DOE–LM/GJ879–2005

Weldon Spring Site Environmental Report for Calendar Year 2004

July 2005

Work Performed Under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management.
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U.S. Department of Energy
Office of Legacy Management

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Acronyms

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	Applicable or Relevant and Appropriate
BTLs	baseline tolerance limits
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESQG	conditionally exempt small quantity generator
CFR	*Code of Federal Regulations*
COD	Chemical Oxygen Demand
CWA	Clean Water Act
CY	calendar year
DA	Department of the Army
DCE	dichlorethene
DCF	Dose Conversion Factor
DNB	dinitrobenzene
DNT	Dinitrotoluene
DOE	U.S. Department of Energy
DOE−LM	U.S. Department of Energy Office of Legacy Management
DRC	Dispute Resolution Committee
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESD	Explanation of Significant Difference
FFA	Federal Facility Agreement
FHHS	Francis Howell High School
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GPS	Global Positioning System
GWOU	Groundwater Operable Unit
ha	hectare(s)
IC	Institutional Control
kg	kilogram(s)
lb	pound(s)
LCRS	Leachate Collection and Removal System
LTS&M	Long-Term Surveillance and Maintenance
MCL	Maximum Contaminant Level
MEI	maximally exposed individual
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
mg	milligram(s)
mg/L	milligram(s) per liter
MoDot	Missouri Department of Transportation
MNA	Monitored Natural Attenuation
mrem/yr	millirem per year
MSD	Metropolitan St. Louis Sewer District
MW	Monitoring Well
MWQS	Missouri Water Quality Standard
µg	microgram(s)

μBq/mL	microbequerel(s) per milliliter
μCi/mL	microcurie(s) per milliliter
μg/L	microgram(s) per liter
NB	nitrobenzene
ND	Non-Detect
NHPA	National Historic Preservation Act
NPL	National Priorities List
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NT	nitrotoluene
OU	Operable Unit
PAHs	Polyaromatic hydrocarbons
PCB	polychlorinated biphenyl
PCE	perchloroethene
pCi	picocurie(s)
pCi/L	picocurie(s) per liter
QA	quality assurance
QROU	Quarry Residuals Operable Unit
RCRA	Resource Conservation and Recovery Act
RME	Reasonable Maximally Exposed
ROD	Record of Decision
RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SE	Southeast
SP	Spring
TCE	Trichloroethene
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TNB	trinitrobenzene
TNT	Trinitrotoluene
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
U-234	uranium-234
U-238	uranium-238
VOC	Volatile Organic Compounds
WSSRAP	Weldon Spring Site Remedial Action Project
WSUFMP	Weldon Spring Uranium Feed Material Plant

Executive Summary

This *Weldon Spring Site Environmental Report for Calendar Year 2004* has been prepared as required by DOE Order 231.1A *Environmental, Safety, and Health Reporting* to provide information about the environmental and health protection programs conducted at the Weldon Spring Site. The Weldon Spring site is in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis. The site consists of two main areas, the former Weldon Spring Chemical Plant and the Weldon Spring Quarry, 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 identify trends and characterize 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. Since the site has reached physical completion, the long-term surveillance and maintenance (LTS&M) activities have become the main focus of the project. Therefore this report has been restructured and revised to reflect the reduction in physical activities and includes more emphasis on LTS&M activities.

Compliance Summary

The Weldon Spring site is listed on the National Priorities List (NPL) and is governed by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Under CERCLA, WSSRAP is subject to meeting or exceeding applicable or relevant and appropriate requirements of Federal, State, and local laws. Primary regulations have included the *Resource Conservation and Recovery Act* (RCRA), *Clean Water Act* (CWA), and because the U.S. Department of Energy (DOE) is the lead agency for the site, the *National Environmental Policy Act* (NEPA) values are incorporated into CERCLA documents as outlined in the Secretarial Policy statement on NEPA. Many of these regulations are no longer applicable due to the reduction in physical activities and waste handling at the site.

The remedial action reports for the Chemical Plant Operable Unit (OU) and the Quarry Residuals OU were completed in January 2004. The final Record of Decision (ROD) for the Groundwater OU was issued in January 2004 and was signed by the Environmental Protection Agency (EPA) in February 2004. The Groundwater OU ROD selected a remedy of monitored natural attenuation (MNA) with institutional controls (ICs) to limit groundwater use during the period of remediation. MNA involves the collection of monitoring data to verify the effectiveness of naturally occurring processes to reduce contaminant concentrations over time.

The remaining National Pollution Discharge Elimination System (NPDES) permit (MO-0107701) at the site was revised in March 2004 to remove the sanitary wastewater treatment plant, which became covered under a new permit issued to Lindenwood University, which now occupies the administration building. The permit now only covers the Site Water Treatment Plant discharge line, which is currently not in use. At this time the Weldon Spring site has approval from the Metropolitan St. Louis Sewer District (MSD) to haul disposal cell leachate and purge water to their Bissell Point Plant. The DOE received notification during 2004 that the leachate must meet the radiological drinking water standard of 30 μg/L (20 pCi/L) prior to acceptance.

The disposal cell leachate was very close to this limit, therefore the DOE exercised a pretreatment contingency process and began treating the leachate through a system of cartridge filters and ion exchange media that is selective for uranium. The leachate was sampled after treatment and found to be significantly below the 30 µg/L limit for uranium.

Environmental Monitoring Summary

Historical water quality and water level data for existing wells can be found on the U.S. Department of Energy Office of Legacy Management website: www.gjo.doe.gov/LM/. Photographs, maps, and physical features can also be viewed on this web page.

Starting in July 2004, the monitoring at the chemical plant was changed to implement the selected remedy of monitored natural attenuation (MNA). Four wells were installed to support the MNA program. A total of 72 wells and 5 springs were routinely sampled during 2004 to monitor the groundwater impacts of historical chemical plant operations and recent remedial activities, and to establish baseline for MNA of contaminants of concern in the shallow aquifer. This number was reduced to 42 wells and 4 springs under the MNA program.

Total uranium continues to be present in the groundwater near the former raffinate pits. Four of the 58 wells sampled for uranium exceeded the drinking water standard of 30 µg/L (20 pCi/L). Average nitrate concentrations exceeded the MCL of 10 mg/L at 37 of the 54 wells sampled for nitrate. Nitroaromatic compounds were monitored in 64 locations across the chemical plant area. The Missouri Water Quality Standard (MWQS) for 2,4-DNT of 0.11 µg/L was equaled or exceeded at 20 locations and the MWQS for 1,3-DNB of 1.0 µg/L was exceeded at one location. Trichloroethene (TCE) was sampled at 43 locations to monitor the extent of contamination and changes in concentration that may have resulted from remedial activities and groundwater field studies performed in the area of TCE impact. Eighteen of these wells exceeded the maximum contaminant level (MCL) of 5 µg/L for TCE.

Burgermeister Spring was sampled for nitrate, uranium, VOCs, and nitroaromatic compounds. Monitoring results for Burgermeister Spring were within historical ranges and, compared to concentrations reported in 2003, these concentrations were in the same general range or lower. Of the nitroaromatic compounds, only 2,4-DNT was observed above its detection limit. No VOCs were reported above detection limits at this spring.

Two springs in the Southeast Drainage and one additional spring located in the Burgermeister Spring Branch were monitored for uranium, nitrate, nitroaromatics, and VOCs during 2004. Uranium and nitrate were monitored at one additional spring within the Burermeister Spring Branch. Concentrations at these springs were similar to those measured during 2003.

During 2004, six wells were plugged and abandoned at the Weldon Spring Quarry area in support of the long-term monitoring program for the QROU. A total of 34 wells were routinely sampled to monitor the contaminant concentrations in close proximity to the Quarry proper and the water quality in the Missouri River alluvium.

At the Quarry, the highest levels of uranium continue to occur in the bedrock downgradient from the Quarry and in the alluvial material north of the Femme Osage Slough. The uranium drinking water standard of 30 µg/L (20 pCi/L) was exceeded at thirteen locations, which were the same locations of uranium exceedance in 2003. 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.

Nitroaromatic compound impact continued to be observed in the alluvial materials or bedrock downgradient of the Quarry and north of the Femme Osage Slough. Results were similar to those reported in 2003. Two wells had reported 2,4-DNT concentrations that exceeded the Missouri Water Quality Standard (MWQS) of 0.11 μg/L.

Uranium concentrations were within background ranges, and no detectable concentrations of nitroaromatic compounds were observed in groundwater south of the Femme Osage Slough.

Five groundwater monitoring wells, one spring, and disposal cell leachate were sampled during 2004 as part of the detection monitoring program for the disposal cell. Results of the sampling indicated that the baseline tolerance limits (BTLs) for iron and manganese were exceeded in MW-2032 during December 2004. Resampling in February 2005 confirmed the elevated values. This well was found to be inundated with organic debris as a result of invasion by ants. As a first step, the well has been purged of this debris and will be resampled to determine to what extent this problem may have contributed to the elevated levels. A demonstration report (DOE 2005c) has been prepared as outlined in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b).

Schote Creek, Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled semi-annually for total uranium. This monitoring was conducted to measure the effects of remediation and surface water discharges from the site on the quality of downstream surface water. Uranium levels at the off-site surface water locations for 2004 were similar to 2003 averages.

Four locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the Quarry. These locations were monitored semiannually for uranium. Uranium concentrations in three of the locations during the 1st semi-annual sampling were three-year highs. The higher uranium levels observed in the slough during the first semi-annual period were collected when the elevation of the water table was high. The increase in water levels results in a short-term condition of increased uranium levels in groundwater north of the slough that can discharge to the slough. The levels decreased during the 2nd semi-annual sampling.

The Leachate Collection and Removal system (LCRS) collects leachate from the disposal cell. The leachate is sampled semiannually in accordance with the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan.* The 2003 and 2004 data have shown a continued downward trend to less than 30 pCi/L. During 2003 and 2004, discharge from the primary leachate collection system generated approximately 250 gallons per day and 200 gallons per day, respectively. The combined leachate from the secondary leachate collection system has averaged approximately 20 gallons per day for 2003 and 2004. The average infiltration rate for the secondary leachate collection system for 2003 and 2004 has been approximately 0.75 gallons/acre/day, less than 1 percent of the action leakage rate, which is 100 gal/acre/day.

Long-Term Surveillance and Maintenance Activity Summary

The *Long-Term Surveillance and Maintenance Plan* (LTS&M Plan) was issued for review in March and August 2004. The plan was reviewed by the EPA, MDNR and the public. Due to issues regarding institutional controls (ICs), the EPA issued a letter to DOE on November 22, 2004, which invoked the Federal Facility Agreement (FFA) dispute resolution process for the LTS&M Plan. The EPA and DOE worked to resolve this dispute and as agreed the DOE issued an Explanation of Significant Difference (ESD) to the public in February 2005. The objective of the ESD is to clarify the objectives and performance standards for the ICs at the site and to set the requirements for further development of the ICs. The LTS&M Plan was reissued as Draft-Final on March 11, 2005.

The Weldon Spring Site Interpretive Center is part of DOE's long-term surveillance and maintenance activities at the site. Attendance for calendar year 2004 totaled 3,575 which represents a 100% increase over the 2003 attendance of 1,786.

A garden surrounding the Interpretive Center that consists entirely of plants native to the state of Missouri was designed and planted during 2004.

The first annual public meeting required by the LTS&M plan was held on March 25, 2004. This meeting was held to discuss the 2003 first annual inspection which took place in October 2003. Also discussed were changes to the LTS&M Plan, a summary of environmental data and the interpretive center/prairie activities.

The 2004 annual inspection took place on November 17 and 18, 2004. The main areas inspected were the disposal cell, the Quarry, the LCRS, and monitoring wells. Areas where future institutional controls will be established were also inspected to verify that no groundwater or resource use that is incompatible with the necessary restrictions was occurring.

1.0 Introduction

This *Weldon Spring Site Environmental Report for Calendar Year 2004* summarizes the environmental monitoring results obtained in 2004 and presents the status of Federal and State compliance activities.

In 2004, environmental monitoring activities were conducted to support remedial action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), the *National Environmental Policy Act* (NEPA), the *Clean Water Act* (CWA), and other applicable regulatory requirements. The monitoring program at the Weldon Spring Site has been designed to protect the public and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Weldon Spring Site Environmental Report for Calendar Year 2004* include:

- Providing general information on the Weldon Spring Site and the current status of remedial activities.
- Presenting summary data and interpretations for the environmental monitoring program.
- Reporting compliance with Federal, State, and local requirements and DOE standards.
- Providing dose estimates for public exposure to radiological compounds due to activities at the Weldon Spring Site.
- Summarizing trends and/or changes in contaminant concentrations to support remedial actions, ensure public safety, maintain surveillance monitoring requirements, and demonstrate the effectiveness of the remediation.

1.1 Site Description

The Weldon Spring Site is located in St. Charles County, Missouri, about 30 miles (48 kilometers) west of St. Louis (Figure 1–1). The site comprises two geographically distinct DOE-owned properties: the Weldon Spring Chemical Plant and Raffinate Pit Sites (Chemical Plant) and the Weldon Spring Quarry (Quarry). The Chemical Plant is located about 2 miles (2.3 kilometers) southwest of the junction of Missouri State Route 94 and U.S. Highway 40/61. The Quarry is about 4 miles southwest of the Chemical Plant. Both sites are accessible from Missouri State Route 94.

During the early 1940s, the Department of the Army (DA) acquired 17,232 acres (6,974 hectares) of private land in St. Charles County for construction of the Weldon Spring Ordnance Works facility. The former ordnance works site has since been divided into several contiguous areas under different ownership as depicted in Figure 1–2. Current land use of the former ordnance works area includes the DOE Weldon Spring Chemical Plant and Weldon Spring Quarry, the U.S. Army Reserve Weldon Spring Training area, Missouri Department of Conservation (MDC) and Missouri Department Natural Resources-Division of State Parks managed lands, the Francis Howell High School, a Missouri Department of Transportation (MoDOT) maintenance facility, the St. Charles County water treatment facility and law enforcement training center, the village of Weldon Spring Heights, and a University of Missouri research park.

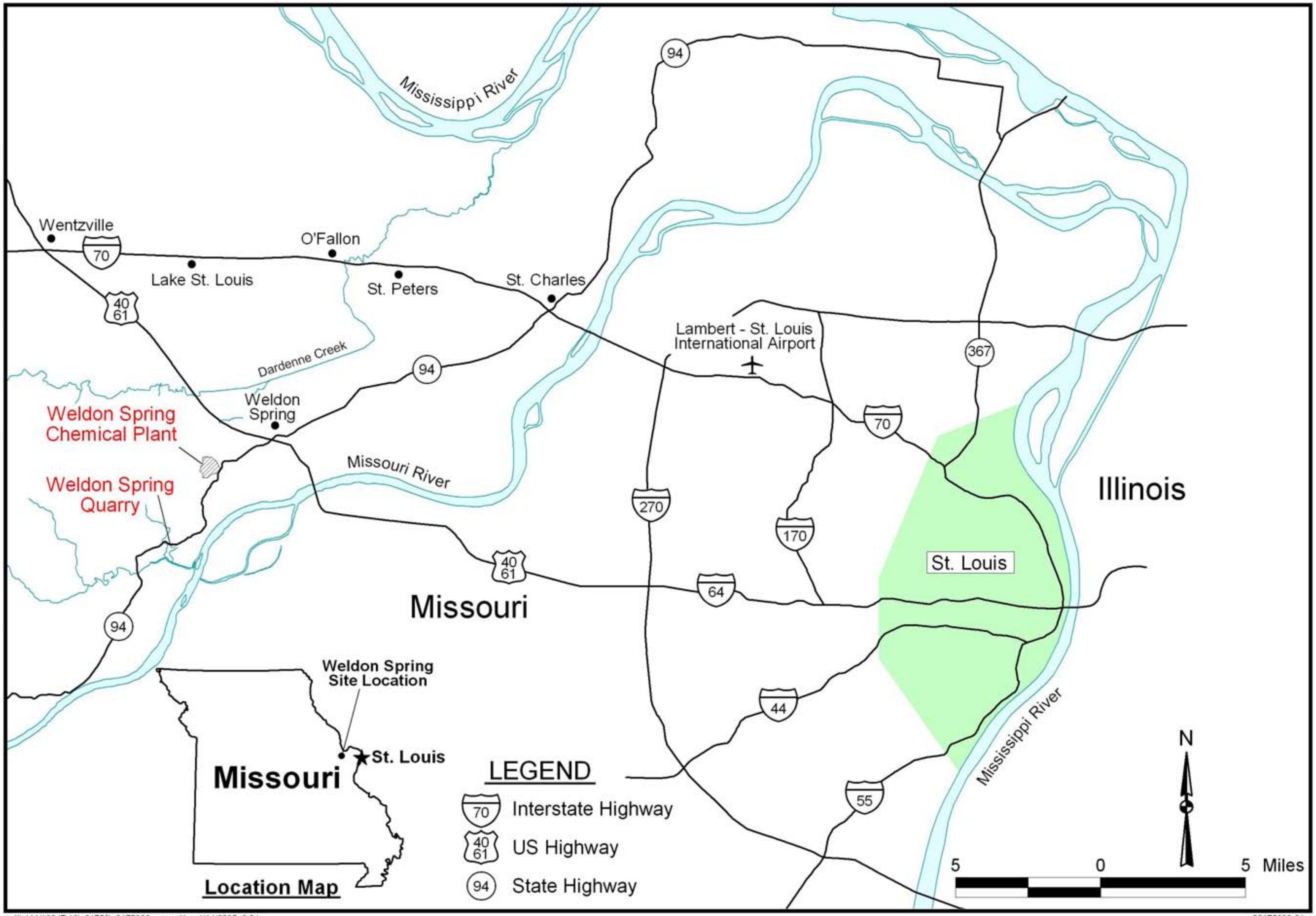

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Figure 1–1. Location of the Weldon Spring, Missouri, Site

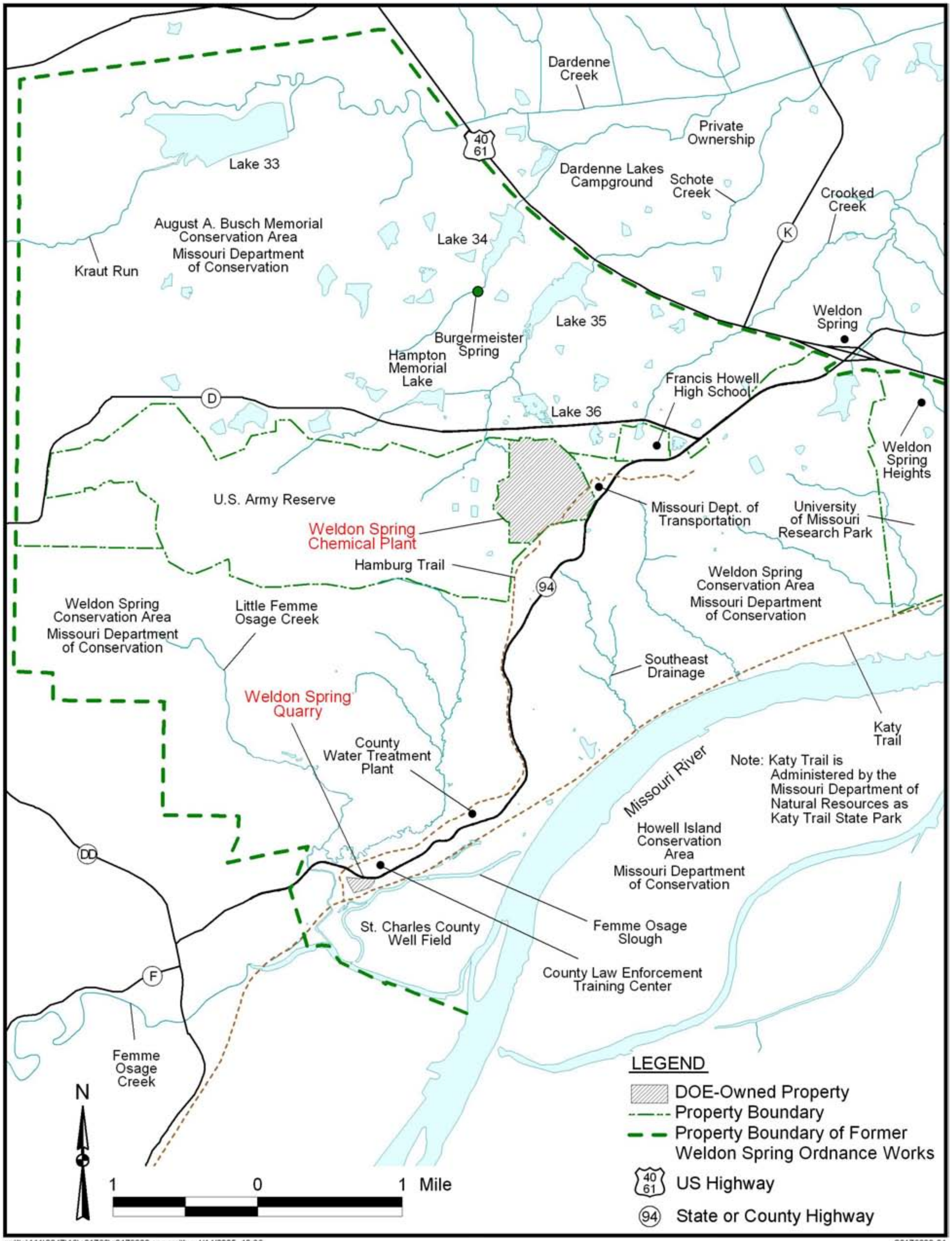

Figure 1–2. Vicinity Map of the Weldon Spring, Missouri, Site

The Chemical Plant and Quarry areas total 228.16 acres (92.33 hectares). The Chemical Plant property is located on 219.50 acres (88.83 hectares); and the Quarry occupies 8.66 acres (3.50 hectares).

1.2 Site History

1.2.1 Operations History

In 1941, the U.S. Government acquired 17,232 acres (6,974 hectares) of rural land in St. Charles County to establish the Weldon Spring Ordnance Works. In the process, the towns of Hamburg, Howell, and Toonerville and 576 citizens of the area were displaced (DA undated). From 1941 to 1945, the DA manufactured trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Ordnance Works site. Four TNT production lines were situated on what was to be the Chemical Plant. These operations resulted in nitroaromatic contamination of soil, sediments, and some off-site springs.

Following a considerable amount of explosives decontamination of the facility by the Army and the Atlas Powder Company, 205 acres (83.0 hectares) of the former ordnance works property were transferred to the U.S. Atomic Energy Commission (AEC) in 1956 for construction of the Weldon Spring Uranium Feed Materials Plant, now referred to as the Weldon Spring Chemical Plant. An additional 14.88 acres (6.02 hectares) were transferred to AEC in 1964. The plant 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 four raffinate pits located on the plant property. Uranium processing operations resulted in radiological contamination of the same locations previously contaminated by former Army operations.

The Weldon Spring Quarry was mined for limestone aggregate used in construction of the ordnance works. The Army also used the Quarry for burning wastes from explosives manufacturing and disposal of TNT-contaminated rubble during operation of the ordnance works. These activities resulted in nitroaromatic contamination of the soil and groundwater at the Quarry.

