145

= 0.9 Ci/y

Box 4:

Release Rate = 274 m x 6 m x 5.7 m/s x 0.03 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.396

= 3.5 Ci/y

Therefore, the total estimated thoron release rate from the quarry is the sum of the results of the four box models, or approximately 84 Ci/y.

Rn-222 Calculations:

Box 1:

Release Rate = 119 m x 6 m x 3.9 m/s x 0.5 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.159

= 7 Ci/y

Box 2:

Release Rate = 219 m x 6 m x 5.2 m/s x 0.17 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.300

= 11 Ci/y

Box 3:

Release Rate = 229 m x 6 m x 4.8 m/s x 0.09 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.145

= 2.7 Ci/y

Box 4:

Release Rate = 274 m x 6 m x 5.7 m/s x 0.09 pCi/l x $10^{-12}$ Ci/pCi x 1,000 l/$m^3$ x 3.16E7 seconds/y x 0.396

= 11 Ci/y

Therefore, the total estimated Radon-222 release rate from the quarry is the sum of the results of the four box models, or approximately 32 Ci/y.

G. Radiation Dose to Native Aquatic Organisms

The DOE guideline for dose to native aquatic organisms is 1 rad/day (0.01 Gy/day). The highest natural uranium concentration measured in these organisms was detected in a sample from Burgermeister Spring which contained 44.2 pCi/g. The following paragraphs explain the methodology and assumptions used for calculation of the absorbed dose rate to the organism.

Assuming a natural isotopic activity ratio of 49.1% U-234, 2.3% U-235, and 48.6% U-238, contributions from each isotope to the total uranium concentration were calculated to be 21.7 pCi/g, 1.0 pCi/g, and 21.5 pCi/g, respectively. Average energy per disintegration (measured in MeV per disintegration) is 4.86 MeV/dis for U-234, 4.67 MeV/dis for U-235, and 4.28 MeV/dis for U-238 (Ref. 56). The following equation was used to obtain the absorbed dose rate in rad/day, given concentration in pCi/g:

# rad/day = 0.01 rad/erg/g x 1.6021 E-6 erg/MeV x energy per disintegration (MeV/dis) x concentration (pCi/g) x 3196.8 dis/day/pCi

U-234: # rad/day = 0.01 rad/erg/g x 1.6021 E-6 erg/MeV x 4.86 MeV/dis x 21.7 pCi/g x 3196.8 dis/day/pCi

= 5.4 E-3 rad/day (5.4 E-5 Gy/day)

U-235: # rad/day = 0.01 rad/erg/g x 1.6021 E-6 erg/MeV x 4.67 MeV/dis x 1.0 pCi/g x 3196.8 dis/day/pCi

= 2.4 E-4 rad/day (2.4 E-6 Gy/day)

U-238: # rad/day = 0.01 rad/erg/g x 1.6021 E-6 erg/MeV x 4.28 MeV/dis x 21.5 pCi/g x 3196.8 dis/day/pCi

= 4.7 E-3 rad/day (4.7 E-5 Gy/day)

Thus, the total absorbed dose rate is the sum of the above results, or 0.01 rad/day (0.0001 Gy/day).

