LMS/WEL/S13516

U.S. Department of Energy
Office of Legacy Management

Weldon Spring Site Fifth Five-Year Review

September 2016

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LMS/WEL/S13516

U.S. Department of Energy
Office of Legacy Management

Weldon Spring Site Fifth Five-Year Review

September 2016

Approved by: Date:

Kenneth Starr 9/16/16

Kenneth I. Starr, PE
Weldon Spring Site Manager
U.S. Department of Energy
Office of Legacy Management

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Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Weldon Spring Quarry/Plant/Pits		
EPA ID: MO3210090004		
Region: 7	**State:** MO	**City/County:** St. Charles/St. Charles

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** Department of Energy
Author name (Federal or State Project Manager): Ken Starr
Author affiliation: DOE Project Manager
Review period: 8/2015 – 9/2016
Date of site inspection: December 1–2, 2015
Type of review: Statutory
Review number: 5
Triggering action date: 9/30/2011
Due date *(five years after triggering action date)*: 9/30/2016

Five-Year Review Summary Form (continued)

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
Chemical Plant Operable Unit, Quarry Bulk Waste Operable Unit, Quarry Residuals Operable Unit, Groundwater Operable Unit

Issues and Recommendations Identified in the Five-Year Review:

OU(s): Sitewide	**Issue Category: Remedy Performance**			
	Issue: There were no issues identified during this five-year review that would prevent the remedies from being protective of human health and the environment.			
	Recommendation: NA			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	NA

Protectiveness Statement(s)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
Chemical Plant Operable Unit	Protective	NA

Protectiveness Statement:
The remedy that has been implemented at the CPOU is protective of human health and the environment. Contaminant sources are contained in an onsite disposal facility at the Chemical Plant. The environmental monitoring data and annual inspections continue to verify that the disposal cell is functioning as intended. The remedy that has been implemented at the Southeast Drainage is protective of human health and the environment. The remedy consisted of removing contaminated soils and sediment to levels that are protective under the current land use. The drainage has recovered from the removal activities and is stable. ICs are used to maintain appropriate land and resource use and ensure that the remedy remains protective over the long term.

Five-Year Review Summary Form (continued)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
Quarry Bulk Waste Operable Unit	Protective	NA

The remedy for the QBWOU is protective of human health and the environment. The action consisted of excavating the bulk wastes from the Quarry and placing them in controlled temporary storage pending final placement in the onsite disposal cell at the Chemical Plant. Excavating the wastes from the Quarry eliminated the potential for direct contact with the waste material and removed the source of ongoing contaminant migration to groundwater.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
Quarry Residuals Operable Unit	Protective	NA

The remedy for the QROU is protective of human health and the environment through long-term monitoring with ICs. The remedy consists of long-term groundwater monitoring and ICs to maintain appropriate land and resource use and ensure that the remedy remains protective over the long-term.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
Groundwater Operable Unit	Will be Protective	NA

The remedy for the GWOU will be protective of human health and the environment upon attainment of groundwater cleanup goals, through MNA, which is expected to require approximately 100 years to achieve. The clean up time for Burgermeister Spring is predicted to be much shorter than the 100 year time frame. In the interim, exposure pathways that could result in unacceptable risks are being controlled and ICs are in place to prevent the groundwater from being used in the restricted area.

Sitewide Protectiveness Statement (if applicable)

Protectiveness Determination:	*Addendum Due Date (if applicable):*
Protective	*NA*

Protectiveness Statement:
This five-year review found the remedy for the entire site to be protective of human health and the environment for all the operable units.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

SEP 30 2016

RECEIVED
NOV 30 2016
BY:

MEMORANDUM:

SUBJECT: Fifth Five-Year Review
Weldon Spring Quarry/Plan/Pits
Weldon Spring, Missouri

FROM: Hoai Tran, Remedial Project Manager
Federal Facility & Post Construction Section

THRU: Lynn M. Juett, Branch Chief
Site Remediation Branch

TO: Mary P. Peterson, Director
Superfund Division

Attached for your approval is the Fifth Five-Year Review Report dated September 2016 that was submitted by the Department of Energy for the Weldon Spring Quarry/Plant/Pits site in Weldon Spring, St. Charles County, Missouri. The site consists of four operable units (OUs): the Chemical Plant Operable Unit (CPOU), the Quarry Bulk Waste Operable Unit (QBWOU), the Quarry Residual Operable Unit (QROU) and the Groundwater Operable Unit (GWOU).