In 1960, the Army transferred the Quarry to AEC, who used it from 1963 to 1969 as a disposal area for uranium and thorium residues from the Chemical Plant (both drummed and uncontained) and for disposal of contaminated building rubble, process equipment, and soils from demolition of a uranium processing facility in St. Louis. Radiological contamination occurred in the same locations as the nitroaromatic contamination.

Uranium processing operations ceased in 1966, and on December 31, 1967, AEC returned the facility to the Army for use as a defoliant production plant. In preparation for the defoliant process, the Army removed equipment and materials from some of the buildings and disposed of them principally in Raffinate Pit 4. The defoliant project was canceled before any process equipment was installed, and the Army transferred 50.65 acres (20.50 hectares) of land encompassing the raffinate pits back to AEC while retaining the Chemical Plant. AEC and subsequently DOE managed the site, including the Army-owned Chemical Plant, under caretaker status from 1968 through 1985. Caretaker activities included site security oversight, fence maintenance, grass cutting, and other incidental maintenance. In 1984, the Army repaired several of the buildings at the Chemical Plant, decontaminated some of the floors, walls, and ceilings, and isolated some equipment. In 1985, the Army transferred full custody of the Chemical Plant to DOE, at which time DOE designated control and decontamination of the Chemical Plant, raffinate pits, and Quarry as a major project.

1.2.2 Remedial Action History

EPA placed the Quarry and Chemical Plant areas on the National Priorities List (NPL) in 1987 and 1989, respectively. Initial remedial activities at the Chemical Plant, a series of Interim Response Actions (IRAs) authorized through the use of Engineering Evaluation/Cost Analysis (EE/CA) reports, included:

- Removal of electrical transformers, electrical poles and lines, and overhead piping and asbestos that presented an immediate threat to workers and the environment.
- Construction of an isolation dike to divert runoff around the Ash Pond area to reduce the concentration of contaminants going off site in surface water.
- Detailed characterization of on-site debris, separation of radiological and nonradiological debris, and transport of materials to designated staging areas for interim storage.
- Dismantling of 44 Chemical Plant buildings under four separate IRAs.
- Treatment of contaminated water at the Chemical Plant and the Quarry.

Remediation of the Weldon Spring Site was administratively divided into four Operable Units (OUs): Quarry Bulk Waste OU, Quarry Residuals OU, Chemical Plant OU, and Groundwater OU. The Southeast Drainage was remediated as a separate action through an EE/CA report (DOE 1996). The selected remedies are described in the following sections.

1.2.2.1 Chemical Plant OU

In the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1993), DOE established the remedy for controlling contaminant sources at the Chemical Plant (except groundwater) and disposing of contaminated materials in an on-site disposal cell.

The selected remedy included:

- Removal of contaminated soils, sludge, and sediment.
- Treatment of wastes, as appropriate, by chemical stabilization/solidification.
- Disposal of wastes removed from the Chemical Plant and stored Quarry bulk wastes in an engineered on-site disposal facility.

The remedy included remediation of 17 off-site vicinity properties affected by Chemical Plant operations. The vicinity properties were remediated in accordance with Chemical Plant ROD cleanup criteria.

The *Chemical Plant Operable Unit Remedial Action Report* (DOE 2004a) was finalized in January 2004.

1.2.2.2 Quarry Bulk Waste OU

DOE implemented remedial activities for the Quarry Bulk Waste OU set forth in the *Record of Decision for Management of Bulk Wastes at the Weldon Spring Quarry* (DOE 1990b).

The selected remedy included:

- Excavation and removal of bulk waste (i.e., structural debris, drummed and unconfirmed waste, process equipment, sludge, and soil).
- Transportation of the waste along a dedicated haul road to a temporary storage area located at the Chemical Plant.
- Staging of bulk wastes at the temporary storage area.

1.2.2.3 Quarry Residuals OU

The Quarry Residuals OU remedy was described in the *Record of Decision for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1998b). The Quarry Residuals OU addressed residual soil contamination in the Quarry proper, surface water and sediments in the Femme Osage slough and nearby creeks, and contaminated groundwater.

The selected remedy included:

- Long-term monitoring and institutional controls to prevent exposure to contaminated groundwater north of the Femme Osage slough.
- Long-term monitoring and institutional controls to protect the quality of the public water supply in the Missouri River alluvium and implementing a well field contingency plan.
- Confirming the model assumptions regarding extraction of contaminated groundwater and establishing controls to protect naturally occurring attenuation processes.
- Restoring the Quarry and establishing institutional controls.

The *Quarry Residual Operable Unit Remedial Action Report* (DOE 2003b) was finalized in January 2004.

1.2.2.4 Groundwater OU

DOE implemented an interim ROD to investigate the practicability of remediating trichloroethene (TCE) contamination in Chemical Plant groundwater, using in situ chemical oxidation (DOE 2000b). The DOE issued a final ROD in January 2004, which was signed by EPA in February 2004. The Groundwater OU ROD selected a remedy of monitored natural attenuation (MNA) with institutional controls (ICs) to limit groundwater use during the period of remediation. MNA involves the collection of monitoring data to verify the effectiveness of naturally occurring processes to reduce contaminant concentrations over time. The ROD establishes remedial goals and performance standards for MNA. Activities regarding the Groundwater OU are further discussed in Section 3.1.

1.2.2.5 Southeast Drainage

Remedial action for the Southeast Drainage was addressed as a separate action under CERCLA. The *Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1996) was prepared in August 1996 to evaluate the human and ecological health risks within the drainage. The EE/CA recommended that selected sediment in accessible areas of the drainage should be removed with track-mounted equipment and transported by off-road haul trucks to the Chemical Plant. The excavated materials would be stored temporarily at an on-site storage area until final disposal in the disposal cell. Soil removal was in two phases: 1997-1998 and again in 1999. Post-remediation soil sampling was conducted. More details are included in the *Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7* (DOE 1999b).

1.3 Final Site Conditions

Contamination remains at the Weldon Spring Site at the following locations:

- An on-site disposal cell contains approximately 1.48 million cubic yards of contaminated material.
- Residual groundwater contamination remains in the shallow aquifer beneath the Chemical Plant, at the Quarry, and at some surrounding areas.
- Several springs near the Chemical Plant discharge contaminated groundwater.
- Residual soil and sediment contamination remain in the Southeast Drainage.
- Contamination remains at two culvert locations along Missouri State Route 94 and Highway D.
- Residual soil contamination remains at inaccessible locations within the Quarry.

Residual contamination is addressed in the *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site* (LTS&M Plan) (DOE 2005a), which includes institutional controls established to maintain protectiveness of contaminants not contained in the disposal cell. Under current land use conditions, the remaining contamination does not pose unacceptable risks to public health and the environment.

1.4 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 (Kleeschulte, et al. 1986).

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

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

The Weldon Spring Quarry is located in low limestone hills near the northern bank of the Missouri River. The mid-Ordovician bedrock of the Quarry area includes, in descending order, the Kimmswick Limestone, Decorah Formation, and Plattin Limestone. These formations are predominantly limestone and dolomite. Near the Quarry, the carbonate rocks dip to the northeast at a gradient of 11 m/km to 15 m/km (58 ft/mi to 79 ft/mi) (DOE 1990a). Massive Quaternary deposits of Missouri River alluvium cover the bedrock to the south and east of the Quarry.

1.5 Surface Water System and Use

The Chemical Plant and raffinate pits areas are on the Missouri –Mississippi River surface drainage divide. Elevations on the site range from approximately 185 m (608 ft) above mean sea level (msl) near the northern edge of the site to 203 m (665 ft) above msl near the southern edge. (The cell is not included in these elevation measurements.) The natural topography of the site is gently undulating in the upland areas, typical of the Central Lowlands physiographic province. South of the site, the topography changes to the narrow ridges and valleys and short, steep streams common to the Ozark Plateau physiographic province (Kleeschulte, et al. 1986).

No natural drainage channels traverse the site. Drainage from the southeastern portion of the site generally flows southward to a tributary referred to as the Southeast Drainage (or 5300 Drainageway - based on the site’s nomenclature) that flows to the Missouri River.

The northern and western portions of the Chemical Plant site drain to tributaries of the Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River. The manmade 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 water from the lakes or creeks is used for irrigation or for public drinking water supplies.

Before remediation of the Chemical Plant and raffinate pits area began, there were six surface water bodies on the site: the four raffinate pits, Frog Pond, and Ash Pond. The water in the raffinate pits was treated prior to release, and the pits were remediated and confirmed clean. Frog Pond and Ash Pond were flow-through ponds that were monitored prior to being remediated and confirmed clean. Throughout the project, retention basins and sedimentation basins were constructed and used to manage potentially contaminated surface water. During 2001, the four sedimentation basins that remained were remediated, and the entire site was brought to final grade and seeded with temporary vegetation. Final seeding was conducted during 2002.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 k (1 mi) northwest of the Missouri River at approximately River Mile 49. Because of the topography of the area, no direct surface water entered or exited the Quarry before it was remediated. A 0.07 ha (0.2-acre) pond within the Quarry proper acted as a sump that accumulated direct rainfall within the Quarry. Past dewatering activities in the Quarry suggested that the sump interacted directly with the local ground water. All water pumped from the Quarry before remediation was treated before it was released. Bulk waste removal, which included removal of some sediment from the sump area, was completed during 1995. The Quarry was backfilled, graded, and seeded during 2002.

The Femme Osage Slough, located approximately 213 m (700 ft) south of the Quarry, is a 2.4 km (1.5 mi) section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri dammed portions of the creeks between 1960 and 1963 during construction of a levee system around the University experimental farms (DOE 1990a). The slough is essentially land-locked and is currently used for recreational fishing. The slough is not used for drinking water or irrigation.

1.6 Ecology

The Weldon Spring Site is surrounded primarily by State Conservation Areas that include the 2,828 ha (6,988 acre) Busch Conservation Area to the north, the 2,977 ha (7,356 acre) 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 1–2).

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 consists of 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 (DOE 1992b). 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.

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. When bulk waste removal began, this habitat was disturbed. The rim and upper portions of the Quarry still consist primarily of slope and upland forest including cottonwood, sycamore, and oak (DOE 1990a).

1.7 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 (Ruffner and Bair).

The National Oceanic and Atmospheric Administration has published the following information based on analysis of long-term meteorological records for the St. Louis area. Taking into account the past 30 years of data, the average annual temperature is 13.4ºC (56.1°F). The average daily maximum and minimum temperatures are 18.6°C (65.4°F) and 8.2°C (46.7°F), respectively. Maximum temperatures above 32.2°C (90°F) occur about 40 days per year. Minimum daily temperatures below 0°C (32°F) occur about 100 days of the year. Temperatures below -18°C (0°F) are infrequent, occurring less than 5 days per year. Mean annual precipitation in the area is approximately 95.0 cm (37.5 in.).

The on-site meteorological station was dismantled in May 2002 to facilitate final site restoration activities. The precipitation and temperature results in Table 1–1 are from the National Weather Service. Precipitation and average temperature were all within historical ranges for the St. Louis area.

Table 1–1. Monthly Meteorological Monitoring Results for 2004

Month	Total Precipitation (cm)[a]	Average Temp (°C)
January	10.1	-.6
February	2.2	2.2
March	11.1	9.9
April	4.9	15.2
May*	24.8	21.6
June*	2.1	23.6
July*	14.0	25.5
August*	10.4	23.1
September*	0.6	21.9
October*	8.2	15.7
November*	14.6	9.6
December*	4.5	2.7

[a]cm = centimeters

1.8 Land Use and Demography

The population of St. Charles County is about 300,000. Twenty percent of the population lives in the city of St. Charles, approximately 22 km (14 mi) northeast of the Weldon Spring Site. The population in St. Charles County has increased by about 30% over the past 10 years. 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 is about 5,000. No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6 percent of county land, and nonurban areas occupy 90 percent; the remaining 4 percent is dedicated to transportation and water uses (DOE 2001b).

Francis Howell High School (FHHS) is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94 (Figure 1–2). The school employs approximately 150 faculty and staff, and about 1,600 students attend school there. In addition, approximately 50 full-time employees work at the high school annex, and about 50 bus drivers park their school buses in the adjacent parking lot.

The Missouri Department of Transportation Weldon Spring Maintenance facility, located adjacent to the north side of the Chemical Plant, employs about 10 workers. The Army Reserve Training Area is to the west of the Chemical Plant and periodically is visited by Department of the Army (DA) trainees and law enforcement personnel (DOE 2001b). 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 adjacent to the Chemical Plant are operated by the Missouri Department of Conservation and employ about 50 people.

2.0 Compliance Summary

2.1 Compliance Status for 2004

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 CERCLA, the WSSRAP is subject to meeting or exceeding the applicable or relevant and appropriate requirements (ARARs) of Federal, State, and local laws and statutes, such as the *Resource Conservation and Recovery Act* (RCRA), *Clean Water Act* (CWA), *Clean Air Act* (CAA), *National Historic Preservation Act* (NHPA), *Safe Drinking Water Act* (SDWA), *Endangered Species Act*, and Missouri State regulations. Because the U.S. Department of Energy (DOE) is the lead agency for the site, *National Environmental Policy Act* (NEPA) values must be incorporated. The requirements of DOE Orders must also be met. Section 2.1.1 is a summary of WSSRAP compliance with applicable Federal and State regulations, Section 2.1.2 is a summary of WSSRAP compliance with major DOE Orders, and Section 2.1.3 is a discussion of WSSRAP compliance agreements and permits. With near completion of the project, the applicability of certain ARARs has been reduced or eliminated.

2.1.1 Federal and State Regulatory Compliance

2.1.1.1 Comprehensive Environmental Response, Compensation and Liability Act

The WSSRAP has integrated the procedural and documentation requirements of CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and NEPA. The remedial actions conducted under CERCLA are discussed in Section 1.2.2.

Because contamination remains at some of the areas of the Site at levels above those that allow unlimited use and unrestricted exposure, CERCLA requires that the remedial actions be reviewed at least every five years. These reviews are commonly called 5-year reviews. DOE is developing institutional controls to insure that the remedies remain protective effective until contaminant levels decrease to levels that are considered protective.

2.1.1.2 Resource Conservation and Recovery Act

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

A RCRA treatment, storage, and disposal permit was not required at the site since the remediation has been performed in accordance with decisions reached under CERCLA. Section 121(e) of 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 Weldon Spring Site is now considered a conditionally exempt small quantity generator.

The disposal cell contents are not regulated under the Resource Conservation and Recovery Act (RCRA), but RCRA postclosure disposal cell monitoring and maintenance requirements are ARARs. The RCRA groundwater protection standard (40 CFR 264 Subpart F) sets forth the general groundwater monitoring requirements for the disposal cell. Generally, the disposal cell groundwater monitoring program must provide representative samples of background water quality, as well as groundwater passing the point of compliance. For a more complete description, see the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b) which was developed to address these requirements. Additional postclosure requirements for the cell are identified in 40 CFR 264 Subpart N and include action leakage rate and leachate collection and removal requirements. These requirements are addressed in the LTS&M Plan (DOE 2005a). Subpart N also includes requirements to maintain the integrity of the final cover, including making repairs as necessary.

2.1.1.3 Clean Water Act

Effluents discharged to waters of the United States are regulated under the *Clean Water Act* (CWA) through regulations promulgated and implemented by the State of Missouri. The Federal government has granted regulatory authority for implementation of CWA provisions to states with regulatory programs that are at least as stringent as the Federal program.

Compliance with the CWA at the WSSRAP has included meeting parameter limits and permit conditions specified in the National Pollutant Discharge Elimination System (NPDES) permits. Under these permits, both effluent and erosion-control monitoring have been performed. The majority of these remaining permits were terminated in 2003. See Section 2.1.3 for additional discussion regarding the remaining permits.

2.1.1.4 Federal Insecticide, Fungicide, and Rodenticide Act

The WSSRAP maintains compliance with the *Federal Insecticide, Fungicide, and Rodenticide Act*. Material Safety Data Sheets are reviewed for all pesticides before they are purchased. The WSSRAP does not currently use restricted-use pesticides and, therefore, does not possess a permit/license to purchase these materials. The WSSRAP meets State requirements for pesticide application, and reviews each application for State licensing requirements.

2.1.1.5 Safe Drinking Water Act

Safe Drinking Water Act (SDWA) regulations are not applicable because maximum contaminant levels (MCLs) are applicable only to drinking water at the tap, not in groundwater. However, under the National Contingency Plan, MCLs are relevant and appropriate to groundwater that is a potential drinking water source. The principal ARARs for the impacted groundwater at the Chemical Plant are the MCLs and Missouri water quality standards, which were established in the GWOU ROD, and are shown in Table 2–1.

Table 2–1. Federal and State Water Quality Standards for the Chemical Plant Groundwater OU

Constituent	Standard	Citation
Nitrate (as N)	10 mg/L	40 CFR 141.62
Total Uranium	20 pCi/L	40 CFR 141
1,3-DNB	1.0 µg/L	10 CSR 20-7[a]
2,4-DNT	0.11 µg/L	10 CSR 20-7[a]
NB	17 µg/L	10 CSR 10-7[a]
TCE	5 µg/L	40 CFR 141.61
2,6-DNT	1.3 µg/L	Risk Based[b]
2,4,6-TNT	2.8 µg/L	Risk Based[c]

[a]Missouri Groundwater Quality Standard.
[b]Risk-based concentration equivalent to 10^{-5} for a resident scenario.
[c]Risk-based concentration equivalent to 10^{-6} for a resident scenario.
Key: DNT = dinitrotoluene; mg/L = milligram(s) per liter; pCi/L = picocurie per liter; µg/L = microgram(s) per liter

Long-term groundwater monitoring for the Quarry Residuals OU consists of two separate programs. Groundwater monitoring is necessary to continue to ensure that uranium-contaminated groundwater has a negligible potential to affect the St. Charles County well field. The first program details the monitoring of uranium and 2,4-DNT south of the slough to ensure that levels remain protective of human health and the environment. The second program consists of monitoring groundwater contaminant levels within the area north of the slough until they attain a predetermined target level indicating negligible potential to affect groundwater south of the slough.

The objective for monitoring groundwater south of the slough is to verify that the groundwater is not impacted. Uranium concentrations south of the slough and in the area of production wells at the St. Charles County well field remain within the observed natural variation within the aquifer; therefore the MCL for uranium of 20 pCi/L has been established as a trigger level only in this area. If concentrations in groundwater south of the slough exceed the MCL of 20 pCi/L, DOE will evaluate risk and take appropriate action.

Under current conditions, groundwater north of the slough poses no imminent risk to human health from water obtained from the well field. A target level of 300 pCi/L for uranium (10 percent of the 1999 maximum) was established to represent a significant reduction in the contaminant levels north of the slough. The target level for 2,4-DNT has been set at 0.11 µg/L, the Missouri Water Quality standard.

2.1.1.6 Emergency Planning and Community Right-to-Know Act

The site no longer stores large quantities of chemicals and none above a threshold level, therefore the site is not required to submit a 2004 *Emergency Planning and Community Right-to-Know Act* (EPCRA) Tier II report.

The Toxic Release Inventory (TRI) report for 2004 is due on July 1, 2005. Based on the chemical usage in 2004, the Weldon Spring Site is not required to submit a TRI report.

2.1.2 DOE Order Compliance

2.1.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment

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

The estimated total effective dose equivalent to the hypothetical maximally exposed individual was due to consumption of water from the Southeast Drainage. This dose was calculated to be 0.20 mrem, which is well below the 100 mrem (1 mSv) guideline for all potential exposure pathways.

2.1.2.2 DOE Order 231.1A, Environmental, Safety, and Health Reporting

DOE Order 231.1A and DOE Manual 231.1-1A ensures collection and reporting of information on environment, safety and health that is required by law or regulation. This site environmental report fulfills the requirement of the order to summarize the environmental data annually. These directives also include requirements for occurrence reporting. There were no occurrences as defined by these directives at the site during 2004.

2.1.3 Permit and Agreement Compliance

2.1.3.1 NPDES Permits

Four active NPDES operating permits which covered storm and treated water discharges were terminated in 2003. These included discharges from the Quarry (MO-0108987); storm water discharges from the Borrow Area (MO-R100B69); hydrostatic test water discharges from the site (MO-G670203); and storm water discharges from the Quarry borrow area (MO-R104031).

The Missouri Department of Natural Resources (MDNR) issued a revised permit (MO-0107701) on October 3, 2003, which eliminated the stormwater outfalls at the Chemical Plant site and revised the same permit on March 5, 2004 to remove the sanitary wastewater treatment plant and transferred it to Lindenwood University under State Operating Permit No. MO-0129917. This permit now only covers the SWTP discharge line. The SWTP discharge line will only be used if the site ever operates Train 3 at the leachate collection and removal system (LCRS) as a contingency to current disposal methods (see Section 2.1.3.3).

MDNR issued a hydrostatic water permit (MO-G67A009) to the Weldon Spring Site in August 2004. This permit allowed discharge of potable water that was used to hydrostatically test the system designed to pre-treat leachate (See Section 3.3). Approximately 4,000 gallons were discharged on September 21, 2004. Samples were collected as required by the permit and all analytical results were in compliance with permitted limits. The data is shown in Table 2–2. A discharge monitoring report summarizing the discharge was issued to MDNR on October 29, 2004.

Table 2–2. Hydrostatic Test Water Results

Parameter	Units	Result
pH	s.u.	7.33
Temperature	°C	22.34
Total Oil and Grease	mg/L	5.0
Total Suspended Solids	mg/L	2.0

2.1.3.2 Federal Facility Agreement

A Federal Facility Agreement (FFA) was signed by the EPA and DOE in 1986, and it was amended in 1992. The main purpose of the FFA is to establish a procedural framework and schedule for developing, implementing and monitoring appropriate response actions at the Site in accordance with CERCLA. An FFA Quarterly report is issued to EPA and MDNR each quarter which documents compliance with the FFA and reports on activities at the site.

2.1.3.3 Metropolitan St. Louis Sewer District (MSD) Agreement

The Weldon Spring Site has approval from the Metropolitan St. Louis Sewer District to haul disposal cell leachate and purge water to their Bissell Point Plant. The DOE received notification in April 2004 that the leachate must meet the radiological drinking water standard of 30 μg/L (20 pCi/L) prior to acceptance. The disposal cell leachate was very close to this limit in 2004, therefore the DOE exercised a pretreatment contingency process and began treating the leachate through a system of cartridge filters and ion exchange media that is selective for uranium. The leachate was sampled after treatment and found to be significantly below the 30 μg/L limit for uranium. The DOE also had an allocation of 0.15 millicuries per year of radioactivity and 15,000 gallons per month. The DOE requested and received approval to raise the allocation of 15,000 gallons per month to 25,000 gallons per month. The disposal cell is not generating any additional leachate, but the increased volume limit provides added operational flexibility related to the pretreatment options and hauling. Further information regarding the leachate is discussed in Section 3.3.

End of current text

3.0 Environmental Monitoring Summary

3.1 Groundwater Monitoring

The following are highlights of the 2004 groundwater monitoring program. These items, and others, are discussed in detail in this chapter.