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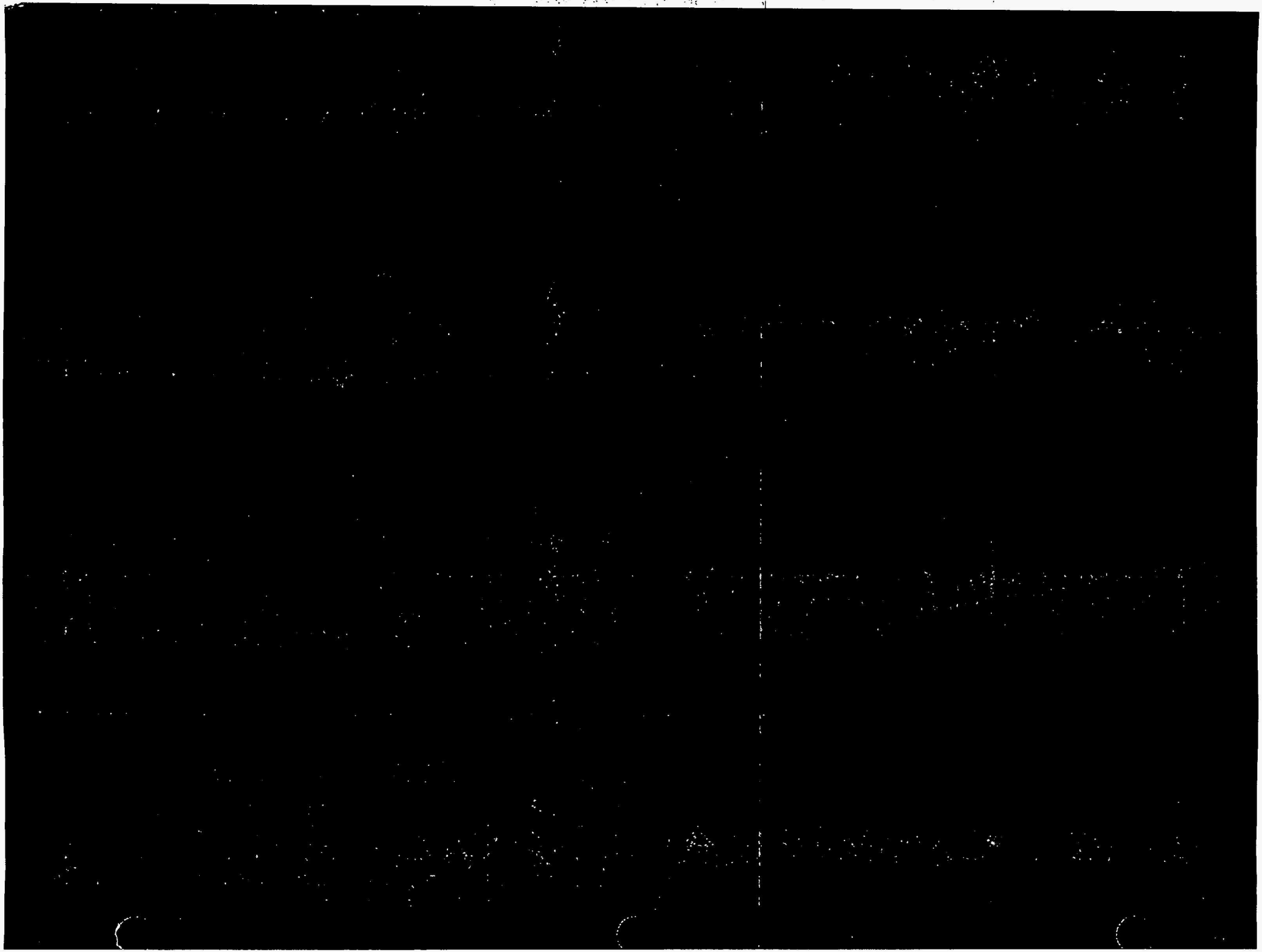
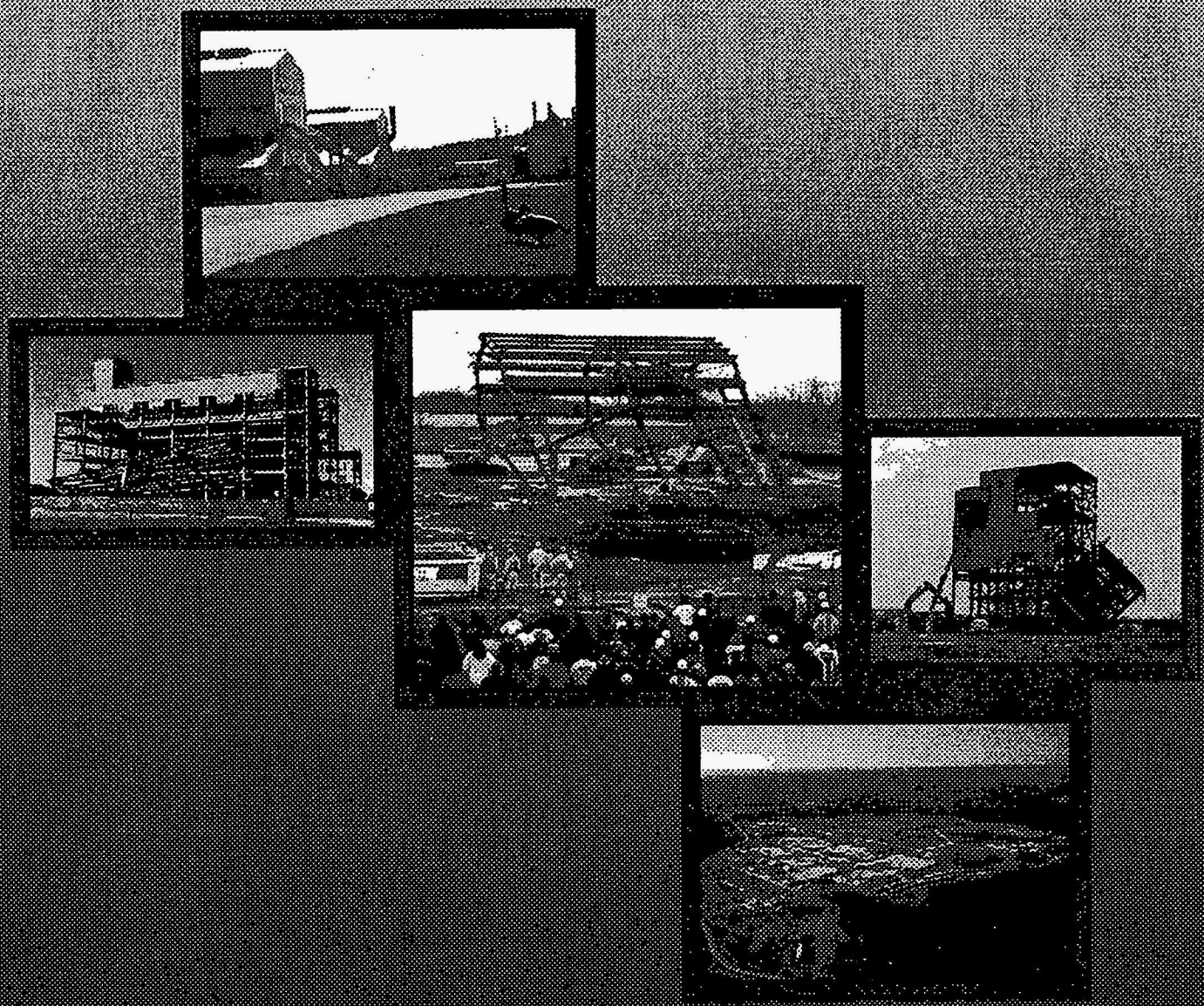


DOE/OR/21548-512
CONTRACT NO. DE-AC05-86OR21548

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

# WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1994



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

May 1995
Rev. 0

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