The Department of Energy provides the following protectiveness statements in the report:

Chemical Plant Operable Unit
The remedy that has been implemented at the CPOU is protective of human health and the environment. Contaminant sources are contained in an onsite disposal facility at the chemical plant. The environmental monitoring data and annual inspections continue to verify that the disposal cell is functioning as intended. The remedy that has been implemented at the southeast drainage is protective of human health and the environment. The remedy consisted of removing contaminated soils and sediment to levels that are protective under the current land use. The drainage has recovered from the removal activities and is stable. Institutional controls are used to maintain appropriate land and resource use, and ensure that the remedy remains protective over the long term.

Quarry Bulk Waste Operable Unit
The remedy for the QBWOU is protective of human health and the environment. The action consisted of excavating the bulk wastes from the quarry, and placing them in controlled temporary storage pending final placement in the on-site disposal cell at the chemical plant. Excavating the wastes from the quarry eliminated the potential for direct contact with the waste material, and removed the source of ongoing contaminant migration to groundwater.

Quarry Residual Operable Unit
The remedy for the QROU is protective of human health and the environment through long-term monitoring with institutional controls. The remedy consists of long-term groundwater monitoring and institutional controls to maintain appropriate land and resource use, and ensure that the remedy remains protective over the long-term.

Groundwater Operable Unit
The remedy for the GWOU will be protective of human health and the environment upon attainment of groundwater cleanup goals, through monitored natural attenuation (MNA), which is expected to require approximately 100 years to achieve. The clean-up time for Burgermeister Spring is predicted to be much shorter than the 100 year time frame. In the interim, exposure pathways that could result in unacceptable risks are being controlled, and institutional controls are in place to prevent the groundwater from being used in the restricted area.

Site-Wide
This five-year review found the remedy for the entire site to be protective of human health and the environment for all OUs.

The EPA provides the following independent protectiveness statements:

The EPA concurs with the protectiveness statements for three of the four OUs. The remedies at the CPOU, the QBWOU, and the QROU are protective of human health and environment, and no issues were found during the five-year review.

Groundwater Operable Unit
For the GWOU, the EPA concurs that the remedy is currently protective of human health and environment, but the agency identified an issue that may potentially affect the long-term protectiveness. The issue, along with the recommendations to address it, is given in the following table:

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): GWOU	**Issue Category: Monitoring**			
	Issue: The MNA remedy for the GWOU is not meeting the objectives, as specified in the 2004 Remedial Design/Remedial Action Work Plan for the GWOU, and the 2008 Long-term Surveillance and Maintenance Plan for the site.			
	Recommendation: Additional sampling locations should be added to the sampling and monitoring program to meet the objectives of the MNA remedy. Additional monitoring and characterization of the uranium impact in the unweathered unit are required to meet the objectives of the MNA remedy.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	9/30/2019

The remedy for the GWOU is currently protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled, and institutional controls are in place to prevent the groundwater from being used in the restricted area. However, in order for the remedy to be protective in the long-term, additional sampling locations and characterization are needed to demonstrate that the objectives of the MNA remedy can be met.

Site-Wide
The change in the protectiveness statement for the GWOU results in a change for the entire site. Therefore, the agency is issuing the following independent protectiveness statement for the entire site:

This five-year review found the remedy for the entire site to be currently protective of human health and the environment. However, in order for the remedy to be protective in the long-term, issues will need to be addressed at the GWOU.