- Starting in July 2004, the monitoring at the Chemical Plant was changed to implement the selected remedy of monitored natural attenuation (MNA). This implementation of the new monitoring program resulted in a more focused monitoring strategy and therefore a reduction of monitoring locations and parameters has occurred.
- Total uranium continues to be present in the groundwater near the former raffinate pits. Four of the 61 wells sampled for uranium exceeded the drinking water standard of 30 μg/L (20 pCi/L). Two of the wells, MW-3024 and MW-3030, also exceeded the standard in 2003. The other two locations are new wells installed in the unweathered zone of the Burlington Keokuk limestone in support of the MNA remedy for the GWOU.
- The areas of highest impact continue to be present in the Raffinate Pit and Ash Pond areas. Average nitrate concentrations exceeded the MCL of 10 mg/L at 37 of the 56 wells sampled for nitrate.
- Nitroaromatic compounds were monitored in 64 locations across the Chemical Plant area. The areas of highest impact occur in the Frog Pond and Raffinate Pit Areas. The Missouri Water Quality Standard (MWQS) for 2,4-DNT of 0.11 μg/L was equaled or exceeded at 20 locations and the MWQS for 1,3-DNB of 1.0 μg/L was exceeded at one location. The risk-based concentration of 2.8 μg/L for 2,4,6-TNT was exceeded at two locations and the risk-based concentration of 1.3 μg/L for 2,6-DNT was exceeded at nine locations. The MWQS for nitrobenzene (NB) of 17 μg/L was not exceeded at any location.
- Volatile organic compounds (VOC) were sampled at 43 locations to monitor the extent of contamination and changes in concentration that may have resulted from remedial activities and groundwater field studies performed in the area of TCE impact. Eighteen of these wells exceeded the MCL of 5 μg/L for TCE.
- Burgermeister Spring was sampled for nitrate, uranium, VOCs, and nitroaromatic compounds. Monitoring results for Burgermeister Spring were within historical ranges and were in the same general range as concentrations reported in 2003.
- Two springs in the Southeast Drainage and two additional springs located in the Burgermeister Spring Branch were monitored for uranium and nitrate during 2004. Concentrations at these springs were similar to those measured during 2003. VOCs and nitroaromatics were monitored in the two Southeast Drainage springs, and one of the additional Burgermeister Spring Branch locations in 2004. The concentrations of these latter constituents were also similar to those measured at the springs in 2003.
- At the Weldon Spring Quarry, the highest levels of uranium continue to occur in the bedrock downgradient from the Quarry and in the alluvial material north of the Femme Osage Slough. The drinking water standard of 30 μg/L (20 pCi/L) was exceeded at thirteen locations, which were the same locations of uranium exceedance in 2003. 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.

- Nitroaromatic compound impact continues to occur in the alluvial materials or bedrock downgradient of the Quarry and north of the Femme Osage Slough. Results were similar to those reported in 2003. Two wells had reported data concentrations of 2,4-DNT that exceeded the MWQS of 0.11 µg/L.
- Uranium concentrations were within background ranges, and no detectable concentrations of nitroaromatic compounds were observed in groundwater south of the Femme Osage Slough.
- Iron and sulfate are monitored as indicators of the geochemistry of the groundwater in the vicinity of the Quarry. Results are similar to those reported during 2003, and continue to confirm the presence of a geochemical reducing zone, which is inhibiting migration of uranium-contaminated groundwater.
- Groundwater detection monitoring for the disposal cell that was initiated in June 1998 continued in 2004. Results of the sampling indicated that the baseline tolerance limits (BTLs) for iron and manganese were exceeded in MW-2032 during December 2004. Resampling in February 2005 confirmed the elevated values. This well was found to be inundated with organic debris as a result of invasion by ants. As a first step, the well has been purged of this debris and will be resampled to determine to what extent this problem may have contributed to the elevated levels. A demonstration report (DOE 2005c) has been prepared as outlined in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b).

The groundwater monitoring program at the Weldon Spring Site includes sampling and analysis of water collected from wells at the Chemical Plant, the Quarry site, adjacent properties, and selected springs in the vicinity of the Chemical Plant site. The groundwater monitoring program is formally defined in the LTS&M Plan (DOE 2005a).

Due to lithologic differences, including geologic features that influence groundwater flow, and the geographical separation of the Chemical Plant and Quarry areas, separate groundwater monitoring programs have been established for the two sites. Generalized geologic and hydrologic descriptions of the two sites are found in Section 1.4. A generalized stratigraphic column for reference is provided in Figure 3–1, and hydrogeologic descriptions of lithologies monitored for the program are in Sections 3.1.1.1 and 3.1.2.1. The appropriate cleanup standards for groundwater for each area of the Weldon Spring Site are summarized in Section 2.1.1.5.

3.1.1 Chemical Plant Groundwater

Since remediation activities began in 1987, more than 100 monitoring locations have been used for groundwater observations and sampling. Each year, wells are installed and/or abandoned as necessary to support the changing needs of the project. During 2004, four wells were installed in support of the long-term monitoring program for the Groundwater Operable Unit (GWOU). A total of 72 wells and 5 springs were routinely sampled to monitor the groundwater impacts of historical Chemical Plant operations and recent remedial activities, and to establish a baseline for monitored natural attenuation of contaminants of concern in the shallow aquifer.

System	Series	Stratigraphic Unit	Typical Thickness (feet)[a]	Physical Characteristics	Hydrostratigraphic Unit
Quaternary	Holocene	Alluvium	0–120	Gravelly, silty loam	Alluvial aquifer
	Pleistocene	Loess and glacial drift[b]	10–60	Silty clay, gravelly clay, silty loam, or loam over residuum from weathered bedrock	Locally a leaky confining unit[c]
Mississippian	Meramecian	Salem Formation[c]	0–15	Limestone, limey dolomite, finely to coarsely crystalline, massively bedded, and thin bedded shale	
		Warsaw Formation[c]	0–80	Shale and thin to medium bedded finely crystalline limestone with interbedded chert	
	Osagean	Burlington-Keokuk Limestone	100–200	Cherty limestone, very fine to very coarsely crystalline, fossiliferous, thickly bedded to massive	Shallow aquifer system
		Fern Glen Limestone	45–70	Cherty limestone, dolomitic in part, very fine to very coarsely crystalline, medium to thickly bedded	
	Kinderhookian	Chouteau Limestone	20–50	Dolomitic argillaceous limestone, finely crystalline, thin to medium bedded	Upper leaky confining unit
Devonian	Upper	Sulphur Springs Group Bushberg Sandstone[d]	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[e]	0–30	Calcareous to dolomitic silty shale and mudstone, thinly laminated to massive	
	Champlainian	Kimmswick Limestone	70–100	Limestone, coarsely crystalline, medium to thickly bedded, fossiliferous and cherty near base	Middle aquifer system
		Decorah Group	30–60	Shale with thin interbeds of very finely crystalline limestone	Lower confining unit
		Plattin Limestone	100–130	Dolomitic limestone, very finely crystalline, fossiliferous, thinly bedded	
		Joachim Dolomite	80–105	Interbedded very finely cystalline, 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 crystalline, minor chert and shale	
		Cotter Dolomite	200–250	Argillaceous, cherty dolomite, fine to medium crystalline, interbedded with shale	
		Jefferson City Dolomite	160–180	Dolomite, fine to medium crystalline	
		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	

[a]Thickness estimates vary depending on data source.
[b]Glacial drift unit includes the Ferrelview Formation and is saturated in the northern portion of the Ordnance Works where this unit behaves locally as a leaky confining unit.
[c]The Warsaw and Salem Formations are not present in the Weldon Spring area.
[d]The Sulphur Springs Group also includes the Bachelor Sandstone and the Glen Park Limestone.
[e]The Maquoketa Shale is not present in the Weldon Spring Area.

Figure 3–1. Generalized Stratigraphy and Hydrostratigraphy of the Weldon Spring, Missouri, Site

3.1.1.1 Hydrogeologic Description

The Chemical Plant site is in a physiographic transitional area between the Dissected Till Plains of the central lowlands province to the north and the Salem Plateau of the Ozark Plateaus province to the south. The Chemical Plant and raffinate pit area lithologies consist of two major geologic units; unconsolidated surficial material and carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated. Thicknesses of the unconsolidated materials range from 6.1 m to 15.3 m (20 ft to 50 ft) (DOE 1992a).

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

Potential groundwater impacts are assessed by monitoring groundwater from the monitoring well network at the site. The aquifer of concern beneath the Chemical Plant, raffinate pits, and vicinity properties is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the uppermost bedrock unit). The Burlington-Keokuk Limestone is composed of two different lithologic zones, a shallow weathered zone underlain by an unweathered zone. The weathered portion of this formation is highly fractured and exhibits solution voids and enlarged fractures. These features may also be found on a limited scale in the unweathered zone. The unweathered portion of the Burlington-Keokuk Limestone is thinly to massively bedded. Fracture densities are significantly less in the unweathered zone than in the weathered zone. Localized aquifer properties are controlled by fracture spacing, solution voids, and preglacial weathering, including structural troughs along the bedrock-overburden interface.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Some wells that are screened in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. Most of the wells are completed in the weathered zone of the bedrock where groundwater has the greatest potential to be contaminated. Where possible, monitoring wells within the boundaries of the Chemical Plant area are located near historical contaminant sources and preferential flow pathways (paleochannels) to assess migration in the groundwater system. Additional wells are located outside the Chemical Plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 3–2).

Springs, a common feature in carbonate terrains, are present in the vicinity of the site. Four springs are monitored routinely. These springs (SP-5303, SP-5304, SP-6301 and SP-6303), shown on Figure 3–3, have been historically influenced by Chemical Plant discharge water and/or groundwater that contained one or more of the contaminants of concern. Spring 6306 is monitored occasionally, as a result of public comments, and has been demonstrated to be unimpacted by site contaminants.

The presence of elevated total uranium and nitrate levels at Burgermeister Spring (SP-6301), which is 1.9 km (1.2 mi) north of the site, indicates that discrete flow paths are present in the vicinity of the site. Groundwater tracer tests performed in 1995 (DOE 1997) indicated that a discrete and rapid subsurface hydraulic connection exists between the northern portion of the Chemical Plant and Burgermeister Spring.

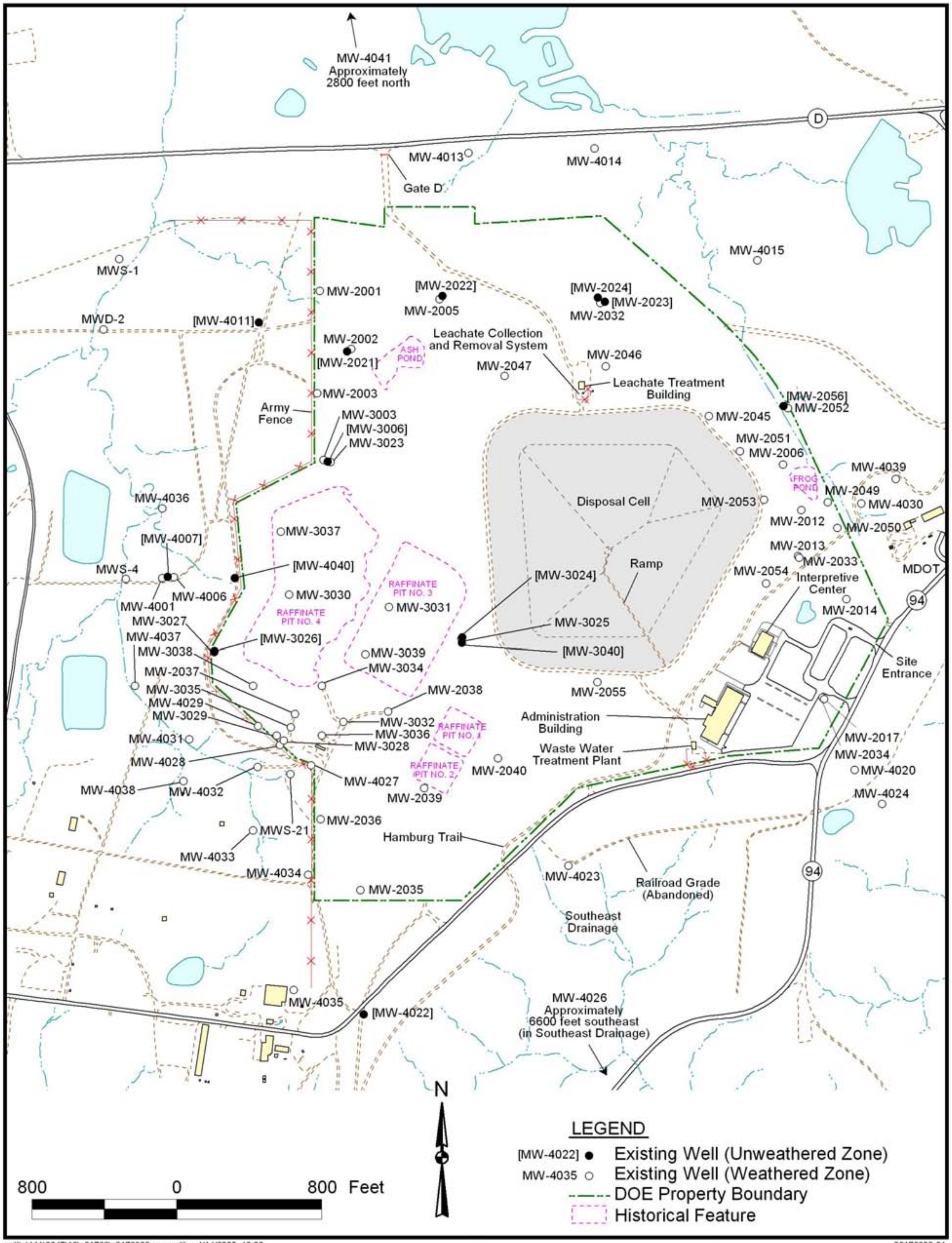

Figure 3–2. Existing Monitoring Well Network

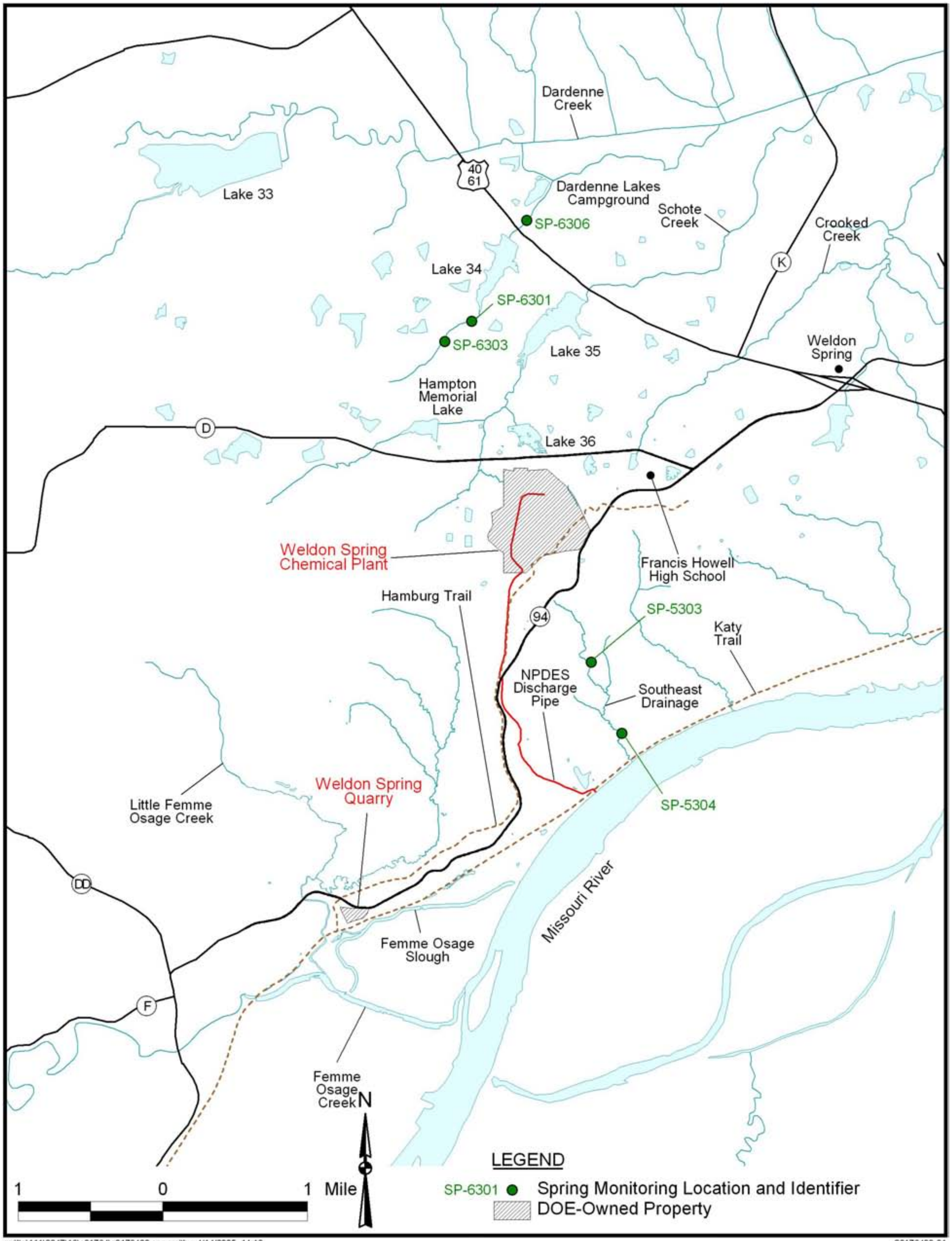

Figure 3–3. Spring Monitoring Locations at the Chemical Plant Area of the Weldon Spring, Missouri, Site

3.1.1.2 Chemical Plant Monitoring Program

Starting in July 2004, the monitoring at the Chemical Plant was changed to implement the selected remedy of monitored natural attenuation (MNA). A sampling program was developed in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit* (DOE 2004c). A summary of monitoring locations and parameters are found in the LTS&M Plan (DOE 2005a). The monitoring well locations are shown in Figure 3–2. The spring locations are shown in Figure 3–3. This implementation of the new monitoring program resulted in a more focused monitoring strategy; therefore, a reduction of monitoring locations and parameters has occurred.

Total uranium, nitroaromatic compounds, VOCs, and nitrate (as N) were monitored at selected locations throughout the Chemical Plant area. The sampling locations target areas of highest impact in the shallow aquifer and migration pathways associated with paleochannels in the weathered unit of the Burlington-Keokuk Limestone. Analytical results for all monitored parameters are summarized and discussed in Section 3.1.1.3.

Prior to construction of the Chemical Plant, the site was part of a Department of the Army Ordnance Works complex for production of the nitroaromatic compounds trinitrotoluene (TNT) and dinitrotoluene (DNT). Nitroaromatic compounds occur in groundwater in the northeastern and southwestern portions of the Chemical Plant, where TNT production lines were located. Four nitroaromatic production lines were located within the boundaries of the Chemical Plant and raffinate pits area. Wastes generated from the initial operation of these early production lines were disposed of in open earthen pits and seepage from these pits impacted the shallow groundwater. One such pit, Lagoon 1, was located along the northeast boundary of the Chemical Plant. Wastewater containing nitroaromatic compounds was initially discharged to surface drainages and then later transported through wooden pipe networks. Starting in 1999, upward trends in nitroaromatic concentrations were observed in the Frog Pond area, notably at well MW-2012. The upward trends are most likely the result of excavation of TNT-impacted soil in this area and in the nearby waste lagoon excavated by the Army, and are expected to be temporary. During 2004, selected locations in the Ash Pond, Frog Pond, and Raffinate Pits areas were analyzed for nitroaromatic compounds.

The highest concentrations of nitrate have typically been measured in the vicinity of the Raffinate Pits and Ash Pond, which are historical sources of this contaminant. Nitrates are mobile in the shallow aquifer system; therefore, their distribution is greater than the other contaminants. The pits contained ore-refining wastes from uranium ore concentrates that were digested with nitric acid during the original Chemical Plant operations. During 2004, groundwater samples from selected locations in the Raffinate Pits and Ash Pond areas were analyzed for nitrate.

TCE was detected in groundwater southeast of the former Raffinate Pit 4 during 1996. The contamination extends from east of former Raffinate Pit 3 to south and southwest of former Raffinate Pit 4, just beyond the boundary of the adjacent Army site. The source of TCE contamination was drums discarded in Raffinate Pit 4. VOC monitoring was conducted at selected wells during 2004 to monitor trends in the area of TCE impact, and evaluate the effect of remediation activities on VOC contamination levels.

Uranium contamination occurs in the Raffinate Pit area. The Raffinate Pits were the historical source of uranium in groundwater as it entered the aquifer via infiltration through the overburden. The adsorption of uranium onto the overburden limited its extent in groundwater. Uranium was monitored at locations in the Raffinate Pits and Ash Pond areas during 2004.

Groundwater moves under the Chemical Plant by both diffuse and discrete flow components. In order to monitor the discrete flow component, five springs were monitored during 2004. All five were monitored for total uranium and nitrate, and nitroaromatic compounds and VOCs were monitored at all but SP-6306.

3.1.1.3 Chemical Plant Monitoring Results

Analytical data for contaminants monitored during 2004 (e.g., uranium, nitrate, volatile organic compounds, and nitroaromatic compounds) are summarized and compared with background levels and/or cleanup standards. Average annual concentrations are compared to background levels established during the GWOU remedial investigation (DOE 1997).

Uranium. Total uranium, which was measured at 58 monitoring wells during 2004, continues to be present in the groundwater near the former raffinate pits. In 2004, groundwater from 33 monitoring well locations exceeded the average background level of 0.93 pCi/L (0.03 Bq/L) established during the GWOU remedial investigation (DOE 1997). Four wells exceeded the drinking water standard of 30 µg/L (20 pCi/L) (40 CFR 141). Average uranium concentrations for all 58 wells are shown in Table 3–1. Two of the wells that exceeded the uranium standard, MW-3024 and MW-3030, also exceeded the standard in 2003. The other two locations where the standard was exceeded (MW-3040 and MW-4040) are new wells installed in support of the MNA remedy for the GWOU. Wells MW-2021, MW-2036, and MW-4002 were previously analyzed for uranium analysis. Due to the change in the monitoring program in July 2004, these locations were deleted from the sampling program.

Nitrate. In 2004, nitrate (as N) was monitored at 54 monitoring wells in the Chemical Plant area as part of the MNA program. The areas of highest impact continue to be present in the Raffinate Pit and Ash Pond Areas. Average nitrate concentrations exceeded the MCL of 10 mg/L (40 CFR 141) at 37 of those locations (Table 3–2). Wells MW-2036 and MW-4002 were previously analyzed for nitrate. Due to changes in the monitoring program in July 2004, these locations were deleted from the sampling program.

Nitroaromatic Compounds. Nitroaromatic compounds, which are not naturally occurring, were monitored in 64 locations across the Chemical Plant area. At least 1 compound was detected in 44 of these monitoring wells (Table 3–3). The areas of highest impact occur near Frog Pond and the Raffinate Pits. New historic highs were reported during 2004 at several wells in the vicinity of Frog Pond. Levels of nitroaromatic compounds have increased in this area since 1997, most likely as a result of soil remediation by the DOE and Army in this area. The Missouri Water Quality Standard (MWQS) for 2,4-DNT of 0.11 µg/L was equaled or exceeded at 20 locations and the MWQS for 1,3-DNB of 1.0 µg/L was exceeded at one location. The risk-based concentration of 2.8 µg/L for 2,4,6-TNT was exceeded at two locations and the risk-based concentration of 1.3 µg/L for 2,6-DNT was exceeded at nine locations. The MWQS for nitrobenzene of 17 µg/L was not exceeded at any location.