The next FYR is due on September 30, 2021.

Approval:

Mary P. Peterson

Mary P. Peterson, Director
Superfund Division

9/30/2016

Date

Attachment

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Abbreviations

ACM	asbestos-containing materials
AEC	Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
BLL	blood lead level
BTL	baseline tolerance limit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COD	chemical oxygen demand
COPC	contaminant of potential concern
CPOU	Chemical Plant Operable Unit
CSR	*Missouri Code of State Regulations*
DA	Department of the Army
DNB	dinitrobenzene
DNT	dinitrotoluene
DOE	U.S. Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Difference
FFA	Federal Facility Agreement
FIMS	Facilities Information Management System
ft	feet
FY	fiscal year
FYR	Five Year Review
gpa	gallons per acre
gpd	gallons per day
GWOU	Groundwater Operable Unit
HDPE	high-density polyethylene
HEAST	Health Effects Summary Tables
IC	institutional control
ICO	in-situ chemical oxidation
IRA	Interim Response Action
IRIS	Integrated Risk Information System
kg	kilograms
LCRS	Leachate Collection and Removal System
LiDAR	light + radar (also, light detection and ranging), a remote sensing technology
LTS&M	long-term surveillance and maintenance
MCL	maximum contaminant level

MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
µg	micrograms
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
mg	milligrams
mg/kg-d	milligrams per kilogram per day
mg/L	milligrams per liter
MNA	monitored natural attenuation
MoDOT	Missouri Department of Transportation
MOU	Memorandum of Understanding
mrem	millirem
MSD	Metropolitan St. Louis Sewer District
msl	mean sea level
mV	millivolts
MW	monitoring well
NA	not applicable
NB	nitrobenzene
NCP	National Contingency Plan
ND	not detected
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NR	analyte not required
NS	not sampled
ORAU	Oak Ridge Associated Universities
ORP	oxidation-reduction potential
OU	operable unit
PAH	polycyclic aromatic hydrocarbon (also called polynuclear aromatic hydrocarbon)
PCB	polychlorinated biphenyl
pCi	picocuries
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PPRTV	provisional peer-reviewed toxicity value
QBWOU	Quarry Bulk Waste Operable Unit
QROU	Quarry Residuals Operable Unit
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RAR	relevant and appropriate
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study

ROD	Record of Decision
RP	Raffinate Pits
RSL	Regional Screening Level (EPA summary table)
SED	Southeast Drainage
SOARS	System Operation and Analysis at Remote Sites
TBC	To Be Considered
TCE	trichloroethene
TDS	total dissolved solids
TEDE	total effective dose equivalent
TNB	trinitrobenzene
TNT	trinitrotoluene
TOC	total organic carbon
TSA	Temporary Storage Area
UUUE	unlimited use and unrestricted exposure
VISL	vapor intrusion screening level
WSSRAP	Weldon Spring Site Remedial Action Project

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Executive Summary

The Weldon Spring Site in St. Charles, Missouri, also known as the Weldon Spring Site Remedial Action Project, has been remediated by the U.S. Department of Energy in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986. The Weldon Spring Site includes the Chemical Plant Area and the Quarry. Remediation of the Weldon Spring Site was administratively divided into four Operable Units: the Chemical Plant Operable Unit (CPOU), the Groundwater Operable Unit (GWOU), the Quarry Bulk Waste Operable Unit (QBWOU), and the Quarry Residuals Operable Unit (QROU).

The CERCLA Five-Year Review is required by statute. Section 121(c) of CERCLA requires that remedial actions resulting in any hazardous substances, pollutants, or contaminants remaining at a site above levels that allow for unlimited use and unrestricted exposure be reviewed every 5 years to ensure protection of human health and the environment. This is a statutory review.