Table 3–1. Annual Averages for Total Uranium at the Weldon Spring Chemical Plant

Location	Zone	Average (pCi/L)	Number of Samples
MW-2001	Weathered	0.58	1
MW-2002	Weathered	0.47	1
MW-2003	Weathered	3.0	2
MW-2005	Weathered	0.89	1
MW-2017	Weathered	8.0	1
MW-2034	Weathered	3.4	1
MW-2035	Weathered	0.39	1
MW-2037	Weathered	0.39	1
MW-2038	Weathered	2.0	2
MW-2039	Weathered	4.0	2
MW-2040	Weathered	2.9	2
MW-2056	Weathered	0.76	1
MW-3003	Weathered	10.8	2
MW-3006	Unweathered	1.2	2
MW-3023	Weathered	9.8	2
MW-3024	Unweathered	**28.8**	3
MW-3025	Weathered	2.7	2
MW-3026	Unweathered	0.96	1
MW-3027	Weathered	0.76	1
MW-3028	Weathered	0.96	1
MW-3029	Weathered	0.89	1
MW-3030	Weathered	**51.1**	3
MW-3031	Weathered	2.7	2
MW-3032	Weathered	0.36	1
MW-3034	Weathered	1.8	1
MW-3035	Weathered	1.1	1
MW-3036	Weathered	1.6	1
MW-3037	Weathered	2.4	1
MW-3038	Weathered	0.76	1
MW-3039	Weathered	1.2	1
MW-3040	Unweathered	**89.8**	4
MW-4001	Weathered	0.39	1
MW-4006	Weathered	1.7	1
MW-4007	Unweathered	0.38	1
MW-4011	Unweathered	0.63	1
MW-4013	Weathered	1.6	1
MW-4014	Weathered	< 0.10	1
MW-4020	Weathered	12.6	1
MW-4022	Unweathered	4.0	2
MW-4023	Weathered	2.3	2
MW-4024	Weathered	4.6	1
MW-4026	Alluvium	< 0.10	2
MW-4027	Weathered	< 0.10	1
MW-4028	Weathered	0.76	1
MW-4029	Weathered	0.69	1
MW-4031	Weathered	0.64	1
MW-4032	Weathered	0.69	1
MW-4033	Weathered	0.60	1
MW-4034	Weathered	0.52	1
MW-4036	Weathered	11.9	3

Table3–1 (continued). Annual Averages for Total Uranium at the Weldon Spring Chemical Plant

Location	Zone	Average (pCi/L)	Number of Samples
MW-4037	Weathered	8.2	1
MW-4038	Weathered	2.2	1
MW-4040	Unweathered	**182**	4
MW-4041	Weathered	2.6	3
MWS-1	Weathered	0.86	2
MWD-2	Unweathered	< 0.10	1
MWS-4	Weathered	0.40	3
MWS-21	Weathered	1.2	1

Concentrations in **BOLD** - Average Concentration exceeds the drinking water standard of 30 µg/L (20 pCi/L).
Note 1: Background uranium concentration equals 0.93 pCi/L (weathered unit) and 0.48 pCi/L (unweathered unit).

Table 3–2. Annual Nitrate Averages at the Weldon Spring Chemical Plant

Location	Zone	Average (mg/L)	Number of Samples
MW-2001	Weathered	**56.5**	1
MW-2002	Weathered	**103**	1
MW-2003	Weathered	**76.5**	1
MW-2005	Weathered	**40.5**	1
MW-2021	Unweathered	ND	2
MW-2035	Weathered	0.32	1
MW-2037	Weathered	**249**	1
MW-2038	Weathered	**632**	2
MW-2039	Weathered	**133**	1
MW-2040	Weathered	**158**	2
MW-3003	Weathered	**268**	2
MW-3006	Unweathered	ND	2
MW-3023	Weathered	**93.4**	1
MW-3024	Unweathered	**108**	1
MW-3025	Weathered	**77.3**	1
MW-3026	Unweathered	**74.6**	1
MW-3027	Weathered	**46.7**	1
MW-3028	Weathered	**221**	1
MW-3029	Weathered	**153**	1
MW-3030	Weathered	**80.7**	1
MW-3031	Weathered	**87.7**	1
MW-3032	Weathered	2.11	1
MW-3034	Weathered	**406**	2
MW-3035	Weathered	**154**	1
MW-3036	Weathered	**58.4**	1
MW-3037	Weathered	**435**	1
MW-3038	Weathered	4.53	1
MW-3039	Weathered	**110**	1
MW-3040	Unweathered	**284**	4
MW-4001	Weathered	**61.9**	1
MW-4006	Weathered	6.01	1
MW-4007	Unweathered	ND	2
MW-4011	Unweathered	**112**	1
MW-4013	Weathered	**180**	2
MW-4014	Weathered	2.12	2
MW-4022	Unweathered	0.32	1

Table 3–2 (continued). Annual Nitrate Averages at the Weldon Spring Chemical Plant

Location	Zone	Average (mg/L)	Number of Samples
MW-4023	Weathered	1.30	1
MW-4026	Alluvium	ND	1
MW-4027	Weathered	5.67	1
MW-4028	Weathered	**135**	1
MW-4029	Weathered	**466**	2
MW-4031	Weathered	**178**	2
MW-4032	Weathered	**137**	1
MW-4033	Weathered	3.62	1
MW-4034	Weathered	ND	1
MW-4036	Weathered	**27.1**	2
MW-4037	Weathered	**180**	1
MW-4038	Weathered	**533**	1
MW-4040	Unweathered	**105**	4
MW-4041	Weathered	0.14	3
MWS-1	Weathered	**12.4**	2
MWD-2	Unweathered	ND	1
MWS-4	Weathered	2.21	3
MWS-21	Weathered	**91.2**	1

Concentrations in **BOLD** - Average concentrations exceeds the MWQS for nitrate (as N) of 10 mg/L.

Table 3–3. Annual Averages for 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	Number Of Samples
Cleanup Standard	None	1.0 µg/L	2.8 µg/L	0.11 µg/L	1.3 µg/L	17 µg/L	---
MW-2001	0.25	0.04	< 0.08	0.10	0.18	< 0.08	1
MW-2002	< 0.04	< 0.05	< 0.08	0.06	0.30	< 0.08	1
MW-2003	< 0.04	< 0.05	< 0.08	**0.14**	0.82	< 0.08	1
MW-2005	0.60	0.21	< 0.08	0.09	0.37	< 0.08	1
MW-2006	6.5	< 0.05	< 0.08	< 0.06	0.63	< 0.08	2
MW-2012	257	**1.66**	**163**	**1087**	**890**	< 0.08	3
MW-2013	6.2	< 0.05	< 0.08	**0.16**	**1.35**	< 0.08	2
MW-2014	2.7	0.07	< 0.08	**0.16**	0.43	< 0.08	3
MW-2017	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-2022	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2
MW-2023	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2
MW-2033	10.6	< 0.05	1.1	**0.40**	**3.4**	< 0.08	2
MW-2035	< 0.05	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-2037	< 0.08	< 0.05	< 0.08	**0.12**	< 0.13	< 0.08	1
MW-2038	< 0.08	< 0.05	< 0.08	**0.19**	< 0.13	< 0.08	2
MW-2039	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-2040	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2
MW-2045	0.08	0.07	< 0.08	0.09	0.68	< 0.08	2
MW-2049	0.18	< 0.05	0.50	**0.13**	**14.4**	< 0.08	2
MW-2050	9.5	0.34	< 0.08	**41.7**	**28.7**	< 0.08	3
MW-2052	3.1	0.07	0.33	< 0.06	< 0.13	< 0.08	3
MW-2053	7.4	< 0.05	**6.8**	< 0.06	**4.0**	< 0.08	3
MW-2054	0.62	0.08	< 0.08	**6.0**	**36.3**	< 0.08	3
MW-2056	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	3
MW-3003	< 0.08	< 0.05	< 0.08	**0.31**	0.51	< 0.08	1
MW-3006	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2

Table 3–3 (continued). Annual Averages for 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	Number Of Samples
MW-3023	< 0.08	< 0.05	< 0.08	0.08	0.65	< 0.08	1
MW-3024	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-3025	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-3026	0.32	< 0.05	< 0.08	**0.11**	0.24	< 0.08	1
MW-3027	0.25	< 0.05	< 0.08	< 0.06	0.15	< 0.08	1
MW-3028	0.31	0.14	< 0.08	**0.14**	< 0.13	< 0.08	1
MW-3029	0.55	0.12	< 0.08	**0.11**	< 0.13	< 0.08	2
MW-3030	< 0.08	< 0.05	< 0.08	**1.0**	0.34	< 0.08	3
MW-3031	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-3032	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-3034	0.18	0.06	< 0.08	**0.41**	0.09	< 0.08	3
MW-3035	0.41	0.10	< 0.08	**0.14**	< 0.13	< 0.08	1
MW-3036	0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2
MW-3037	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2
MW-3038	0.16	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	2
MW-3039	0.20	0.06	< 0.08	**0.78**	< 0.13	< 0.08	3
MW-3040	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-4001	35	< 0.05	2.0	< 0.06	**1.9**	< 0.08	1
MW-4006	15	< 0.05	< 0.08	< 0.06	**2.4**	< 0.08	1
MW-4007	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-4013	24.5	< 0.05	< 0.08	< 0.06	0.62	< 0.08	2
MW-4014	< 0.08	< 0.05	< 0.08	0.07	< 0.13	< 0.08	2
MW-4015	4.9	< 0.05	< 0.08	0.06	0.96	< 0.08	3
MW-4026	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-4027	< 0.08	0.07	< 0.08	0.06	< 0.13	< 0.08	1
MW-4028	< 0.08	< 0.05	< 0.08	0.07	< 0.13	< 0.08	1
MW-4029	1.4	0.18	0.07	**0.14**	< 0.13	< 0.08	2
MW-4030	6.4	0.09	2.2	**0.18**	0.73	< 0.08	2
MW-4031	3.4	< 0.05	0.69	< 0.06	< 0.13	< 0.08	1
MW-4032	1.7	0.06	< 0.08	0.08	< 0.13	< 0.08	1
MW-4033	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MW-4036	0.27	< 0.05	< 0.08	< 0.06	0.25	< 0.08	2
MW-4039	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	3
MW-4040	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	3
MW-4041	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	3
MWS-1	< 0.08	< 0.05	< 0.08	< 0.06	0.12	< 0.08	2
MWD-2	< 0.08	< 0.05	< 0.08	< 0.06	< 0.13	< 0.08	1
MWS-21	0.08	0.08	< 0.08	< 0.06	< 0.13	< 0.08	1

< All samples less than the highest detection limit.
Concentrations in **BOLD** - Average concentration exceeds the cleanup standard.

Fourteen monitoring locations in the Frog Pond area were also selected to monitor for the following breakdown products of nitroaromatics: 2-AM-4,6-DNT; 4-AM-2,6-DNT; 2-NT; 3-NT; and 4-NT. The breakdown product data were evaluated to try to determine whether the contaminants were originating from the area of Production Line #1 or from the area of Army Lagoon #1. Nitroaromatic contaminants at Army Lagoon #1 should differ from those associated with Production Line #1 due to photodegradation processes at the Lagoon . Wells downgradient from both of these previously remediated areas showed contamination consistent with nitroaromatic breakdown, although the higher concentrations at MW-2012 continue to point toward the area of Production Line #1 as the primary contributor to groundwater contamination. Results are presented in Table 3–4. The monitoring of breakdown products will not be continued in 2005 as the investigation regarding source areas in this part of the site was completed in 2004. It was concluded that two source areas contributed to the contamination in this area. A more complete discussion can be found in the Completion Report for the Frog Pond Groundwater Investigation (DOE 2004e).

Table 3–4. Annual Averages for Nitroaromatic Breakdown Compounds Near Frog Pond (μg /L)

Location	2-AM-4,6-DNT	4-AM-2,6-DNT	2-NT	3-NT	4-NT	Number of Samples
MW-2006	1.4	1.1	0.26	< 0.07	< 0.05	2
MW-2012	14.5	< 0.07	1650	125	106	2
MW-2013	1.4	1.4	0.14	0.14	< 0.05	2
MW-2014	0.37	0.52	< 0.11	< 0.07	< 0.05	2
MW-2033	1.8	1.7	0.87	0.27	< 0.05	2
MW-2045	0.70	0.69	< 0.11	0.17	< 0.05	2
MW-2049	1.0	1.2	4.2	0.43	< 0.05	2
MW-2050	3.1	2.8	28.5	2.2	8.2	2
MW-2052	1.5	0.78	< 0.11	< 0.07	< 0.05	2
MW-2053	4.4	2.8	0.32	0.10	< 0.05	2
MW-2054	0.34	0.40	4.0	0.80	0.13	2
MW-4015	2.3	2.8	0.21	0.12	< 0.05	2
MW-4030	1.6	1.4	0.16	0.09	< 0.05	2
MW-4039	< 0.05	< 0.07	< 0.11	< 0.07	< 0.05	2

Volatile Organic Compounds. VOC monitoring continued through 2004 to monitor the extent of contamination and changes in concentration that may have resulted from remedial activities and groundwater field studies performed in the area of TCE impact. Twenty-one wells demonstrated detectable levels of at least one VOC. The analytical results for 1,2-DCE, PCE, TCE or vinyl chloride are summarized in Table 3–5. Eighteen of these wells exceeded the MCL of 5 μg/L for TCE.

Table 3–5. Annual Average VOC Concentrations at the Weldon Spring Chemical Plant

Location	1,2-DCE (µg/L)	PCE (µg/L	TCE (µg/L)	Vinyl Chloride (µg/L)	Number of Samples
MW-2013	< 2	< 1	< 1	NA	1
MW-2035	< 2	< 1	< 1	NA	1
MW-2037	2.15	< 1	**195**	NA	2
MW-2038	< 2	< 1	**19.0**	NA	1
MW-2039	< 2	< 1	< 1	NA	1
MW-2056	< 2	< 1	< 1	< 2	1
MW-3003	< 2	< 1	< 1	< 2	1
MW-3006	< 2	< 1	< 1	< 2	2
MW-3023	< 2	< 1	< 1	< 2	1
MW-3024	< 2	< 1	**9.60**	< 2	1
MW-3025	< 2	< 1	**5.10**	< 2	1
MW-3026	< 2	< 1	3.20	< 2	1
MW-3027	< 2	< 1	2.20	< 2	1
MW-3028	< 2	< 1	**27.5**	NA	2
MW-3029	3.70	< 1	**235**	NA	2
MW-3030	19.5	0.96	**415**	< 2	2
MW-3031	< 2	< 1	< 1	NA	2
MW-3032	< 2	< 1	< 1	NA	1
MW-3034	14.0	< 1	**450**	NA	3
MW-3035	2.50	< 1	**345**	NA	2
MW-3036	< 2	< 1	**5.20**	NA	1
MW-3037	< 2	0.70	< 1	NA	2
MW-3038	< 2	< 1	< 1	< 2	1
MW-3039	8.30	< 1	**265**	NA	2
MW-3040	< 2	< 1	< 1	< 2	3
MW-4001	< 2	< 1	**6.3**	NA	1
MW-4006	< 2	< 1	< 1	NA	1
MW-4007	< 2	< 1	< 1	NA	2
MW-4027	< 2	1.1	< 1	NA	1
MW-4028	< 2	< 1	< 1	< 2	2
MW-4029	7.30	< 1	**597**	NA	3
MW-4031	< 2	< 1	**140**	NA	1
MW-4032	< 2	< 1	**41.5**	NA	2
MW-4033	< 2	< 1	< 1	NA	1
MW-4036	< 2	< 1	< 1	NA	2
MW-4037	< 2	< 1	**53.0**	NA	1
MW-4038	< 2	< 1	**17.0**	NA	1
MW-4040	< 2	< 1	< 1	< 2	3
MW-4041	< 2	< 1	< 1	< 2	3
MWS-1	< 2	< 1	< 1	< 2	2
MWD-2	< 2	< 1	< 1	< 2	1
MWS-4	< 2	< 1	< 1	< 2	3
MWS-21	< 2	< 1	**45.5**	NA	2

<DL All samples less than highest detection limit.
NA Parameter not analyzed at this location
Concentrations in **BOLD**: Concentration exceeds the Missouri water quality standard of 5 µg/L for TCE.

Burgermeister Spring (SP-6301) is a perennial spring that represents a primary localized emergence of groundwater impacted by a recognizable contribution of contaminants from the Chemical Plant throughout the year. It is monitored to evaluate contaminant contributions from groundwater and occasional runoff. Average measured concentrations during 2004 at Burgermeister Spring for nitroaromatic compounds, nitrate, TCE, and uranium, are presented in Table 3–6. These results are similar to those observed during 2003. With the exception of

2,4-DNT, the levels of nitroaroamatic chemicals at the spring were consistently below their corresponding detection limits. TCE was not detected during the year and nitrate was measured at levels below its standard. Uranium occurred at relatively low concentrations.

Table 3–6. 2004 Monitoring Data for Burgermeister Spring

Parameter	Average	Maximum
1,3,5-Trinitrobenzene (µg/L)	<0.08	<0.08
1,3-Dinitrobenzene (µg/L)	<0.07	<0.07
2,4,6-Trinitrotoluene (µg/L)	<0.08	<0.08
2,4-Dinitrotoluene (µg/L)	0.04	0.09
2,6-Dinitrotoluene (µg/L)	<0.13	<0.13
Nitrate as Nitrogen (mg/L)	2.05	3.49
Trichloroethene (µg/L)	<0.13	<0.13
Uranium (pCi/L)	24.18	38.9

Four other springs were monitored during 2004 to assess the potential for contaminated groundwater discharge to additional exposure points. Two of these springs are located in the Southeast Drainage (SP-5303 and SP-5304), and the remaining two are located in the Burgermeister Spring Branch (SP-6303 and SP-6306). Spring water in the Southeast Drainage is impacted by residual contamination deposited in fractures in the bedrock. The source of this residual material was historical process sewer discharges from the Chemical Plant site and wastewater discharges from the former ordnance works. Results from the sampling of additional springs are shown in Table 3–7. TCE was reported at concentrations less than its detection limit.

Table 3–7. 2004 Annual Average Monitoring Data for Springs

Parameter	SP-5303	SP-5304	SP-6303	SP-6306
1,3,5-Trinitrobenzene (µg/L)	0.20	<0.08	0.11	NA
1,3-Dinitrobenzene (µg/L)	<0.05	<0.05	<0.07	NA
2,4,6-Trinitrotoluene (µg/L)	22.67	0.06	<0.08	NA
2,4-Dinitrotoluene (µg/L)	0.04	<0.06	0.04	NA
2,6-Dinitrotoluene (µg/L)	0.22	<0.13	0.17	NA
Nitrate as Nitrogen (mg/L)	0.20	0.49	2.37	0.04
Trichloroethene (µg/L)	<1.0	<1.0	<1.0	NA
Uranium (pCi/L)	39.90	53.48	1.09	1.98

< All samples less than the highest detection limit.
NA Parameter not analyzed at this location

3.1.1.4 Trend Analysis

Statistical tests for time-dependent trends at the Chemical Plant were performed on historical and current data from select groundwater wells. Trending was performed on total uranium, nitrate, TCE, and nitroaromatic compounds data for the Chemical Plant area.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-

Kendall test. Results of the TREND analyses indicate the potential presence of statistically significant trends and their direction upward or downward. The trend testing output data are to be interpreted as screening indicators based on existing cumulative data. Results of the analyses are not intended to be used for the prediction of future concentrations, but they may be used to indicate areas that should be more closely monitored in the future.

The TREND program was selected because it can easily facilitate missing data and does not require the data to conform to a particular distribution (such as a normal or log-normal distribution). The nonparametric method used in this program is valid for scenarios where there are a high number of non-detect data points. Data reported as trace concentrations or less than the detection limit can be used by assigning them a common value that is smaller than the smallest measured value in the data set (i.e., one-half the specified quantitation limit). This approach is valid since only the relative magnitudes of the data, rather than their measured values, are used in the method. The TREND program has been used in past analyses of the site groundwater data. Thus, use of the TREND program offered the advantage of maintaining continuity in the analysis methodology.

The two-tailed version of the Mann-Kendall test was employed to detect either an upward or downward trend for each data set. In this approach, a test statistic, Z, is calculated. A positive value of Z indicates that the data are skewed in an upward direction, and a negative value of Z indicates that the data are skewed in a downward direction. The alpha value (or error limit) used to identify a significant trend was 0.05. In the two-tailed test at the 0.05 alpha level of significance, the null hypothesis of "no trend" was rejected if the absolute value of the Z statistic was greater than Z_1-$\alpha/_2$, where Z_1-$\alpha/_2$ was obtained from a cumulative normal distribution table. In other words, the absolute value of the TREND output statistic, Z was compared to the table $Z_{.975}$ value of 1.96. If the absolute value of the Z output statistic was greater than 1.96, then a significant trend was reported.

The linear slope, which is calculated independently of the trend was estimated for all data sets in which an upward or downward trend was identified. The slope was estimated using a nonparametric procedure included in the computer code for the TREND program. A 100% (1-α) two-sided confidence interval about the true slope was obtained by the nonparametric technique. The direction and magnitude of the slope, along with the upper and lower 95% confidence limit estimates, are included in the summary tables.

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

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

3.1.1.5 Chemical Plant Trend Results

Starting in July 2004, the monitoring program was modified to reflect the required sampling to support the selected remedy of monitored natural attenuation for the shallow aquifer at the Chemical Plant. A set of wells has been selected to verify that contamination concentrations are declining with time at a rate and in a manner so that cleanup standards will be met in approximately 100 years (DOE 2004c). These wells are sampled for uranium, nitrate, nitroaromatic compounds, or TCE based on their position near the locations of highest concentrations of contamination, both near former source areas and along expected migration pathways. The monitoring program outlines that these wells will be trended for uranium, nitrate, nitroaromatic compounds, or TCE to indicate the potential presence of statistically significant trends. Two new wells (MW-3040 and MW-4040) were not trended because sufficient data has not been collected from these two locations.

The springs discharge groundwater that includes contaminated groundwater originating from the Chemical Plant site. Continued improvement of the water quality in these affected springs should be observed over time. Trend analyses are performed at the springs to evaluate if downward trends are occurring.

A total of 17 well locations and 4 springs were trended for specified parameters (Table 3–8). Stationary trends were reported at the majority of the well locations trended. Stationary trends were reported at each of the springs for the parameters trended. Upward trends were reported for four wells at the Chemical Plant. Downward trends were reported for 3 wells. A summary is presented below:

- Uranium levels in MW-3030 in the Raffinate Pit area exhibited an upward trend in 2004. This is a change from 2003 where a stationary trend was determined. This well also had a uranium value that was a 3-year high. This well is located within the area of highest uranium impact and it is expected that some temporary upward trends will be observed due to dispersion of the plume along the known migration pathways as uranium attenuates over time.
- TCE exhibited an upward trend in MW-3034 in 2004. This well was influenced by a chemical oxidation treatment for TCE during 2002 when TCE was destroyed at this location. Since completion of this treatment in this area, concentrations of TCE in this well have rebounded to pre-treatment concentrations. Concentrations during 2004 reflect 3-year highs; however, they are not historical highs. This well is located within the area of highest impact for TCE and it is expected that some temporary upward trends will be observed due to dispersion of the plume along the known migration pathways as TCE attenuates over time.
- The nitroaromatic compound 2,4-DNT also exhibited an upward trend in MW-3034 in 2004. During 2002 a study of groundwater withdrawal and artificial recharge was performed in the vicinity of this well and the dilution effects of these activities were observed in the well. This well is now apparently showing a gradual rebound to pre-study concentrations. Concentrations in 2004 reflect 3-year highs; however, they are not historical highs. This well is likely exhibiting signs of reaching equilibrium with the remainder of the area of 2,4-DNT impact.
- The concentrations of 2,6-DNT in MW-2050 and MW-2054 in the Frog Pond area have exhibited an upward trend in 2004. Both of these locations also had concentrations that were 3-year highs. Upward trends were also reported for these locations in 2003. A possible explanation for the upward trends is rebound from recent remedial actions in the Frog Pond area.