This is the fifth Five-Year Review conducted for the Weldon Spring Site. Remedial activities at the Chemical Plant and the Quarry have been completed with the exception of long-term groundwater monitoring at both locations. The GWOU Record of Decision (ROD) (DOE 2004a) was finalized in January 2004 and was signed by the U.S. Environmental Protection Agency (EPA) in February 2004. The GWOU ROD selected the remedy of monitored natural attenuation (MNA) with institutional controls (ICs) to limit groundwater use during the period of remediation. The site has reached construction completion, which was documented in the Preliminary Closeout Report issued by EPA on August 22, 2005. Since the site has reached physical completion, the long-term surveillance and maintenance activities have become the main focus of the project. Establishment and monitoring of ICs, conducting annual surveillance inspections, monitoring the groundwater, and establishing the Interpretive Center and Howell Prairie have been major activities for the project.

The site reached construction completion under CERCLA on August 22, 2005. The site also received the EPA Superfund Sitewide Ready for Anticipated Use (SWRAU) designation from EPA in a letter dated March 20, 2013. The SWRAU performance measure reports sites documented as ready for reuse when the entire construction-completed NPL site meets the following requirements:

- All cleanup goals in the RODs or other remedy decision documents have been achieved for media that may affect current and reasonably anticipated future land uses of the site, so that there are no unacceptable risks.
- All institutional or other controls required in the RODs or other remedy decision documents have been put in place.

After a review of all relevant site documents, including the RODs, the LTS&M Plan, five-year reviews, annual inspections and monitoring data, and ICs documentation, EPA determined that DOE has achieved the SWRAU performance measure for all DOE-owned land at the site. This includes the former Chemical Plant and Quarry areas and totals approximately 229 acres. The SWRAU measure was recorded as completed in the EPA Comprehensive Environmental Response, Compensation, and Liability Information System database on February 13, 2013.

This Five-Year Review found the remedy for the entire site to be protective of human health and the environment for all the operable units. The remedies for the completed activities for the CPOU and QBWOU are protective of human health and the environment, with ICs to restrict certain land use. The remedy for the GWOU is protective of human health and the environment upon attainment of groundwater cleanup goals through MNA, with ICs. The cleanup times for completion of the MNA remedy are generally within the projected time frame of 100 years. The clean up time for Burgermeister Spring is predicted to be much shorter than the 100 year time frame. The remedy for the QROU is protective through long-term monitoring with ICs. In the interim, exposure pathways that could result in unacceptable risks are being controlled, and ICs are in place to prevent the groundwater from being used in the restricted areas.

1.0 Introduction

The purpose of the Five-Year Review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues that could prevent the remedy from being protective of human health and the environment, if any, and identify recommendations to address them.

The U.S. Department of Energy (DOE) is preparing this Five-Year Review report pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §121 and the National Contingency Plan (NCP). CERCLA §121 states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

The U.S. Environmental Protection Agency (EPA) interpreted this requirement further in the NCP; Title 40 *Code of Federal Regulations* (CFR) §300.430(f)(4)(ii) states:

> If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

DOE, with the assistance of the DOE long-term surveillance and maintenance (LTS&M) contractor, conducted the Five-Year Review of the remedies implemented at the Weldon Spring Site in St. Charles, Missouri. This review was conducted for the entire site, which includes four operable units (OUs), from October 2011 through September 2016. This report documents the results of the review.

This is the fifth Five-Year Review for the Weldon Spring Site. The triggering action for this statutory review is the completion of the fourth Five-Year Review, on September 30, 2011. The Five-Year Review is required due to the fact that hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