Table 3–8. Chemical Plant Groundwater Wells Trend Analysis Summary For 2002-2004

Well ID	Location	Parameter	No. of Samples	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope	95% Upper & Lower Confidence Intervals On Slope 2002-2004	2004 New High Concentration
MW-2012	Frog Pond Area	1,3-DNB	14	1	S	0.6	-0.069 , 1.66	No
		2,4,6-TNT	14	0	S	-25	-61.758 , 20.0	No
		2,4-DNT	14	0	S	-50	-253.451 , 142.079	No
		2,6-DNT	14	0	S	-50	-181.876 , 100.0	No
MW-2014	Frog Pond Area	2,4-DNT	12	0	S	0.012	-0.005 , 0.043	No
		2,6-DNT	12	1	S	0.06	-0.079 , 0.150	No
MW-2038	Raffinate Pit Area	2,4-DNT	10	1	S	-0.01	-0.070 , 0.075	No
		Nitrate	11	0	S	-83	-222.241 , 97.948	No
MW-2040	Raffinate Pit Area	Nitrate	8	0	S	11.75	-32.244 , 58.244	No
MW-2046	Frog Pond Area	2,4,6-TNT	6	0	S	0	-0.476 , 0.676	No
MW-2050	Frog Pond Area	2,4-DNT	13	1	S	5.25	-0.691 , 11.0	No
		2,6-DNT	13	1	U	11.5	8.0 , 14.845	33.0
MW-2052	Frog Pond Area	2,4-DNT	14	7	D	-0.033	-0.055 , -0.005	No
		2,6-DNT	14	6	S	-0.04	-0.158 , 0.017	No
MW-2053	Frog Pond Area	2,4,6-TNT	14	2	S	1.05	-0.617 , 2.309	11.0
		2,4-DNT	14	9	D	-0.085	-0.151 , 0.0	No
		2,6-DNT	14	1	S	-0.15	-1.0 , 1.527	No
MW-2054	Frog Pond Area	2,4-DNT	14	1	S	1.7	-0.589 , 5.535	14.0
		2,6-DNT	14	3	U	17.5	5.975 , 23.976	49.0
MW-3003	Raffinate Pit Area	Nitrate	8	0	S	14	-134.968 , 127.074	No
		Uranium	9	0	S	-0.9	-3.825 , 0.20	No
MW-3024	Raffinate Pit Area	Uranium	11	0	D	-13.825	-18.787 , -4.18	No
MW-3030	Raffinate Pit Area	2,4-DNT	14	0	S	0	-0.081 , 0.081	No
		Uranium	14	0	U	109	49.0 , 156.01	58.7
		TCE	12	0	S	-2	-3.735 , -0.20	500
MW-3034	Raffinate Pit Area	2,4-DNT	14	1	U	0.065	0.014 , 0.13	0.49
		Nitrate	11	0	S	0.5	-234.949 , 131.239	773
		TCE	14	5	U	202.5	31.902 , 304.75	610
MW-3039	Raffinate Pit Area	2,4-DNT	10	0	S	-0.1	-0.547 , 0.20	No
MW-4013	Ash Pond Area	Nitrate	5	0	S	44.2	N too small, 169.503	286
MW-4029	Raffinate Pit Area	Nitrate	11	0	S	-15.5	-89.44 , 85.378	No
		TCE	14	0	S	60	-10.345 , 125.863	740
MW-4031	Raffinate Pit Area	Nitrate	11	0	S	-49.75	-88.779 , -22.08	No
MW-4036	Raffinate Pit Area	Nitrate	4	0	S	-6.05	N too small	No
SP-5303	Southeast Drainage	Uranium	10		S	-18.71	-54.96 , 8.805	No
		Nitrate	6		S	-0.179	N too small , -0.027	No
SP-5304	Southeast Drainage	Uranium	13		S	1.3	-12.494 , 11.942	No
		Nitrate	9		S	-0.277	-0.809 , 0.003	No
SP-6301	Burgermeister Spring Area	Uranium	14		S	-0.3	-15.315 , 10.519	No
		Nitrate	16		S	-0.712	-1.808 , 0.155	No
SP-6303	Burgermeister Spring Area	Uranium	12		S	-0.255	-0.759 , 0.344	No
		Nitrate	10		S	-1.07	-2.898 , 0.186	No

D = Downward U = Upward S = Stationary
Units: Uranium – pCi/L/yr; nitroaromatic compounds – µg/L/yr; Nitrate – µg/L/yr; TCE – µg/L/yr

- Downward trends in 2,4-DNT were determined for MW-2052 and MW-2053 in the Frog Pond area for 2004. This is a change from 2003, when stationary trends were reported for both of these locations.
- Uranium in has exhibited a downward trend in MW-3024 in the Raffinate Pits area. A downward trend was also reported in 2003 for this well.

3.1.2 Weldon Spring Quarry

Since the project began in 1987, more than 100 monitoring wells have been used for groundwater observations and sampling in the Quarry area. Each year, wells are installed and/or abandoned as necessary to support the changing needs of the project. During 2004, six wells were abandoned in support of the long-term monitoring program for the Quarry Residuals Operable Unit (QROU). These wells were not designated for long-term monitoring of the project. A total of 34 wells were routinely sampled to monitor the contaminant concentrations in close proximity to the Quarry proper and the water quality in the Missouri River alluvium (Figure 3–4).

3.1.2.1 Quarry Hydrogeologic Description

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 (DOE 1989). Three Ordovician-age formations comprise the bedrock: the Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium along the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium thickness increases with distance from the bluff towards the river where the maximum thickness is approximately 31 m (100 ft). The alluvium is truncated at the erosional contact with the Ordovician bedrock bluff (Kimmswick, Decorah, and Plattin formations), which also composes the rim wall of the Quarry. The bedrock unit underlying the alluvial materials north of the Femme Osage Slough is the Decorah Group. Primary sediments between the bluff and the Femme Osage Slough are intermixed and interlayered clays, silts, and sands. Organic materials are intermixed throughout the sediments.

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

Eight groundwater monitoring wells once located in the Darst Bottom area approximately 1.6 km (1 mi) southwest of the St. Charles County well field were utilized to study the water quality of the Missouri River alluvium upgradient of the Quarry. These wells provided a reference for background values for uranium in the well field area and have been sampled by both the USGS (1992) and the DOE (1994). These wells have since been abandoned. A summary of uranium background values used at the Quarry is provided in Table 3–9 (DOE 1998a).

Table 3–9. Background Uranium Values for Aquifer Units at the Quarry

Unit	Uranium (pCi/L)	
	Background Value (UCL95)[d]	Background Range
Alluvium[a]	2.77 pCi/L	0.1 - 16
Kimmswick/Decorah[b]	3.41 pCi/L	0.5 - 8.5
Plattin[c]	3.78 pCi/L[e]	1.2 - 5.1

[a]Darst Bottom Wells (USGS and DOE)
[b]MW-1034 and MW-1043 (DOE)
[c]MW-1042 (DOE)
[d]UCL95 = 95th percentile upper confidence limit on the mean concentration
[e]This background value is lower than previously published based on recent data evaluation

3.1.2.2 Quarry Monitoring Program

Long-term monitoring at the Quarry consists of two programs designed to (1) monitor uranium levels south of the slough to ensure they remain protective of human health and the environment, and (2) monitor contaminant levels within the area of groundwater impact north of the slough until they attain target levels that have been identified as having negligible impact on the groundwater south of the slough (DOE 2000a).

The groundwater monitoring strategy consists of a stepped approach. The wells have been separated into 4 lines (Figure 3–4) that provide specific information:

- The first line of wells (Line 1) monitors the area of impact within the bedrock rim of the Quarry proper. These wells (MW-1002, MW-1004, MW-1005, MW-1027, MW-1030) are sampled to establish trends in contaminant concentrations within the areas of higher impact.

- The second line of wells monitors the area of impact within the alluvial materials and shallow bedrock north of the slough (MW-1006, MW-1007, MW-1008, MW-1009, MW-1012, MW-1013, MW-1014, MW-1015, MW-1016, MW-1028, MW-1031, MW-1032, MW-1045, MW-1046, MW-1047, MW-1048, MW-1049, MW-1051, MW-1052). These wells are also sampled to establish trends in contaminant concentrations within the areas of higher impact and to monitor the oxidizing and reducing environments that are present within this area.

- The third line of wells monitors the alluvial material directly south of the slough. These wells (MW-1017, MW-1018, MW-1019, MW-1021, MW-1044, MW-1050) have shown no impact from Quarry contaminants and are monitored as the first line of warning for potential migration of uranium south of the slough.

- The fourth line of wells monitors the same portion of the alluvial aquifer that supplies the well field. These wells (RMW-1, RMW-2, RMW-3, RMW-4) are sampled to monitor the groundwater quality of the productive portions of the alluvial aquifer and to determine the occurrence of uranium outside the range of natural variation.

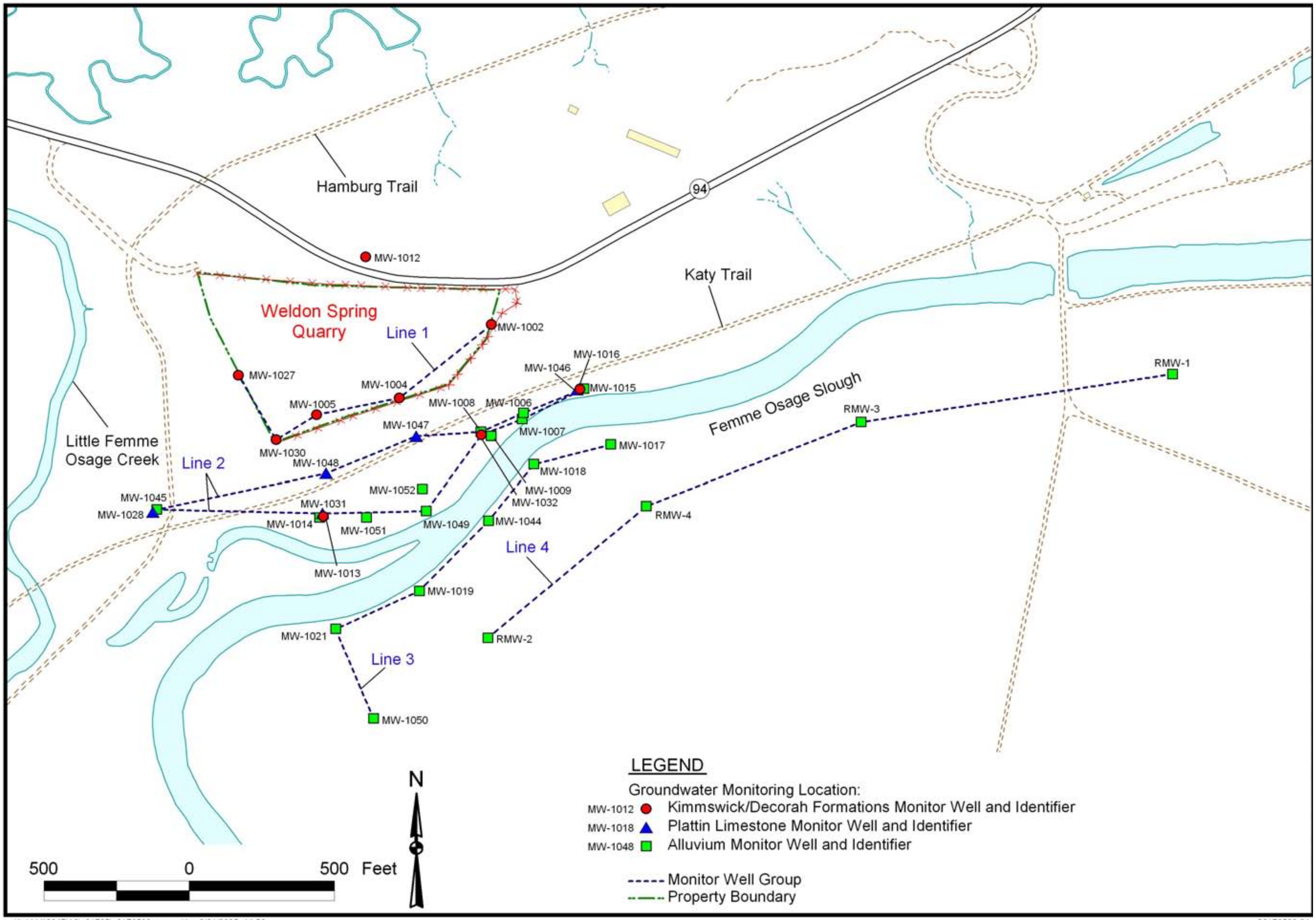

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Figure 3–4. Groundwater Monitor Well Locations at the Quarry Area of the Weldon Spring, Missouri, Site

The frequency of sampling for each location is based on the distance of the well from the source or migration pathway. Monitoring wells on the Quarry rim are sampled quarterly for total uranium. The quarterly sampling helps establish the trend in concentrations at these locations and monitors the effects of Quarry dewatering and bulk waste removal activities on the groundwater system. All Quarry locations are sampled at least annually for uranium, nitroaromatic compounds, and sulfate.

St. Charles County has its own well field monitoring program that was initiated in 1989 as a result of cooperative efforts between DOE, St. Charles County, and MDNR. This program is funded by a DOE grant. The program for 2004 consisted of annual, quarterly, and monthly sampling events of operating production wells, the RMW-series wells, and raw and treated water from the water plant. Results of this monitoring program can be obtained through the Division of Environmental Services for St. Charles County.

3.1.2.3 Monitoring Results for Groundwater Within the Area of Impact at the Quarry

Uranium. The uranium values continue to indicate that the highest levels occur in the bedrock and alluvial materials between the Quarry rim and the Femme Osage Slough. The 2004 annual averages for total uranium are summarized in Table 3–10. Fourteen locations north of the slough exceed applicable maximum background concentrations for uranium listed in Table 3–9.

Table 3–10. Annual Groundwater Averages for Total Uranium (pCi/L) at the Weldon Spring Quarry

Location	Line	Unit	Average (pCi/L)	Number of Samples
MW-1002	1	Kimmswick-Decorah	4.36	4
MW-1004	1	Kimmswick-Decorah	**924**	4
MW-1005	1	Kimmswick-Decorah	**784**	4
MW-1027	1	Kimmswick-Decorah	245	4
MW-1030	1	Kimmswick-Decorah	8.24	4
MW-1006	2	Alluvium	**1326**	4
MW-1007	2	Alluvium	8.48	4
MW-1008	2	Alluvium	**2432**	4
MW-1009	2	Alluvium	0.78	4
MW-1012	2	Kimmswick-Decorah	2.32	4
MW-1013	2	Kimmswick-Decorah	**676**	4
MW-1014	2	Alluvium	**1353**	4
MW-1015	2	Kimmswick-Decorah	140	4
MW-1016	2	Alluvium	109	4
MW-1028	2	Plattin	1.65	2
MW-1031	2	Plattin	12.0	4
MW-1032	2	Kimmswick-Decorah	**1106**	4
MW-1045	2	Alluvium	2.42	4
MW-1046	2	Plattin	2.47	4
MW-1047	2	Plattin	1.18	4
MW-1048	2	Plattin	**329**	4
MW-1049	2	Alluvium	15.9	4
MW-1051	2	Alluvium	**1057**	4
MW-1052	2	Alluvium	**1101**	4

Concentrations in **BOLD** - Annual average exceeds target level of 300 pCi/L.
Applicable background concentrations are given in Table 3–9

The attainment objective for the long-term monitoring for the groundwater north of the slough is that the 90th percentile of the data within a monitoring year is below the target level of 300 pCi/L for uranium (DOE 2000a). Ten wells north of the slough exceeded the target level of 300 pCi/L in 2004. Based on the 2004 data, the 90th percentile of the data is 1,289 pCi/L. This is a slight increase from 2003, when the 90th percentile of the uranium data was 1,110 pCi/L. Uranium monitoring will continue in 2005.

Nitroaromatic Compounds. In 2004, samples from Quarry monitoring wells were analyzed for the 6 primary nitroaromatic compounds. The monitoring wells, which have historically been impacted with nitroaromatic compounds, are situated in the alluvial materials or bedrock downgradient of the Quarry and north of the Femme Osage Slough. Results were similar to those reported in 2003.

A summary of the annual averages for 2,4-DNT for those locations where detectable concentrations were reported is provided in Table 3–11. The 2,4-DNT average concentration for location MW-1027 remained above the Missouri Water Quality Standard of 0.11 µg/L during 2004. Location MW-1006 had three reported concentrations that exceeded 0.11 µg/L; although the average concentration is less than 0.11 µg/L. Background comparisons are not discussed since nitroaromatic compounds are not naturally occurring compounds.

Table 3–11. Annual Groundwater Averages for 2,4-DNT (µg/L) at the Weldon Spring Quarry

Location	Unit	Average (µg/L)	Maximum (µg/L)	Number of Samples
MW-1004	Kimmswick-Decorah	0.04	0.08	4
MW-1006	Alluvium	0.10	**0.15**	4
MW-1027	Kimmswick-Decorah	**10.3**	**13.0**	4
MW-1032	Kimmswick-Decorah	0.03	0.07	4

Concentrations in BOLD – Annual average exceeds the Missouri Water Quality Standard of 0.11 µg/L for 2,4-DNT

The attainment objective for the long-term monitoring of groundwater north of the slough is that the 90th percentile of the data within a monitoring year is below the target level of 0.11 µg/L for 2,4-DNT and that all wells exhibit stable or downward trends (DOE 2000a). Based on the 2004 data, the 90th percentile of the data is 0.03 µg/L; however, an upward trend has been observed in MW-1027. Monitoring for 2,4-DNT will continue in 2005.

Sulfate. Sulfate levels in 2004 (Table 3–12) in the monitoring wells in the bedrock of the Quarry rim and in the alluvial materials north of the Femme Osage Slough were similar in magnitude to those observed in 2003. Sulfate is monitored as an indicator of the geochemistry of the groundwater, as higher sulfate concentrations are generally observed in an oxidizing environment. Oxidizing conditions in 2003 and 2004 could also cause the relatively elevated uranium concentrations observed in this area (Table 3–10).

Table 3–12. Annual Groundwater Averages for Sulfate (mg/L) at the Weldon Spring Quarry

Location	Line	Unit	Annual Average (mg/L)	Number of Samples
MW-1002	1	Kimmswick-Decorah	102	4
MW-1004	1	Kimmswick-Decorah	123	4
MW-1005	1	Kimmswick-Decorah	182	4
MW-1027	1	Kimmswick-Decorah	60.4	4
MW-1030	1	Kimmswick-Decorah	67.7	4
MW-1006	2	Alluvium	97.2	4
MW-1007	2	Alluvium	9.10	4
MW-1008	2	Alluvium	72.6	4
MW-1009	2	Alluvium	39.8	4
MW-1012	2	Kimmswick-Decorah	47.2	4
MW-1013	2	Kimmswick-Decorah	102	4
MW-1014	2	Alluvium	126	4
MW-1015	2	Kimmswick-Decorah	101	4
MW-1016	2	Alluvium	95.2	4
MW-1028	2	Plattin	19.4	2
MW-1031	2	Plattin	22.1	4
MW-1032	2	Kimmswick-Decorah	130	4
MW-1045	2	Alluvium	33.5	4
MW-1046	2	Plattin	68.2	4
MW-1047	2	Plattin	92.4	4
MW-1048	2	Plattin	69.4	4
MW-1049	2	Alluvium	0.22	4
MW-1051	2	Alluvium	108	4
MW-1052	2	Alluvium	41.8	4

Iron. Iron is also monitored as an indicator of the geochemistry of the groundwater. Iron concentrations generally increase in a reducing environment. The average concentrtions for iron in 2004 are summarized in Table 3–13. These results are similar to those reported during 2003, and continue to confirm the presence of a geochemical reducing zone along the northern margin of the slough, which is inhibiting migration of uranium-contaminated groundwater.

Table 3–13. Annual Groundwater Averages for Iron (µg/L) at the Weldon Spring Quarry

Location	Line	Unit	Annual Average (µg/L)		Number of Samples
			Iron (Filtered)	Ferrous Iron	
MW-1002	1	Kimmswick-Decorah	29.0	22.5	4
MW-1004	1	Kimmswick-Decorah	66.8	57.5	4
MW-1005	1	Kimmswick-Decorah	1,461	672	4
MW-1027	1	Kimmswick-Decorah	60.9	< 10.0	4
MW-1030	1	Kimmswick-Decorah	3,857	2,455	4
MW-1006	2	Alluvium	2,474	1,610	4
MW-1007	2	Alluvium	41,460	19,502	4
MW-1008	2	Alluvium	384	345	4
MW-1009	2	Alluvium	27,640	10,612	4
MW-1012	2	Kimmswick-Decorah	22.4	27.5	4
MW-1013	2	Kimmswick-Decorah	35,960	3,095	4
MW-1014	2	Alluvium	215	208	4
MW-1015	2	Kimmswick-Decorah	47.9	15.0	4
MW-1016	2	Alluvium	27.7	< 10.0	4
MW-1028	2	Plattin	183	175	2
MW-1031	2	Plattin	16.9	< 10.0	4
MW-1032	2	Kimmswick-Decorah	687	748	4
MW-1045	2	Alluvium	21.1	22.5	4
MW-1046	2	Plattin	155	100	4
MW-1047	2	Plattin	95.3	17.5	4
MW-1048	2	Plattin	933	982	4
MW-1049	2	Alluvium	43,302	25,762	4
MW-1051	2	Alluvium	35.3	330	4
MW-1052	2	Alluvium	3,949	2,808	4

3.1.2.4 Monitoring Results for the Missouri River Alluvium

Uranium. The 10 monitoring wells located south of the slough were analyzed for uranium to verify that the levels remain within the range of natural variation. The uranium results are provided in Table 3-14. One location, RMW-2, exceeds the average background value for the Missouri River alluvium. However, the reported value is well within the range used to calculate the average background and does not indicate impact from the groundwater north of the slough. None of the locations exceed the drinking water standard of 20 pCi/L (30 µg/L).

Table 3–14. Annual Averages for Total Uranium in the Missouri River Alluvial Aquifer

Location	Line	Average (pCi/L)	Number of Samples
MW-1017	3	< 0.10	2
MW-1018	3	< 0.10	4
MW-1019	3	< 0.10	2
MW-1021	3	< 0.10	2
MW-1044	3	< 0.10	2
MW-1050	3	< 0.10	2
RMW-1	4	0.56	1
RMW-2	4	4.05	1
RMW-3	4	0.46	1
RMW-4	4	0.96	1

Background concentrations given in Table 3-9.