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2.0 Site Chronology

Table 1. Site Chronology

Event	Date
Army Ordnance Works begins operations	1941
Army begins burning waste and dumping rubble	1942
Army Ordnance Works ends operations	1945
Majority of Army Ordnance Works property transferred to State of Missouri	1949
Army stops Quarry activity	1949
Chemical Plant site transferred to U.S. Atomic Energy Commission (AEC)	1955
Uranium Feed Materials Plant operations begin	1958
AEC acquires Quarry title	1958
AEC begins waste disposal in Quarry	1963
Uranium Feed Materials Plant operations end	1966
Chemical Plant site transferred to Army	1967
AEC stops waste disposal at Quarry	1967
Army starts waste disposal at Quarry	1968
Army begins decontaminating buildings and removing equipment at Chemical Plant	1968
Army stops waste disposal in Quarry	1969
Army transfers Raffinate Pits to AEC	1971
DOE designates Weldon Spring Site Remedial Action Project (WSSRAP) as a major project	1985
Federal Facility Agreement (FFA) signed between EPA and DOE	1986
Prime management contractor is selected	2/1986
DOE and prime management contractor establish site office	7/1986
Prime management contractor assumes site control	10/1986
Quarry is placed on National Priorities List (NPL)	7/1987
WSSRAP designated as a major systems acquisition	5/1988
Chemical Plant and Raffinate Pits added to NPL	3/1989
Remedial Investigation for the Quarry Bulk Waste complete	12/1989
Feasibility Study for the Quarry bulk waste complete	2/1990
Record of Decision (ROD) for management of the bulk waste at the Quarry complete	9/1990
Quarry Bulk Waste excavation support begins	6/1991
FFA amended	1992
Building dismantlement begins	3/1992
Remedial Investigation/Feasibility Study (RI/FS) for Chemical Plant complete	11/1992
First batch of water discharged from Quarry Water Treatment Plant	1/1993
Quarry bulk waste excavation begins	5/1993
First batch of water discharged from Site Water Treatment Plant	5/1993
ROD for Remedial Action at the Chemical Plant Area of the Weldon Spring Site complete	9/1993
Remedial Design Work Plan for the Chemical Plant complete	1/1994
Chemical Stabilization/Solidification Pilot Plant testing	1995
Building dismantlement complete	1/1995
Remedial Action Work Plan for the Chemical Plant complete	11/1995

Table 1 (continued). Site Chronology

Event	Date
Quarry bulk waste excavation complete	12/1995
First Five-Year Review Report Issued	6/1996
Remedial Action Report for the Quarry bulk waste complete	3/1997
Remedial Investigation for Groundwater Operable Unit (GWOU) complete	7/1997
Remedial Investigation for Quarry Residuals Operable Unit (QROU) complete	2/1998
Feasibility Study for QROU complete	3/1998
First load of waste placed in disposal cell	3/5/1998
Chemical Stabilization/Solidification Plant begins operation	7/1998
ROD for QROU complete	9/1998
Chemical Stabilization/Solidification Plant completes operations	11/13/1998
Feasibility Study for GWOU complete	12/1998
Supplemental Feasibility Study for GWOU complete	6/1999
Remedial Design/Remedial Action Work Plan for QROU complete	1/2000
Demolition of Site Water Treatment Plant complete	7/6/2000
Interim ROD for GWOU complete	9/2000
Confirmation of Chemical Plant soil complete	3/2001
Demolition of Quarry Water Treatment Plant complete	5/2001
Placement of waste in disposal cell complete	6/3/2001
Second Five-Year Review Report issued	8/2001
Last rock placed on disposal cell	10/23/2001
150 acres around disposal cell prepared for planting of Howell Prairie	6/2002
Quarry Residuals Interceptor Trench Field Study complete	4/26/2002
Ribbon-cutting for and opening of Interpretive Center	8/5/2002
Site transferred to DOE LTS&M program	10/1/2002
Second planting for Howell Prairie	1/2003
Performance Evaluation Report for Interceptor Trench Field Study complete	5/8/2003
Third planting for Howell Prairie	1/2004
Remedial Action Report for CPOU complete	1/30/2004
Remedial Action Report for QROU complete	1/30/2004
ROD for groundwater complete	2/20/2004
Inspection Report issued	2/25/2004
Groundwater remedial action inspection complete	7/20/2004
Remedial Design/Remedial Action Work Plan for GWOU complete	7/29/2004
Second annual LTS&M inspection	11/17–18/2004
Inspection Report issued	1/2005
Explanation of Significant Differences for institutional controls complete	2/2005
Interim Remedial Action Report for Groundwater complete	3/2005
Final LTS&M Plan issued	7/2005
Preliminary Closeout Report issued by EPA	8/22/2005
Third annual LTS&M inspection	11/7–8/2005
Inspection Report issued	3/2006
FFA revised and signed by EPA, MDNR and DOE	3/2006

Table 1 (continued). Site Chronology

Event	Date
Third Five-Year Review Report issued	9/2006
Fourth annual LTS&M inspection	12/5,6,15/2006
Inspection Report issued	1/2007
Fifth annual LTS&M inspection	10/24–26/2007
Inspection Report issued	12/2007
Sixth annual LTS&M inspection	10/28–30/2008
LTS&M Plan revised	12/2008
Inspection Report issued	1/2009
Seventh annual LTS&M inspection	10/27–29/2009
Inspection Report issued	1/2010
Eighth annual LTS&M inspection	10/26–28/2010
Inspection Report issued	1/2011
Fourth Five-Year Review Report issued	9/2011
Ninth annual LTS&M inspection	10/25–27/2011
Inspection Report issued	1/2012
Tenth annual LTS&M inspection	10/23–25/2012
Superfund Sitewide Ready for Anticipated Use achieved	2/2013
Inspection (Annual) Report issued	6/2013
Eleventh annual LTS&M inspection	11/5–7/2013
Inspection (Annual) Report Issued	6/2014
Twelfth annual LTS&M inspection	12/9–10/2014
Inspection (Annual) Report issued	6/2015
Thirteenth annual LTS&M inspection	12/1–2/2015
Inspection (Annual) Report issued	6/2016

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3.0 Background

3.1 Physical Characteristics

3.1.1 Site Description

The Weldon Spring Site is located in St. Charles County, Missouri, about 30 mile west of St. Louis (Figure 1). The site comprises two geographically distinct DOE-owned properties: the Weldon Spring former Chemical Plant and Raffinate Pit Sites (Chemical Plant) and the Weldon Spring Quarry (Quarry). The former Chemical Plant is located about 2 miles southwest of the junction of Missouri State Route 94 and Interstate 64. The Quarry is about 4 miles southwest of the former Chemical Plant. Both sites are accessible from Missouri State Route 94.

During the early 1940s, the Department of the Army acquired 17,232 acres 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 2. Current land use of the former Ordnance Works site includes the former Chemical Plant and Quarry, the U.S. Army Reserve Weldon Spring Training Area, Missouri Department of Conservation (MDC) and Missouri Department of Natural Resources (MDNR) Division of State Parks (MDNR-Parks), Francis Howell High School, a St. Charles County highway maintenance (formerly Missouri Department of Transportation (MoDOT), the Public Water Supply District #2 water treatment facility, a law-enforcement training center, the village of Weldon Spring Heights, and a University of Missouri research park.

The Chemical Plant and Quarry Areas total 228.16 acres. The former Chemical Plant property occupies 219.50 acres; the Quarry occupies 8.66 acres.

3.1.2 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 is the Mississippian Burlington-Keokuk Limestone. Overlying the bedrock are unconsolidated units consisting of fill, topsoil, loess, glacial till, and limestone residuum, of thicknesses ranging from a few feet to several tens of feet.

Three bedrock aquifers underlie St. Charles County. The shallow aquifer consists of Mississippian Burlington-Keokuk Limestone and Fern Glen Formation, 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.