Nitroaromatic Compounds. The RMW-series monitoring wells were sampled for the six primary nitroaromatic compounds. No detectable concentrations were observed at these locations.

Sulfate and Iron. The monitoring wells south of the slough were sampled for sulfate and iron to evaluate the geochemistry of the Missouri River alluvial aquifer. The 2004 annual averages are summarized in Table 3-15. The data indicate that a strongly reducing environment is prevalent in the groundwater immediately south of the slough, as exhibited by the high iron concentrations and low sulfate concentrations. The RMW-series wells indicate a slightly less reducing environment when compared to the wells immediately south of the slough. This is likely the influence of the Missouri River on the groundwater quality in this portion of the alluvial aquifer.

Table 3–15. Annual Average for Iron and Sulfate in the Missouri River Alluvial Aquifer

Location	Sulfate (mg/L)	Iron (Filtered) (µg/L)	Ferrous Iron (µg/L)	Number of Samples
MW-1017	0.17	32,800	18,200	2
MW-1018	2.75	27,200	8,945	4
MW-1019	0.10	19,500	15,100	2
MW-1021	0.30	15,000	10,300	2
MW-1044	0.07	22,350	8,645	2
MW-1050	5.3	20,300	5,660	2
RMW-1	20.3	9,780	3,720	1
RMW-2	14.5	11,900	2,600	1
RMW-3	22.6	16,000	2,910	1
RMW-4	14.6	3,590	2,390	1

3.1.2.5 Quarry Trend Analysis

Statistical tests for time-dependent trends at the Quarry were performed on historical data from groundwater wells north of the Femme Osage Slough. Trending was performed on total uranium and 2,4-DNT data collected from 2002 to 2004. Total uranium trends were analyzed at all of the locations north of the slough. Trending of 2,4-DNT data was performed only on those locations exhibiting detectable concentrations over the 3 year timeframe. The computer program, TREND, which is described in detail in Section 3.1.1.4, was used for this trend analysis. The method employed was the nonparametric Mann-Kendall test.

3.1.2.6 Quarry Trend Results

The cumulative results for the period 2002 through 2004 for each parameter that were evaluated using the TREND program are summarized in Table 3–16. A total of 21 locations were trended for uranium (Table 3–16). Three of these locations were trended for 2,4-DNT. The majority of the locations exhibited stationary trends for both uranium and 2,4-DNT. Upward trends were determined at 5 wells and downward trends at 5 wells. A summary is presented below:

- Downward trends in uranium were exhibited in MW-1004, MW-1005, MW-1030, MW-1045, and MW-1046. These wells are located closer to the Quarry and the decreases in uranium are likely the result of bulk waste removal and restoration of the Quarry. The downward trends are expected with the removal of the source materials in the Quarry and filling of the Quarry to prevent infiltration of precipitation and storm water into the residually contaminated fracture system. Downward trends were also reported for these 5 locations in 2003.
- Upward trends in uranium have been determined in MW-1013, MW-1014, MW-1016, and MW-1052. These wells are located in the area of highest uranium impact in the Quarry area.
- An upward trend in 2,4-DNT was determined in MW-1027. This well is located on the western side of the Quarry proper.

The upward trends observed at these locations are likely related to an increase in groundwater elevations in the area north of the slough. Review of water level data in this area indicates an overall increase in elevation over the past few years, although water levels are within historical ranges. A correlation appears to exist between uranium activity and groundwater levels Assuming that water levels rise in response to recharge or rainfall, the associated increase in oxidizing conditions probably leads to increased uranium dissolution. Increases in 2,4-DNT levels are also probably caused by recharge.

3.1.3 Disposal Cell Monitoring

Five groundwater monitoring wells, one spring, and disposal cell leachate were sampled during 2004 as part of the detection monitoring program for the permanent disposal cell. Under the detection monitoring program, data for only the signature parameters (barium, iron, manganese, and uranium) from each monitoring event will be compared to BTLs to track general changes in groundwater quality and determine whether statistically significant increases in these parameters have occurred. Signature parameters are those parameters that exist at significantly higher concentrations in the leachate than in the groundwater near the cell and provide a reliable means of detecting potential impacts due to leakage of the disposal cell.

Table 3–16. Quarry Groundwater Trend Analysis Summary for 2002 to 2004

Well ID	Location	Parameter	No. of Samples	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope	95% Upper & Lower Confidence Intervals On Slope	2004 New High Concentration 2002 to Date
MW-1002	Bedrock – east rim	Uranium	12	0	S	0.305	-0.045 , 0.626	4.8
MW-1004	Bedrock – rim	Uranium	12	0	D	-59.275	-149.022 , -17.198	No
MW-1005	Bedrock – south rim	Uranium	12	0	D	-206.05	-311.541 , -138.439	No
MW-1006	Alluvium – north of slough	Uranium	12	0	S	103.5	-131.325 , 281.562	No
		2,4-DNT	12	7	S	0.012	-0.005 , 0.060	No
MW-1007	Alluvium - north of slough	Uranium	12	0	S	-0.625	-6.125 , 4.236	No
MW-1008	Alluvium – north of slough	Uranium	12	0	S	-238.75	-978.38 , 436.743	No
MW-1009	Alluvium - north of slough	Uranium	12	0	S	-0.042	-0.373 , 0.306	No
MW-1013	Bedrock – north of slough	Uranium	12	0	U	80.725	14.763 , 152.176	832.7
MW-1014	Alluvium - north of slough	Uranium	12	0	U	297.85	178.963 , 420.662	1510
MW-1015	Bedrock – north of slough	Uranium	12	0	S	-5.5	-36.0 , 13.95	No
MW-1016	Alluvium - north of slough	Uranium	12	0	U	11.325	1.976 , 20.483	118
MW-1027	Bedrock – west of Quarry	Uranium	12	0	S	5.75	-58.475 , 52.356	341
		2,4-DNT	12	0	U	4.725	3.10 , 5.726	13.0
MW-1028	Bedrock – north of slough	Uranium	6	0	S	-0.087	-1.048 , 0.828	No
MW-1030	Bedrock – south rim	Uranium	12	0	D	-2.29	-3.517 , -0.836	No
MW-1031	Bedrock - north of slough	Uranium	12	0	S	-0.45	-1.522 , 0.911	No
MW-1032	Bedrock – north of slough	Uranium	12	0	S	7.25	-79.962 , 72.094	1273
		2,4-DNT	12	10	S	0	-0.005 , 0.0	No
MW-1045	Bedrock – north of slough	Uranium	12	0	D	-0.97	-2.285 , -0.614	No
MW-1046	Bedrock – north of slough	Uranium	12	0	D	-0.74	-1.218 , -0.388	No
MW-1048	Bedrock – north of slough	Uranium	12	0	S	-5.25	-35.187 , 10.187	No
MW-1051	Alluvium - north of slough	Uranium	10	0	S	196	98.21 , 758.379	1110
MW-1052	Alluvium - north of slough	Uranium	10	0	U	591.15	223.978 , 1004.55	1205

D = Downward U = upward S = Stationary
Units: Uranium – pCi/L/yr 2,4-DNT – µg/L/yr

This monitoring is performed to meet the substantive requirements of 40 CFR 264, Subpart F; 10 CSR 25-7.264(2)(F); and 10 CSR 80-3.010(8). These Federal and State hazardous and/or solid waste regulations were identified as applicable or relevant and appropriate requires (ARARs) for the selected remedy in the *Record of Decision for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1993). Monitoring of these wells and the spring was performed in accordance with the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan, Rev. 2* (DOE 2004b).

3.1.3.1 Disposal Cell Monitoring Program

The disposal cell groundwater detection monitoring network consists of one upgradient well (MW-2055), four downgradient wells (MW-2032, MW-2046, MW-2047, and MW-2051), one downgradient spring (SP-6301), and the leachate collection and removal sump (LCRS). Semiannual detection monitoring began in mid-1998, after cell construction had begun and waste placement activities were initiated.

The detection monitoring program for the disposal cell consisted of semiannual sampling for the following parameters:

- Uranium.
- Anions (chloride, fluoride, nitrate (as N), and sulfate).
- Metals (arsenic, barium, chromium, cobalt, iron, lead, manganese, nickel, selenium, and thallium).
- Nitroaromatic compounds.
- Radiochemical parameters (Radium-226 [Ra-226], Radium-228 [Ra-228], Thorium-228 [Th-228], Thorium-230 [Th-230], and Thorium-232 [Th-232]).
- Polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons (PAHs).
- Miscellaneous indicator parameters (pH, specific conductance, chemical oxygen demand [COD], total dissolved solids [TDS], and total organic carbon [TOC]).

Under the detection monitoring program, signature parameter (barium, iron, manganese, and uranium) data from each monitoring event are compared to BTLs to trace general changes in groundwater quality and determine whether statistically significant evidence of contamination due to cell leakage exists. Tolerance limits for signature parameters have been calculated using the dataset from 1997 through 2002, using 95% confidence and 95% coverage, based on the assumption that the data are normally distributed (Table 3–17). In the case of the newer wells (MW-2051 and MW-2055), period of record for available data is fairly small; however, the tolerance limits for these wells are representative of groundwater conditions at these locations.

The data from the remainder of the parameters are reviewed to evaluate the general groundwater quality in the vicinity of the disposal cell and to determine if changes are occurring in the groundwater system. Data are compared to the three most recent years of data to determine if statistically significant increases or trends in concentrations are present. A measured concentration is considered statistically significant if it is greater than the arithmetic mean plus three times the standard deviation for a given location.

Wells with data showing statistically significant increases or decreases are resampled to confirm the exceedance. If the results of the resampling confirm the exceedance, historical leachate analytical data and volumes are evaluated to assess the integrity of the disposal cell. If the leachate data do not indicate that the exceedance could be the result of leakage from the cell, an assessment of the analytical data and review of sitewide monitoring data is performed. If the exceeding parameter is a contaminant of concern for the GWOU, this information is evaluated under the monitoring program for that operable unit.

3.1.3.2 Disposal Cell Monitoring Results

The 2004 monitoring results for the signature parameters are presented in Table 3–17. The BTLs for each sampling event are also included in the table. Results of the sampling, as shown in Table 3–17, indicate that the BTLs for iron and manganese were exceeded in MW-2032 during December 2004. Resampling in February 2005 confirmed the elevated values. A demonstration report has been prepared as outlined in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan.*

Table 3–17. Signature Parameter Results and Associated BTLs

Parameter	Location	Baseline Tolerance Limit	Results	
			June 2004	December 2004
Barium (µg/L)	MW-2032	337	168	153
	MW-2046	277	170	194
	MW-2047	471	353	360
	MW-2051	285	144	174
	MW-2055	98	18.2	20.4
	SP-6301	180	107	93.7
Iron (µg/L)	MW-2032	1,125	191	1,520
	MW-2046	1,578	192	39.2
	MW-2047	1,485	185	19.1
	MW-2051	2,896	663	1,110
	MW-2055	10,579	201	548
	SP-6301	2,608	245	855
Manganese (µg/L)	MW-2032	57	20.8	159
	MW-2046	187	27.0	17.0
	MW-2047	171	2.8	2.8
	MW-2051	265	7.7	19.8
	MW-2055	179	4.1	22.5
	SP-6301	88	5.1	11.9
Uranium (pCi/L)	MW-2032	6.4	3.04	3.45
	MW-2046	1.8	1.02	0.95
	MW-2047	2.7	1.35	1.15
	MW-2051	4.5	1.01	0.95
	MW-2055	7.5	2.03	2.03
	SP-6301	159	38.9	13.6

Results of general groundwater quality monitoring for the disposal cell wells in June 2004 are presented in Table 3–18. Noteworthy data include:

- Sulfate in MW-2032 was a new high and in MW-2046 was a 3-year high. However, none of these values are considered statistically significant because they are less than the mean plus 3 standard deviations for the last 3 years of data.
- The concentration of chloride in MW-2046 was a new high and was at a 3-year high in MW-2047, but neither value was considered statistically significant. Well MW-2046 exhibited elevated levels of sulfate in 2003.
- Levels of specific conductance, TDS, and COD were at 3-year highs in MW-2032. Only the concentration for COD was considered to be statistically significant (greater than the mean plus 3 standard deviations for the last 3 years of data).
- The concentration of nitrate was detected at a new high in MW-2055; however, the value was not considered statistically significant. The value returned to normal ranges in December 2004.
- Chromium and nickel were elevated in the two newest wells (MW-2051 and MW-2055); however, the values were not considered statistically significant. These wells are constructed of 304-grade stainless steel and the increased concentrations of these two parameters are possibly the result of leaching of these metals from the well materials. Increases in these two metals have been observed before in wells constructed of the same materials at the Chemical Plant. Stainless steel is generally preferred for long-term monitoring rather that polyvinyl chloride (PVC) the longevity of which has not been established.

Results of general groundwater quality monitoring for the disposal cell wells in December 2004 are presented in Table 3–19. Noteworthy data include:

- Chloride concentrations in MW-2046 were still elevated and a new 3-year high for chloride was also reported at MW-2047. The chloride concentration in MW-2032 was also relatively high. However, none of these values are considered statistically significant because they are less than the mean plus 3 standard deviations for the last 3 years of data.
- Sulfate, nickel, COD, and TOC concentrations in MW-2032 were elevated and considered statistically significant increases (greater than the mean plus 3 standard deviations for the last 3 years of data). This location was resampled in February 2005 to confirm these elevated values.
- The total dissolved solids concentration was elevated in MW-2032, but the value was not considered statistically significant.
- Chromium and nickel remained elevated in MW-2051 and MW-2055. The concentration of chromium in MW-2051 was considered statistically significant and the location was resampled in February 2005 to confirm the elevated value.
- Nitrate in MW-2046 and MW-2047 was at a 3-year high; however, only the concentration reported in MW-2046 was considered statistically significant. This location was resampled to confirm the elevated value.
- The concentration of 2,6-DNT at MW-2046 was a 3-year high, however the value was not considered statistically significant.

Table 3–18. Summary of Monitoring Data for Disposal Cell Well Network (June 2004)

Parameter	MW-2032	MW-2046	MW-2047	MW-2051	MW-2055	SP-6301
Chloride (mg/L)	7.7	28.0	7.9	30.3	5.01	12.4
Fluoride (mg/L)	0.19	0.11	0.10	0.14	0.10	0.05
Nitrate-N (mg/L)	3.89	2.17	58.0	1.55	1.4	3.09
Sulfate (mg/L)	80.7	57.1	24.1	40.7	249	23.0
Arsenic (µg/L)	ND	ND	ND	ND	ND	ND
Chromium (µg/L)	3.1	2.3	5.4	50.1	22.3	2.1
Cobalt (µg/L)	0.8	0.27	0.28	0.54	0.10	0.20
Lead (µg/L)	1.1	ND	ND	ND	ND	ND
Nickel (µg/L)	7.9	10.9	6.8	83.3	38.4	2.5
Selenium (µg/L)	ND	3.3	2.8	ND	12.5	ND
Thallium (µg/L)	ND	ND	ND	ND	ND	ND
COD (mg/L)	18	ND	ND	ND	ND	ND
TDS (mg/L)	483	591	721	343	734	268
TOC (mg/L)	1.8	1.6	0.67	1.3	0.67	1.5
1,3,5-TNB (µg/L)	ND	2.3	ND	0.15	ND	ND
1,3-DNB (µg/L)	ND	0.13	ND	0.21	ND	ND
2,4,6-TNT (µg/L)	ND	4.4	ND	ND	ND	ND
2,4-DNT (µg/L)	ND	ND	0.09	0.08	ND	ND
2,6-DNT (µg/L)	ND	1.8	0.21	0.32	ND	ND
Nitrobenzene (µg/L)	ND	ND	ND	ND	ND	ND
Radium-226 (pCi/L)	ND	0.18	0.33	0.35	ND	ND
Radium-228 (pCi/L)	ND	ND	ND	ND	ND	ND
Thorium-228 (pCi/L)	ND	ND	ND	ND	ND	ND
Thorium-230 (pCi/L)	0.24	0.26	0.33	0.20	0.19	0.28
Thorium-232 (pCi/L)	ND	ND	ND	ND	ND	ND
PCBs/PAHs (µg/L)	ND	ND	ND	ND	ND	ND
DO (mg/L)	5.68	7.96	5.75	8.30	9.74	7.97
ORP (mV)	179	252	205	126	186	237
pH (s.u.)	7.22	6.89	7.01	7.51	7.29	6.75
SC (µmohs/cm)	755	979	1233	5.90	1082	425
Temperature (C)	16.9	17.1	18.9	16.5	16.9	13.3

ND Non-detect.

Table 3–19. Summary of Monitoring Data for Disposal Cell Well Network (December 2004)

Parameter	Results					
	MW-2032	MW-2046	MW-2047	MW-2051	MW-2055	SP-6301
Chloride (mg/L)	4.3	29.5	8.2	27	4.1	6.7
Fluoride (mg/L)	0.17	0.11	0.12	0.17	0.12	0.10
Nitrate-N (mg/L)	0.59	71	78.4	0.78	0.20	0.58
Sulfate (mg/L)	120	57.8	24.9	31.4	292	18.2
Arsenic (µg/L)	0.15	ND	ND	ND	ND	ND
Chromium (µg/L)	4.3	2.6	5.0	204	22.3	2.3
Cobalt (µg/L)	2.3	0.23	0.22	1.00	1.00	0.30
Lead (µg/L)	ND	ND	ND	ND	ND	ND
Nickel (µg/L)	31.1	10.7	6.9	53.1	38.4	3.2
Selenium (µg/L)	ND	4.5	3.7	1.3	14.8	ND
Thallium (µg/L)	ND	ND	ND	ND	ND	0.92
COD (mg/L)	38	6	ND	ND	ND	11
TDS (mg/L)	516	568	659	ND	792	183
TOC (mg/L)	11.6	1.8	1.0	1.3	0.87	2.9
1,3,5-TNB (µg/L)	ND	2.5	ND	ND	ND	ND
1,3-DNB (µg/L)	ND	0.07	ND	ND	ND	ND
2,4,6-TNT (µg/L)	ND	1.1	ND	ND	ND	ND
2,4-DNT (µg/L)	ND	ND	ND	ND	ND	ND
2,6-DNT (µg/L)	ND	2.5	0.24	0.23	ND	ND
Nitrobenzene (µg/L)	ND	ND	ND	ND	ND	ND
Radium-226 (pCi/L)	ND	ND	0.35	0.29	ND	ND
Radium-228 (pCi/L)	ND	ND	ND	ND	ND	ND
Thorium-228 (pCi/L)	ND	ND	ND	ND	ND	ND
Thorium-230 (pCi/L)	ND	0.20	0.19	0.44	ND	0.30
Thorium-232 (pCi/L)	ND	ND	ND	ND	ND	ND
PCBs/PAHs (µg/L)	ND	ND	ND	ND	ND	ND
DO (mg/L)	5.52	7.29	8.08	9.68	10.8	9.37
ORP (mV)	-99	162	152	59	180	147
pH (s.u.)	6.77	6.90	7.26	7.53	7.40	7.22
SC (µmohs/cm)	795	956	1042	624	1164	286
Temperature (C)	12.9	14.7	14.7	11.2	14.0	11.8

ND Non-detect.

Monitoring wells MW-2032, MW-2046, and MW-2051 were resampled in February 2005 to address the elevated signature parameters and other statistically significant parameters reported for the December 2004 sampling event. The nickel concentration in MW-2032 was lower than that reported in December; however the value was still elevated. The chromium concentration in MW-2051 was lower than that reported in December. Comparison of the concentrations of these two parameters in groundwater to concentrations present in the leachate (Table 3–20) indicates that the concentrations in the leachate are not sufficiently high to contribute to the concentrations observed in the groundwater. These wells are constructed of 304-grade stainless steel and the increased concentrations of these two parameters are potentially the result of leaching of these metals from the well materials. Increases in these two metals have been observed before in wells constructed of the same materials at the Chemical Plant. It is possible, however, that the elevated nickel concentrations in MW-2032 were related to local biodegradation processes affecting iron and manganese in this well during the 2004/2005 winter. (DOE 2005c).

Table 3–20. Summary of Leachate Monitoring Data for Cell Well Network

Parameter	Concentrations	
	June 2004	December 2004
Chloride (mg/L)	35.1	33.8
Fluoride (mg/L)	0.28	0.30
Nitrate-N (mg/L)	0.27	0.07
Sulfate (mg/L)	36.6	31.6
Arsenic (µg/L)	2.9	2.4
Barium (µg/L)	859	785
Chromium (µg/L)	ND	ND
Cobalt (µg/L)	5.5	4.1
Iron (µg/L)	2,820	6,620
Lead (µg/L)	ND	ND
Manganese (µg/L)	1,150	50,000
Nickel (µg/L)	9.7	8.6
Selenium (µg/L)	2.3	3.2
Thallium (µg/L)	0.72	ND
COD (mg/L)	31.0	33.0
TDS (mg/L)	767	665
TOC (mg/L)	10.2	9.9
1,3,5-TNB (µg/L)	ND	ND
1,3-DNB (µg/L)	ND	ND
2,4,6-TNT (µg/L)	ND	ND
2,4-DNT (µg/L)	ND	ND
2,6-DNT (µg/L)	ND	ND
Nitrobenzene (µg/L)	ND	ND
Radium-226 (pCi/L)	0.44	0.58
Radium-228 (pCi/L)	ND	ND
Thorium-228 (pCi/L)	ND	ND
Thorium-230 (pCi/L)	0.34	0.26
Thorium-232 (pCi/L)	ND	ND
Uranium (pCi/L)	25.6	17.0
PCBs/PAHs (µg/L)	ND	ND

ND Non-detect.

The 2004 monitoring results for the leachate are presented in Table 3–20. The LCRS is sampled semiannually for disposal cell well analytes and the data are used for comparison if elevated concentrations of constituents are identified in the groundwater. The composition of the leachate is similar to that measured in 2003. The four signature parameters (barium, iron, manganese, and uranium) remain at concentrations higher than those measured in nearby groundwater.

The elevated concentrations of non-signature parameters that exhibited statistically significant increases in the disposal cell monitoring wells tend to be larger than constituent concentrations in the leachate, indicating that the source of these elevated constituents is external of the disposal cell. The elevated signature parameters reported in MW-2032 have been addressed in a demonstration report (DOE 2005c) as outlined in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b).

3.1.3.3 Groundwater Flow

Groundwater flow rate and direction are evaluated annually as specified in the *Disposal Cell Groundwater Monitoring Plan* (DOE 2004b). The groundwater flow direction was determined by constructing a potentiometric surface map of the shallow aquifer using the available wells at the Chemical Plant (Figure 3–5). The potentiometric surface has remained relatively unchanged since the construction of the disposal cell. The groundwater flow direction is generally to the north. A groundwater divide is present along the southern boundary of the site.

The average groundwater flow rate (average linear velocity) is calculated using the following equation:

$$v = -Ki/n_e$$

The average hydraulic conductivity (K) using data from the cell monitoring wells is 7×10^{-3} cm/s. An effective porosity (n_e) of 0.10 was selected to estimate the maximum groundwater flow rate in this area. The hydraulic gradient (i) in the disposal cell area is 0.011 ft/ft and is based on data from MW-2032 and MW-2055, located 2,100 ft apart. This approach is consistent with the calculations presented in the *Disposal Cell Groundwater Monitoring Plan* (DOE 2004b). The average flow rate for 2004 was 2.2 ft/day, which is similar to the average flow rates calculated since 1998 (DOE 2004b).

3.2 Surface Water

3.2.1 Chemical Plant Surface Water

In accordance with the surface water monitoring program, Schote Creek, Dardenne Creek, and Busch Lakes 34, 35 and 36 (Figure 3–6) were sampled semi-annually for total uranium. This monitoring was conducted to measure the effects of remediation and surface water discharges from the site on the quality of downstream surface water.

The results for the Chemical Plant surface water sampling are presented in Table 3–21 along with the recent 3 year high for each location for comparison. Uranium levels at the off-site surface water locations for 2004 were similar to 2003 averages. The uranium levels at Busch Lake 34 continue to be elevated compared to the remainder of the locations, however, uranium levels at the Busch Lake outlets have shown an overall decline since remediation started. The Schote Creek and Dardenne Creek locations are downstream of the lakes and have always shown relatively low levels because the chemical plant portion of the watershed is much smaller than the total watershed area.

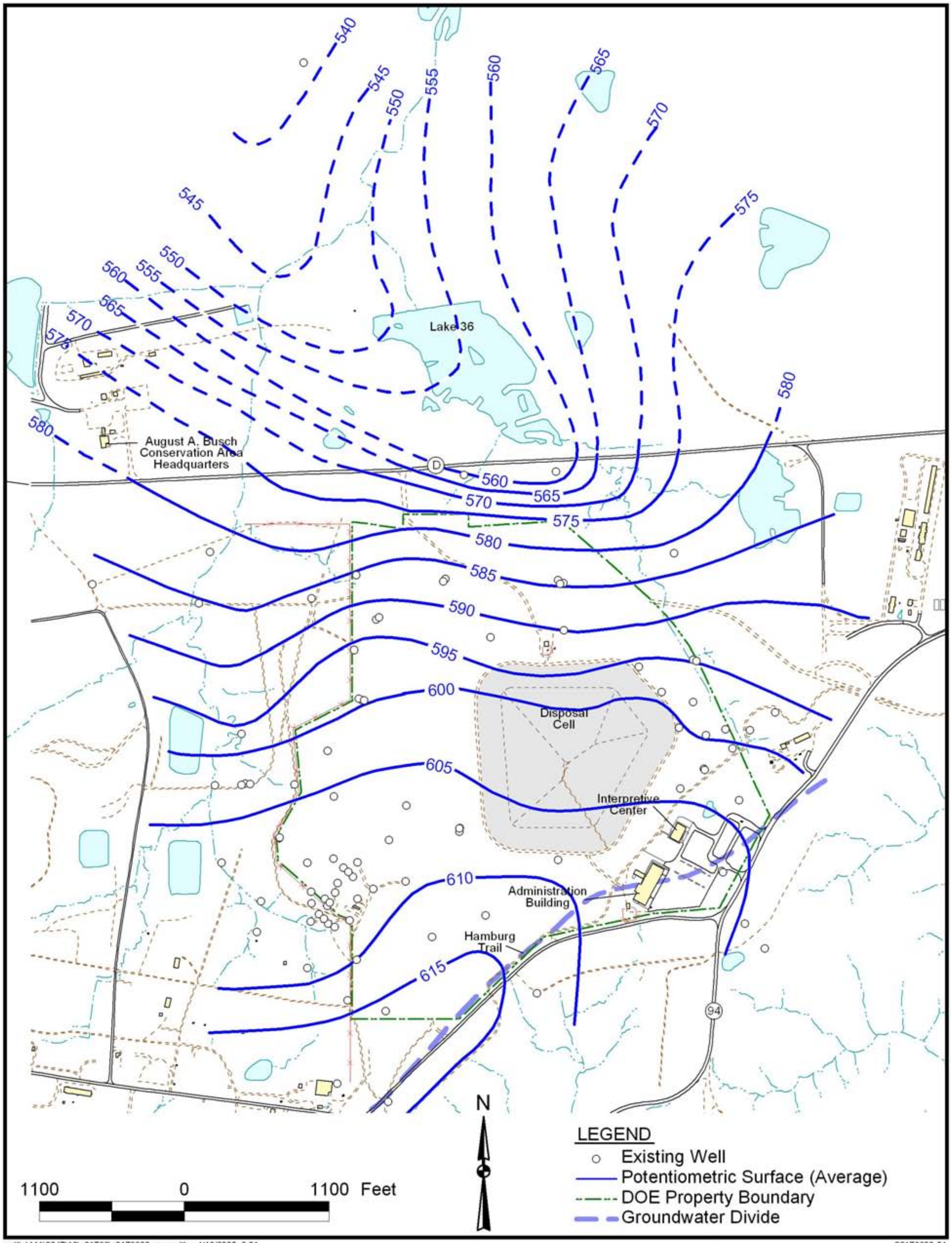

Figure 3–5. Potentiometric Surface of the Shallow Aquifer (Weathered Zone)

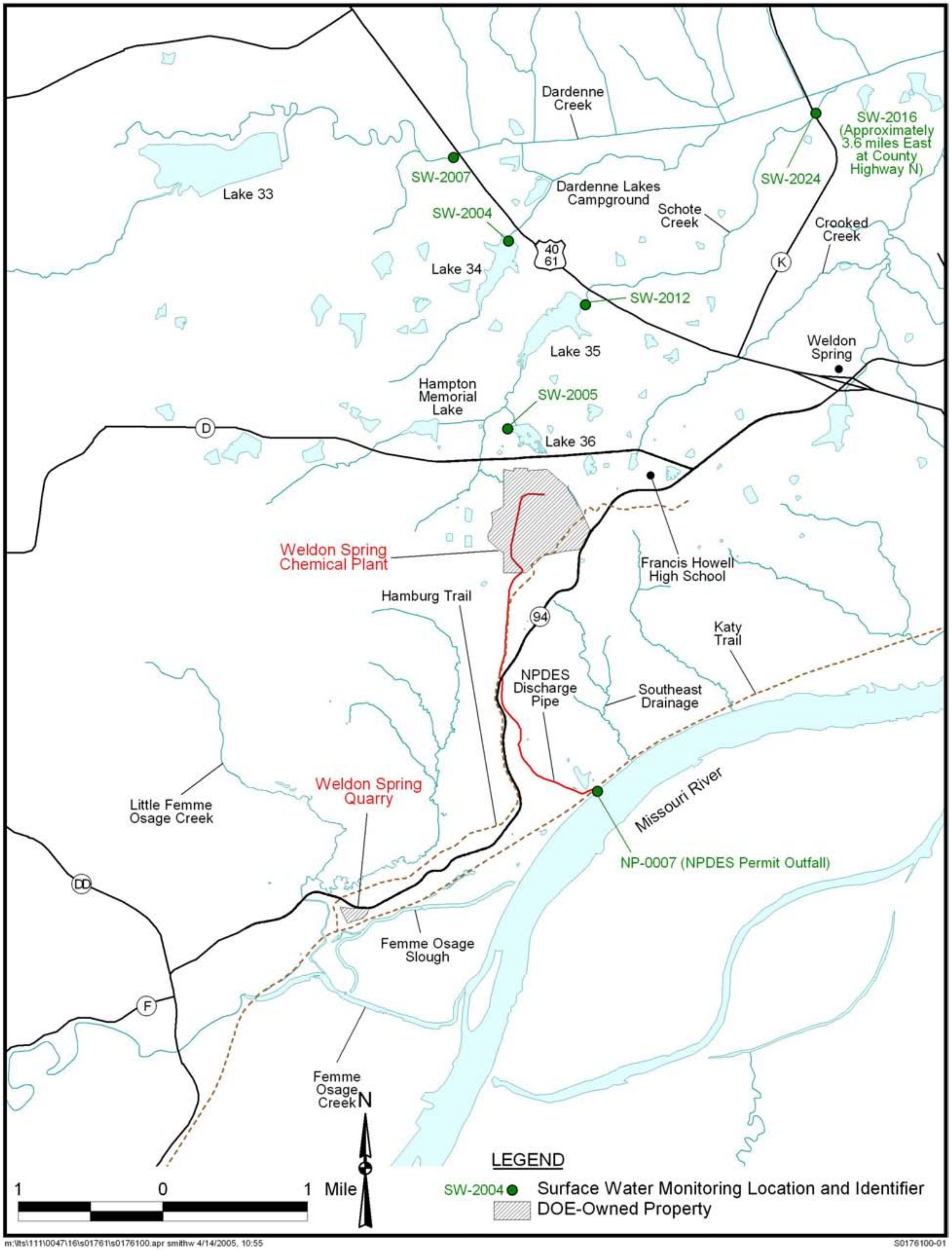

Figure 3–6. Surface Water Monitoring Locations at the Chemical Plant Area of the Weldon Spring, Missouri, Site

Table 3–21. 2004 Results for Total Uranium (pCi/L) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations

LOCATION	1st Semi-annual 3/2/2004	2nd Semi-annual 8/10/2004	Average	Recent 3 Year High*
SW-2004 (Lake 34)	5.3	7.0	6.2	8.1
SW-2005 (Lake 36)	2.9	1.9	2.4	4.1
SW-2012 (Lake 35)	1.2	2.2	1.7	4.7
SW-2016 (Dardenne)	0.8	1.1	0.9	1.4
SW-2024 (Schote)	1.8	2.3	2.1	2.8

* 2001-2003

3.2.2 Quarry Surface Water

Four locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the Quarry. These locations, which are shown on Figure 3–7 were monitored semiannually for uranium. The samples are located from the upper section of the Femme Osage Slough. This section of the slough is known to receive groundwater contribution from the area of uranium impact. The 2004 semi-annual uranium concentrations for the Quarry surface water locations are summarized in Table 3–22. Uranium levels in SW-1003, SW-1004, and SW-1010 during the 1st semi-annual sampling were 3-year highs. The higher uranium levels observed in the slough during the first semi-annual period were collected when the elevation of the water table was high. The increase in water levels apparently causes increases in concentrations either because of enhanced uranium leaching of uranium residual in the vadose zone or increased uranium mobility under oxidizing conditions. The levels decreased during the 2nd semi-annual sampling.

Table 3–22. 2004 Results for Total Uranium (pCi/L) at Weldon Spring Quarry Surface Water Locations

Location	1st Semi-annual	2nd Semi-annual	Average	Recent 3 Year High *
SW-1003	33.1	20.9	27.0	25.5
SW-1004	36.4	21.5	29.0	24.6
SW-1005	7.0	15.8	11.4	21.0
SW-1010	24.8	20.4	22.6	27.5

* 2001-2004

3.3 Leachate Collection and Removal System

The Leachate Collection and Removal System (LCRS) collects leachate from the disposal cell. The leachate had been sampled quarterly since generation for an extensive list of chemical and radiological constituents; however, beginning in CY 2003, the leachate is sampled semiannually in accordance with the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b). The leachate analytical data for semi-annual sampling is shown in Table 3–20.

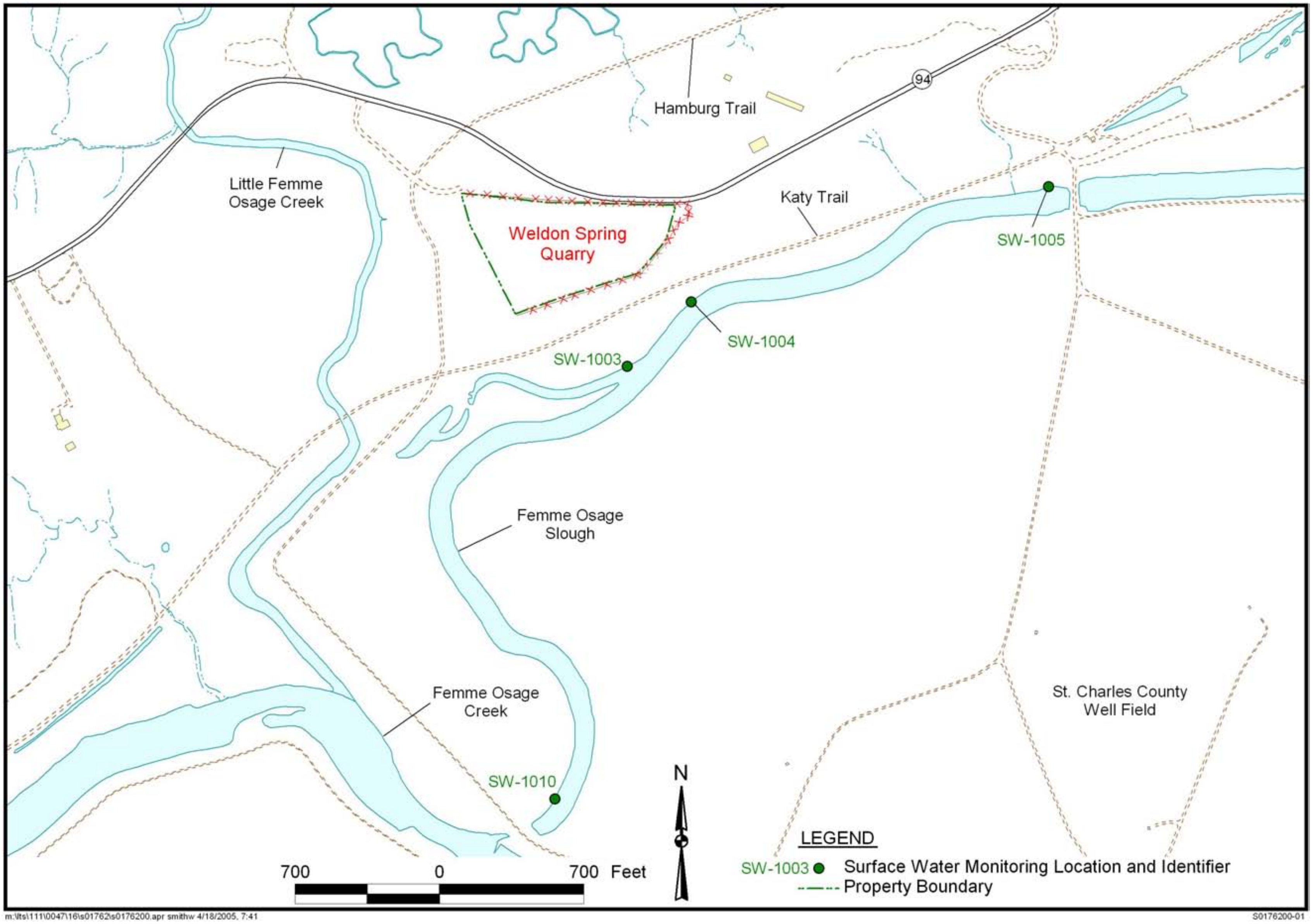

Figure 3–7. Surface Water Monitoring Locations at the Quarry Area of the Weldon Spring, Missouri, Site

As needed, the leachate is pumped from the sump and transported to the Metropolitan St. Louis Sewer District (MSD) for treatment in their Bissell Point plant wastewater treatment facility. A sample of leachate is collected and analyzed in accordance with MSD requirements for each hauling event. The MSD requirements for the leachate are discussed in Section 2.1.3.3.

The leachate uranium activity during 2002 typically was 50 pCi/L, which is equivalent to annual radioactivity of approximately 0.02 millicuries. The 2003 and 2004 data have shown a continued downward trend to about 30 pCi/L. The average uranium concentrations are shown in Figure 3–8.

Leachate level and flow rates continue to be monitored and recorded weekly. If reliable and stable data continues, DOE may modify the sump level monitoring frequency in accordance with regulations in 40 CFR 264.303(c) which requires only monthly and then quarterly flow recording. Flow rates will be reported in units of gallons per day and compared to the action leakage rate of 100 gallons/acre/day established for the secondary (or lower) leachate collection system.

During 2003 and 2004, discharge from the primary leachate collection system has generated approximately 250 gallons per day and 200 gallons per day, respectively. The daily averages for the primary leachate flow rate are shown in Figure 3–9. The combined leachate from the secondary leachate collection system has averaged approximately 20 gallons per day for 2003 and 2004. The average leak rate for the secondary leachate collection system for 2003 and 2004 has been approximately 0.75 gallons/acre/day, less than 1 percent of the action leakage rate.

3.4 Air

In the past, the Weldon Spring Site Remedial Action Project (WSSRAP) operated an extensive environmental airborne monitoring and surveillance program in accordance with U.S. Department of Energy (DOE) Orders, U.S. Environmental Protection Agency (EPA), National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, and the WSSRAP *Environmental Monitoring Plan* (DOE 2003a). Throughout the remediation of contaminated soils and materials, the potential for airborne releases and atmospheric migration of radioactive contaminants was closely monitored by measuring concentrations of radon, gamma exposure, airborne radioactive particulates, airborne asbestos, and fine particulate matter at various site perimeter and off-site locations. The potential for airborne release of radionuclides was eliminated with the final disposition of contaminated materials in the permanent disposal cell. With the completion of most site activities, no air monitoring has been conducted since 2001 (DOE 2001a).

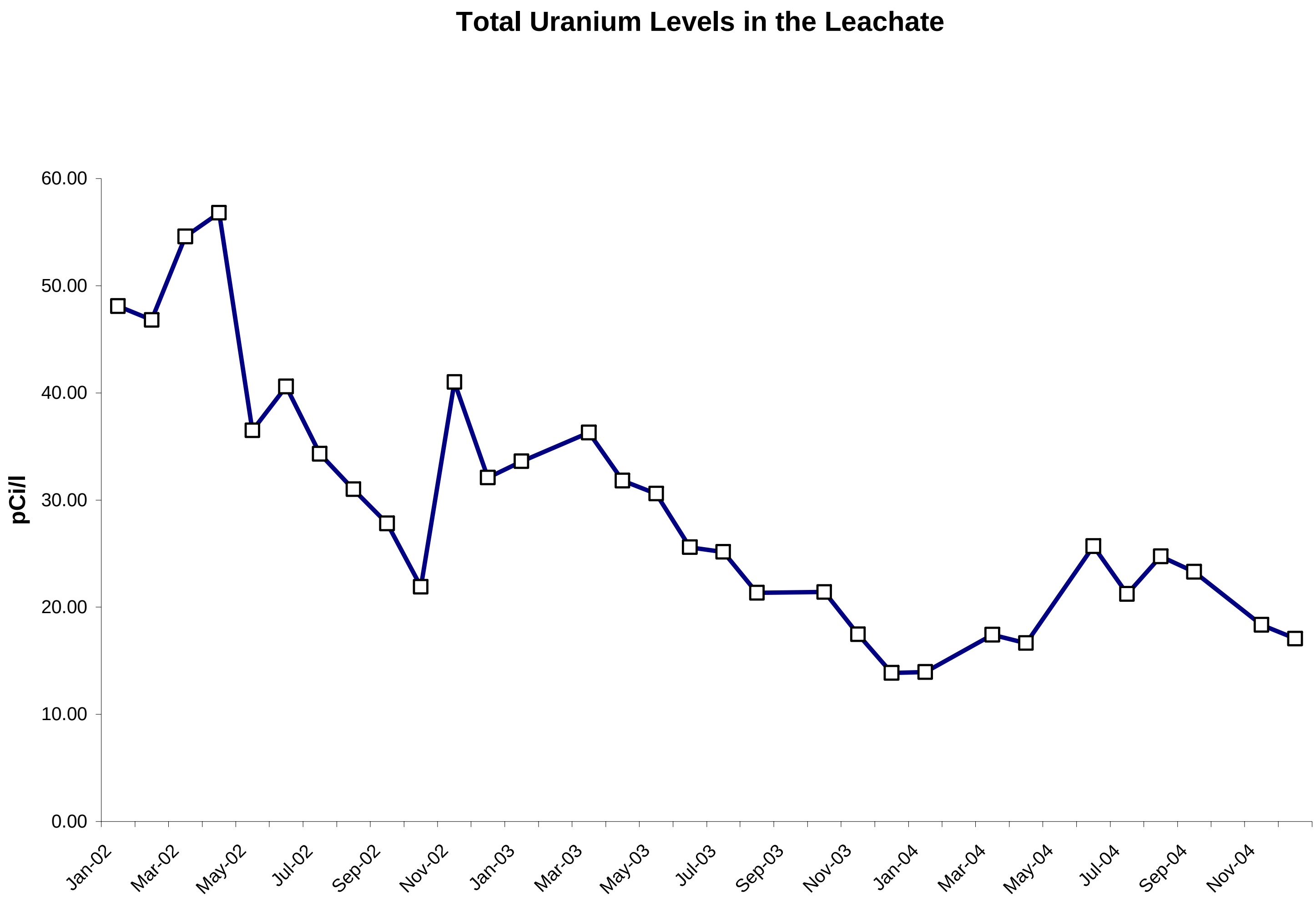

Figure 3–8. Average Uranium Concentrations

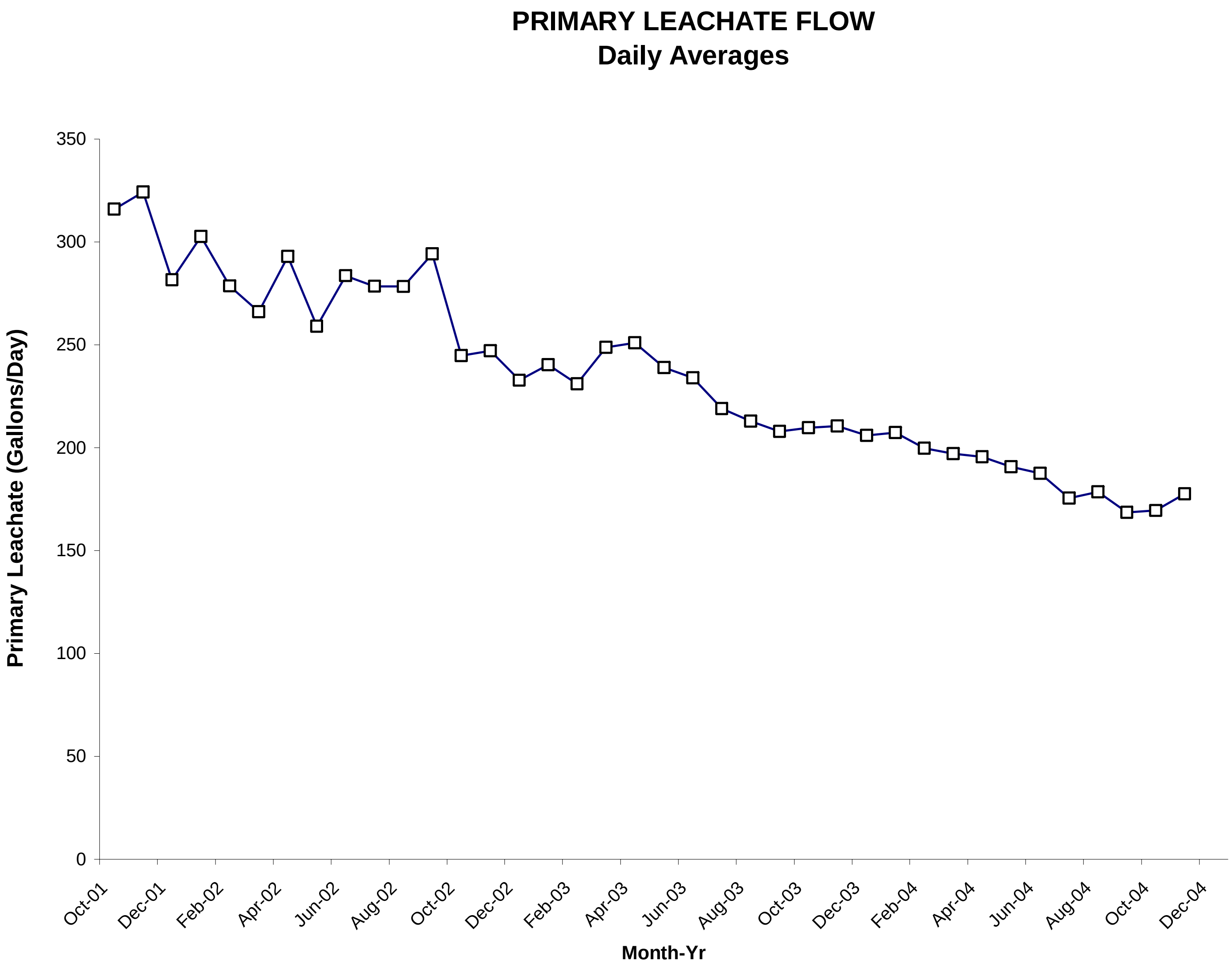

Figure 3–9. Daily Averages

3.5 Radiation Dose Analysis

This section evaluates the potential effects of remaining surface water and groundwater discharges of radiological contaminants from the Weldon Spring Site in 2004. Effective dose equivalent has been calculated for 2004 based on the applicable exposure pathway. Doses resulting from airborne emissions are no longer calculated since the potential for airborne release of radiological contaminants has been eliminated and, therefore, 40 CFR 61, Subpart H *(National Emission Standards for Emissions of Radionuclides other than Radon From Department of Energy Facilities)* regulations are no longer relevant. Similarly, doses resulting from external gamma radiation are no longer calculated since the radon sources have been remediated and are contained within the permanent disposal cell. The cell cover effectively mitigates radon releases to levels comparable to background locations.