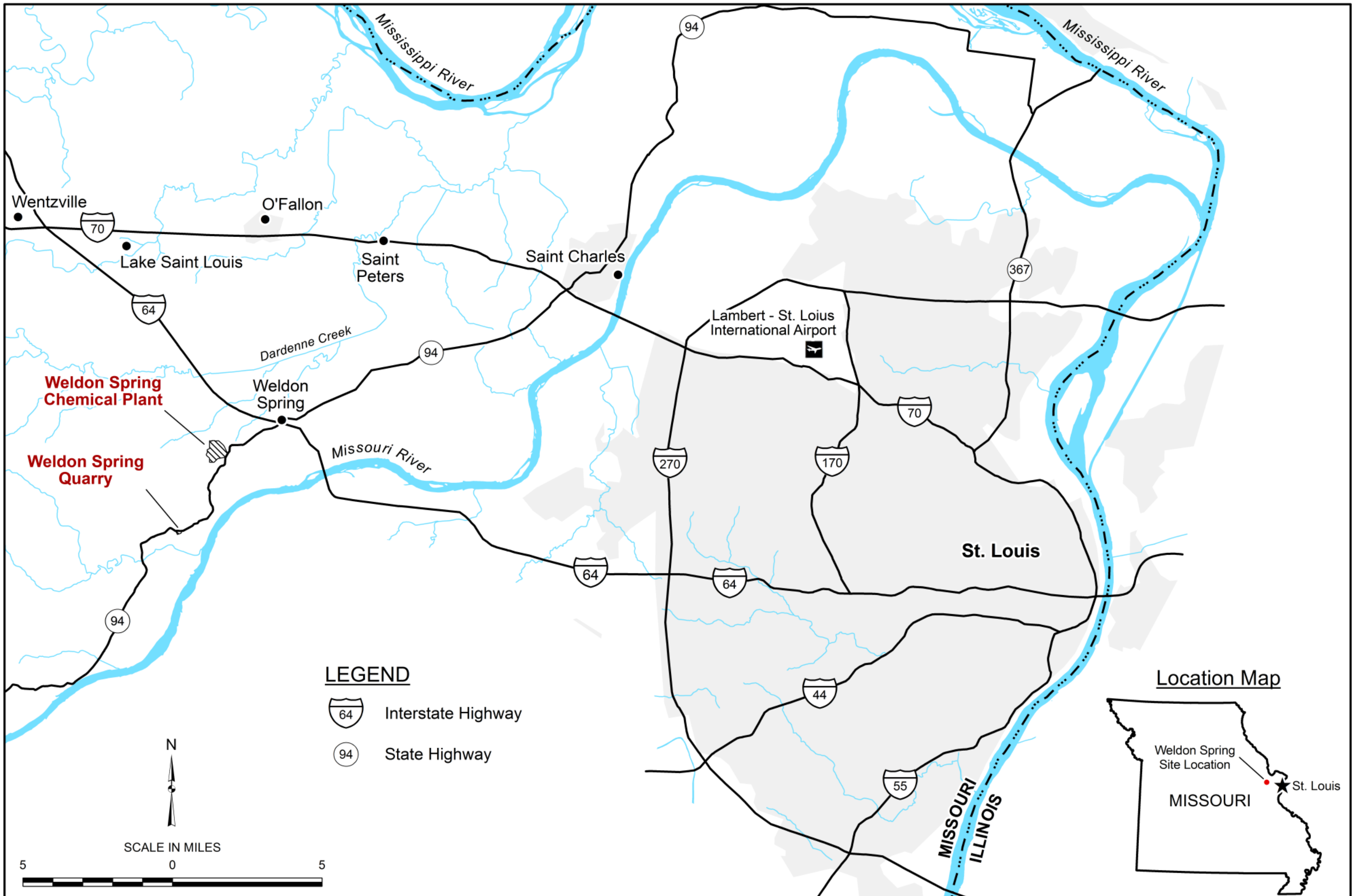

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Figure 1. Location of the Weldon Spring, Missouri, Site