For this report, the potential exposure in terms of dose to an individual who consumes spring water contaminated with uranium is calculated. This calculation represents that exposure for the reasonable maximally exposed (RME) individual since data from the spring with the highest uranium concentration is used (i.e., for SP-5404 which is located in the SE Drainage with a reported uranium concentration of 70 pCi/L for 2004). The estimated total effective dose equivalent (TEDE) to this RME is about 0.2 mrem (2.0 E-3 mSv). This result is compared to U.S. Department of Energy (DOE) limits contained in DOE Order 5400.5 to demonstrate compliance with regulatory requirements.

3.5.1 Pathway Analysis and Exposure Scenario

In developing specific elements of the Weldon Spring Site environmental monitoring program, potential exposure pathways and health effects of the radioactive and chemical materials present on site are evaluated to determine if potential pathways of exposure exist. Under current site conditions, the only potential pathway to consider is that of a recreational visitor to the Weldon Spring Conservation Area possibly coming into contact with spring water specifically at the Southeast Drainage. A dose calculation for a population within 80 km (49.6 mi) of the site is not estimated since airborne release of radioactive contaminants is not a factor.

Consumption of contaminated groundwater both at the Chemical Plant/former Raffinate Pits and the Quarry areas is not a pathway of concern under current conditions as no drinking water wells are located in the vicinity of the contaminated groundwater in the Chemical Plant and raffinate pits area, and there is no access to the impacted groundwater at the Quarry area. Concentrations of uranium in the production wells near the Weldon Spring Quarry are comparable to background concentrations.

The inhalation of airborne particulates, radon gas and external gamma irradiation pathways are also no longer pathways of concern since the contaminated soils and other materials have been remediated and placed in the on-site cell. Hence, these pathways were not included in the dose estimates for 2004.

The radiological public dose guideline contained in DOE Order 5400.5 is applicable for comparing potential doses at the Weldon Spring Site. This guideline provides for an annual limit of 100 mrem (1 mSv) total effective dose equivalent accounting for all exposure pathways (excluding background).

3.5.2 Dose Equivalent Estimates

Total effective dose equivalent (TEDE) estimate for the exposure scenario was calculated using 2004 environmental monitoring data. The dose is well below the standards set by the DOE for annual public exposure.

This section discusses the estimated total effective dose equivalent to a hypothetical individual assumed to frequent the SE Drainage (SP-5304) of the Weldon Spring Conservation Area. No private residences are adjacent to the SE Drainage, which is situated on land currently managed by the Missouri Department of Conservation (MDC). Therefore, the calculation of dose equivalent is based on a recreational user of the Conservation Area who drank from Spring 5304 twenty times per year during 2004.

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

- The maximally exposed individual drank one cup (0.2 liter [L]) of water from the Spring twenty times per year (equivalent to 1.05 gal (4.0L) of water for the year).
- The Maximum uranium concentration in water samples taken from spring locations during 2004 was found at SP-5304 (70 pCi/L). This concentration was assumed to be present in all of the water ingested by the maximally exposed individual. For comparison, the maximum uranium concentration at Burgermeister Spring during 2004 was 38.8 pCi/L.

On the basis of the following natural uranium activity ratios: U-234: 49.1%, U-235: 2.3%, and U-238: 48.6%, the dose conversion factors (DCFs) for ingestion for U-238 and U-234 were used for calculating the dose. These DCFs are 2.69E-4 mrem/pCi and 2.83E-4 for U-238 and U-234, respectively (Eckerman 1988).

The total effective dose equivalent (TEDE) is calculated as shown below:

TEDE (ingestion of contaminated water for uranium) = Concentration (pCi/L) x Volume of Water Ingested (l) x DCF (U-238 + U-234) (mrem/pCi)

TEDE (total uranium) = 70 pCi/L x 4L x (2.69 E-4 mrem/pCi + 2.83E-4 mrem/pCi) = 0.2 mrem (2.0 E-3mSv)

[Note: This dose estimate is the same as that reported for CY 2003 with the contribution from U-234 incorporated. That is, 0.1 mrem would be added to the 0.1 mrem dose estimate reported for 2003, resulting in a dose estimate of 0.2 mrem.]

This value represents less than 0.2 % of the DOE standard of 100 mrem (1 mSv) TEDE above background. In comparison, the annual average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem (3 mSv) (Beir 1990).

4.0 Environmental Quality

4.1 Highlights of the Quality Assurance Program

- Quality assurance for sampling activities for 2004 followed the *Groundwater and Surface Water Sampling and Analysis Plan for GJO Projects* (DOE 2003c).
- Average relative percent differences calculated for groundwater, surface water, samples, and springs were generally within the 20% criterion recommended by the Contract Laboratory Program (CLP).
- The data validation program accepted 98.3% of the all data in 2004 (including field data).
- The data validation program accepted 99.9% of off-site analytical data in 2004.

4.2 Program Overview

The environmental quality assurance program includes management of the plans and procedures governing environmental monitoring activities at the Weldon Spring Site and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the Weldon Spring Site and the goals for these programs, plans and procedures.

The environmental quality assurance program provides the Weldon Spring Site 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; use of quality control samples; complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness (Data Validation).

The *Groundwater and Surface Water Sampling and Analysis Plan for GJO Projects* (DOE 2003c) summarizes the data quality requirements for collecting and analyzing environmental data. The LTS&M Plan (DOE 2005a) lists the sampling locations and provides site-specific detail for quality control samples. These plans describe administrative procedures for managing environmental data, data validation, database administration, and data archiving.

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in reporting and calculations of annual averages (when available). Uncensored data are data that do not represent a non-detect and instead report instrument responses that quantitative to values below the reported detection limit. When there was no instrument response, non-detect data were used in calculations of averages at a value of one-half the detection limit.

4.2.1 Applicable Standards

Applicable standards for environmental quality assurance include: (1) use of the approved 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.

4.2.2 Analytical and Field Measurement Methodologies

Analytical and field measurement methodologies used at the Weldon Spring Site comply with applicable standards required by the DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring primarily follow the EPA SW-846 requirements and the EPA drinking water and radiochemical methodologies or methods that are reviewed prior to analysis. Field measurement methodologies typically follow the American Public Health Association *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association 1992).

4.3 Quality Control Samples

Quality control samples for environmental monitoring are collected in accordance with the required sampling plan, which specifies the frequency of quality control sample collection. Quality control samples are normally collected in accordance with guidelines. Descriptions of the Quality Control samples collected at the Weldon Spring Site are detailed in Table 4–1.

Table 4–1. Quality Control Sample Description

Type of Qc Sample	Description
Equipment Rinsate Blank	Monitors the effectiveness of decontamination procedures used on non-dedicated sampling equipment. Equipment blanks include rinsate and filter blanks.
Trip Blank	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory. Trip blanks are collected in the Weldon Spring Site laboratory with distilled water.
Field Duplicate	Monitors field conditions that may affect the reproducibility of samples collected from a given location. Field replicates are collected in the field at the same location.
Matrix Spike*	Assesses matrix and accuracy of laboratory measurements for a given matrix type. The results of this analysis and the routine sample are used to compute the percent recovery for each parameter.
Matrix Duplicate*	Assesses matrix and precision of laboratory measurements for inorganic parameters in a given matrix type. The results of the matrix duplicate and the routine sample are used to compute the relative percent difference for each parameter.
Matrix Spike Duplicate*	Assesses matrix and precision of laboratory measurements for organic compounds. The matrix spike duplicate is spiked in the same manner as the matrix spike sample. The results of the matrix spike and matrix spike duplicate are used to determine the relative percent difference for organic parameters.

*A laboratory sample is split from the parent sample.

4.3.1 Quality Control Sample Results

The quality control program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

4.3.2 Duplicate Results Evaluation

Field duplicate analyses were evaluated in 2004. The matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring Site and are not summarized in this document. Matrix duplicates were used to assess the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interference of sample matrixes. Matrix duplicates were assessed during data validation process for each sample group.

Generally, field duplicate samples were analyzed for the same parameters as the original samples and are collected at the rate of approximately one for every 20 samples. Twenty-three field duplicates were collected in 2004 from 315 locations sampled (7.3%). Typically, duplicate samples were analyzed for more common parameters (e.g., uranium, inorganic anions, and metals).

When field duplicate samples were available, the average relative percent difference (RPD) was calculated. This difference represents an estimate of precision. The equation used was:

$$RPD = |S-D| /((S+D) /2) \times 100\%$$

Where: S = concentration in the normal sample
D = concentration in the duplicate analysis

Table 4–2 summarizes the calculated relative percent difference (RPD) for field duplicate samples for groundwater, springs, and surface water matrices. Parameters that were not commonly analyzed for and/or were not contaminants of concern were not evaluated. The RPD was calculated only for samples whose analytical results exceeded five times the detection limit and did not have any quality control problems, (i.e., blank contamination).

Table 4–2. Summary of Calculated Relative Percent Differences

Parameter	Number of Samples	Avg. RPD
Uranium	13	4.1
Iron	9	4.2
Barium	1	0.0
Nitrate-N	8	25.5
Chloride	1	0.0
Sulfate	10	9.0
Total Organic Carbon	1	0.0
Total Dissolved Solids	1	4.5
Volatiles	6	4.2
Nitroaromatics	20	19.2

The results in Table 4–2 demonstrate that most average relative percent differences (RPDs) calculated were within the 20% criterion. The nitrate as nitrogen average RPD was greater than 20% due to one field duplicate result (out of 8 total) was higher than acceptable criteria. All other average RPDs were acceptable. As a result, the average field duplicate sample analyses in 2004 were of acceptable quality.

4.4 Blank Sample Results Evaluation

Various types of blanks are collected to assess the conditions and/or contaminants that may be introduced during sample collection and transportation. These conditions and contaminants are monitored by collecting blank samples to ensure that environmental samples are not being contaminated. Blank samples evaluate the:

- Environmental conditions under which the samples (i.e., volatile analyses) were shipped (trip blanks).
- Ambient conditions in the field that may affect a sample during collection (trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).

Sections 4.4.1 through 4.4.2 discuss the sample blank analyses and the potential impact of blank contamination upon the associated samples.

4.4.1 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 2004, 23 trip blanks were analyzed for volatile organic compounds. No compounds were detected in 19 trip blanks and 4 trip blanks detected common laboratory contaminants such as acetone at very low concentrations. All environmental samples associated with these trip blank samples were evaluated. Several locations were potentially impacted where acetone had been detected. However, acetone found in the trip blanks are associated as a common laboratory solvent and were also found in the internal laboratory blanks. Therefore, acetone is probably not associated with transportation or field contamination, but were caused within the laboratory.

4.4.2 Equipment Blank Evaluation

Equipment blanks are samples that are collected by rinsing decontaminated equipment with distilled water. The collected rinse water is then analyzed for contaminants of concern. This procedure is used to determine the effectiveness of the decontamination process. At the Weldon Spring Site, most of the groundwater samples are collected from dedicated equipment (ex. pumps, dedicated bailers), and spring water is collected by placing the sample directly into a sample container. Therefore, no equipment blanks are required for groundwater or spring locations.

Surface water is collected using a dip cup or similar container. An equipment blank (rinsate) is collected to assess the cleanliness of the equipment. Three equipment rinsate blanks were collected in 2004 to assess the cups used for surface water sampling. Samples were analyzed for only total uranium. Uranium was detected in one blank slightly above the instrument detection limit. All samples associated with this blank were evaluated and all had uranium concentrations significantly above the blank concentration and these surface water locations were within historical range.

4.5 Data Validation Program Summary

In 2003, the data validation program at the WSSRAP was changed to follow the *Groundwater and Surface Water Sampling and Analysis Plan for GJO Projects* (DOE 2003c). This program involves reviewing and qualifying 100% of the data collected during a calendar year. The data points represent the number of parameters analyzed (e.g., toluene), not the number of physical analyses performed (e.g., volatile organics analyses).

Table 4–3 identifies the number of quarterly and total data points that were validated in 2004, and indicates the percentage of those selected that were complete. Data points in this table include all sample types including field parameters.

Table 4–3. WSSRAP Validation Summary for Calendar Year 2004

Calendar Quarter	No. of Data Points Validated	No. of Validated Data Points Rejected	Completeness[a]
Quarter 1	1559	100[b]	93.6
Quarter 2	2028	1	99.9
Quarter 3	925	0	100
Quarter 4	1471	1	99.9
2004 Total	5983	102	98.3

[a]Completeness is a measure of acceptable data. The value is given by:

$$\text{Completeness} = \frac{(\#\ \text{validated} - \#\ \text{rejected})}{\#\ \text{validated}}$$

[b]97 of 100 rejected data points were field measurements for Oxidation Reduction Potential that were rejected due to misfunctioning probe

Reflects all validatable data for the calendar year.

Table 4–4 identifies validation qualifiers assigned to the selected data points as a result of data validation. The WSSRAP validation technical review was performed in accordance with the *Sampling and Analysis Plan for GJO Projects* (DOE 2003c). For calendar year 2004, 100% of data validation has been completed. Data points in this table include groundwater, leachate, surface water, and spring water samples.

Table 4–4. WSSRAP Validation Qualifier Summary for Calendar Year 2004

	Number of Data Points								
	FIELD	ANIONS	METALS	MISC.	NITRO-AROMATICS	RADIO-CHEMICAL	SEMI-VOLATILES	VOLATILES	TOTAL
Accepted	1877	281	779	91	1778	141	400	534	5881
Rejected	97[(a)]	1	0	0	1	3	0	0	102
Not Validatable	0	0	0	0	0	0	0	0	0
Total	1974	282	779	91	1779	144	400	534	5983
	Percentages								
Accepted	95.1%	99.6%	100%	100%	99.94%	97.9%	100%	100%	98.3%
Rejected	4.9%	0.4%	0%	0%	0.04%	2.1%	0%	0%	1.7%
Not Validatable	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

[a]These 97 rejected data points were field measurements for Oxidation Reduction Potential that were rejected due to misfunctioning probe

End of current text

5.0 Long-Term Surveillance and Maintenance

The site has entered the LTS&M phase of the project in many aspects. The status of these different aspects and activities which took place during 2004 are discussed below:

5.1 Long-Term Surveillance and Maintenance Plan

The LTS&M Plan (DOE 2005a) has been under development for several years. It has undergone several rounds of regulator and stakeholder review and comments. Several public meetings/workshops were held on the development of this plan. The status of the plan for 2004 is as follows:

The third draft of the LTS&M Plan was issued on March 12, 2004. This plan reflected updates regarding institutional controls, *the Disposal Cell Groundwater Monitoring Plan*, and the Groundwater Operable Unit.

The LTS&M Plan was resubmitted to EPA and the State in August 2004 as a Draft-Final in accordance with the FFA. In response to EPA comments, the DOE issued the *Institutional Controls Evaluation (ICE) Report: Summary of Supporting Information for the Identification and Evaluation of Institutional Controls for the Weldon Spring Site* (DOE 2004d) and a revised LTS&M Appendix E: Institutional Controls Plan on October 1, 2004. Due to issues regarding institutional controls, the EPA issued a letter to DOE on November 2, 2004, which invoked the FFA dispute resolution process for the LTS&M Plan.

On November 23, 2004, EPA issued a letter to DOE, which agreed on several steps toward resolution and extended the Dispute Resolution Committee (DRC) period of time to consider the dispute until December 22, 2004.

On December 1, 2004, DOE issued a letter to EPA, which responded to three issues contained in the November 2, 2004, dispute letter.

On December 9, 2004, EPA issued a letter to DOE, which provided DOE an initial response to their December 1 letter and provided an update on the work the EPA agreed to provide.

On December 22, 2004, DOE, as agreed, issued to EPA a Draft-Final Explanation of Significant Difference (ESD) to complete the decision making for the remedial actions as well as the Southeast Drainage removal action. The objective of the ESD is to clarify the objectives and performance standards for the ICs at the site and to set the requirements for the further development of the ICs.

The ESD (DOE 2005b) was finalized on February 20, 2005. The LTS&M Plan was reissued on March 11, 2005.

5.2 Interpretive Center

The Weldon Spring Site Interpretive Center is part of DOE’s long-term surveillance and maintenance activities at the Weldon Spring Site. The purpose of this facility is to inform the public of site history, remedial action activities, and final conditions. The center provides information about the long-term surveillance and maintenance program for the site, provides access to surveillance and maintenance information, and supports community involvement activities.

Current exhibits in the Interpretive Center present:

- The history of the towns that once occupied this area.
- A timeline of significant events at the Weldon Spring Site from 1900 to the present.
- The legacy of the Weldon Spring Ordnance Plant and Uranium Feed Material Plant and the manufacturing wastes.
- The events and community efforts to cleanup the Site and the people that made it happen.
- The multi-faceted phases of the Weldon Spring Site Remedial Action Project.

These exhibits may be changed as appropriate to changing conditions or emerging issues at and near the site. The hours of operation at the Interpretive Center are posted at the Site. The current hours of operation are Monday through Friday: 9:00 a.m. to 5:00 p.m., Saturday: 10:00 a.m. to 4:00 p.m. (10:00 a.m. to 2 p.m. November 1 – March 31), and Sunday: 12:00 p.m. to 4:00 p.m. The Interpretive Center is closed on holidays. These hours are subject to change and current hours will be posted on the website.

Attendance at the Interpretive Center has seen a steady upward trend since opening in August of 2002. Walk-in attendance (general public) has risen as the community continues to gain awareness about the Center. Local school involvement (primary, secondary and college) has risen sharply as the Centers educational programs have been developed and promoted.

Interpretive Center marketing and communication efforts have allowed contact with many St. Charles and St. Louis County schools and community groups to ensure awareness of Center educational programs. These efforts have led to an overall increase in attendance.

Attendance for calendar year 2004 totaled 3,573 which represents a 100% increase over the 2003 attendance of 1,786.

The 150 acres surrounding the disposal cell has been planted with over 80 species of native prairie grasses and wildflowers. Plants such as Prairie Blazing Star, Little Bluestem, and Wild Bergamot will once again dominate this area which was a large native prairie prior to European settlement. Howell Prairie is one of the largest planting of its kind in the St. Louis metropolitan area.

In October, the Weldon Spring Site hosted the first annual 'Howell Prairie Walk and Talk' open to the general public. Prairie establishment experts from the Howell Prairie Council gave walking tours through the prairie area and were available to answer questions from attendees. A presentation about the Weldon Spring Site was given to the more than 70 attendees.

A garden that consists entirely of plants native to the state of Missouri was designed and planted during 2004. The Native Plant Educational Garden contains extensive planting of species from Howell Prairie as well as other perennials, shrubs and trees. Walking paths, benches, and markers to identify the various plants are located through the 8-acre garden.

The Howell Prairie, Native Plant Educational Garden, and Interpretive Center were designed to serve as institutional controls. These areas will attract visitors to the Weldon Spring Site, thus ensuring long-term community education about the remediation project and enhancing the overall educational mission of the site.

5.3 Inspections

The annual LTS&M inspection took place at the Weldon Spring Site on November 17 and 18, 2004. Representatives from EPA and the Missouri Department of Natural Resources (MDNR) participated in the inspection. Representatives from the Weldon Spring Citizen's Commission and the Missouri Department of Conservation participated in portions of the inspection.

The main areas inspected at the site were areas where future institutional controls will be established, the Quarry, the disposal cell, Leachate Collection and Removal System (LCRS), and monitoring wells.

The Institutional Control areas were inspected to ensure that pending restrictions such as excavating soil, groundwater withdrawal, and residential use were not being violated. Each area was inspected and no indications of violations of future restrictions were observed.

The disposal cell was inspected by walking ten transects over the cell and around the cell perimeter at the grade break and the base. Some small depression areas on the cell top and a minor surface disturbance on the side slope were noted for further observation. These areas were located and mapped by global positioning system (GPS) survey equipment in December so that they could be closely monitored. Five areas of the cell which had been marked and located by global positioning system (GPS) survey equipment during the 2003 annual inspection were located and observed for any signs of rock degradation. The LCRS also was inspected and found to be in good condition. Fifty-seven of 119 groundwater wells were inspected and found to be in generally good condition. One well in the Southeast Drainage had been repainted and the number had not been reapplied, although the brass monument with the well number, which is on every well, was clearly visible. Other site features including the prairie, site markers and roads also were inspected. Areas of erosion were identified on the chemical plant property. The areas are north of the disposal cell. The locations of the shallow erosion gullies are shown in Figure 2. One of the erosion areas is slightly inside the buffer zone area and threatens to wash out a buffer zone survey pin. The inspection report was issued in January 2005.

During the 2003 inspection, erosion areas were identified on the north and northwest sides of the disposal cell. These areas had been recently repaired with soil and mulch at the time of the 2003 inspection. During the spring of 2004, these areas were greatly affected by one or more heavy rainfalls and the repairs were washed out resulting in very large erosion gullies. Also during the 2003 inspection, an area of erosion was identified at the outfall NP-0050 on the southwest side of the property. Runoff from the chemical plant property had flowed under the fence onto the Army property and had eroded out a gravel road used to travel around the Army property. Both of the areas were repaired during July 2004 and were stable at the time of the inspection. A discussion of the repairs was held during the inspection.

The first annual public meeting required by the LTS&M Plan (DOE 2005a) was held on March 25, 2004. This meeting was held to discuss the 2003 inspection which took place in October 2003. Also discussed were changes to the LTS&M Plan, a summary of environmental data and the interpretive center/prairie.

6.0 References

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