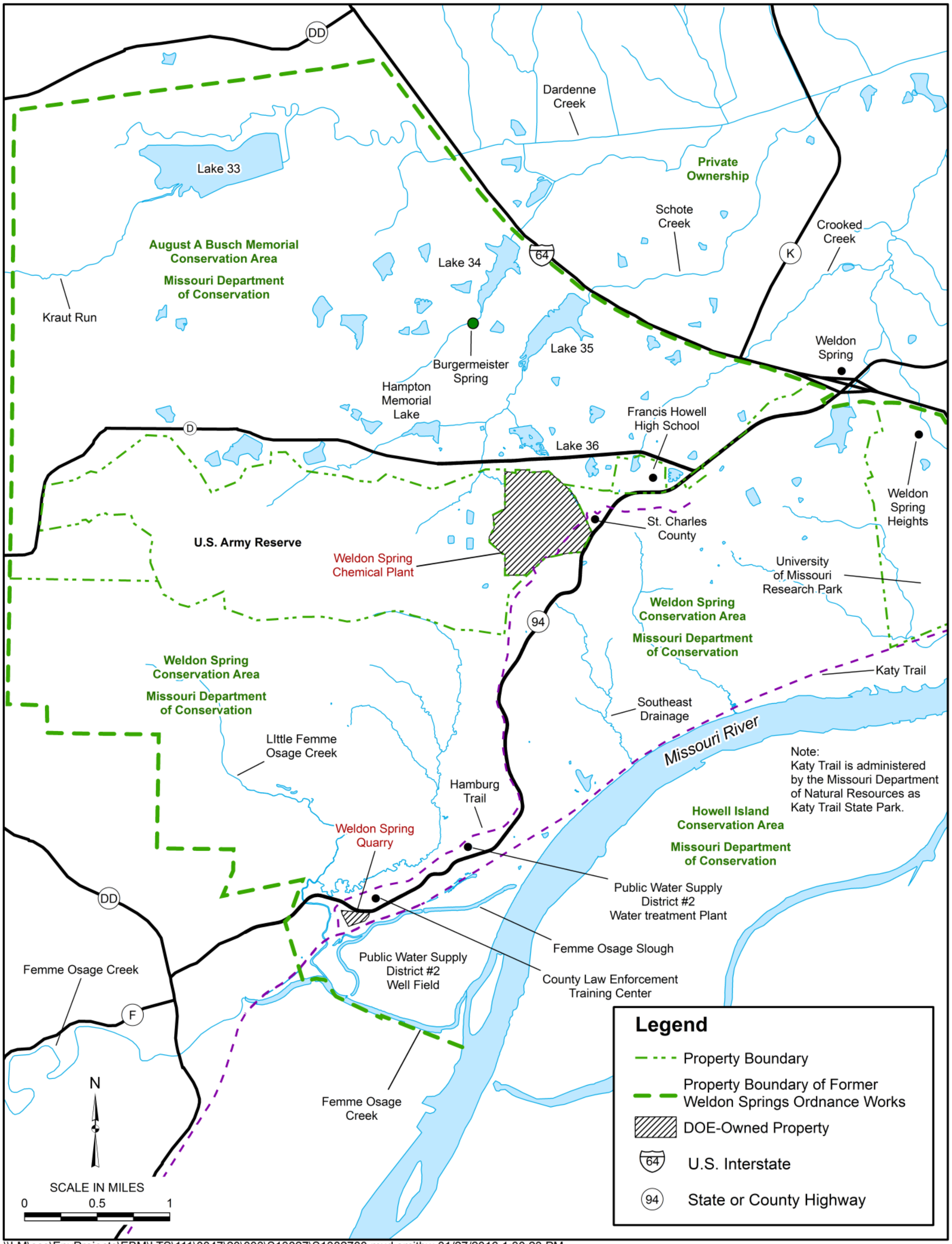

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Figure 2. Vicinity Map of the Weldon Spring, Missouri, Site

The Weldon Spring Quarry is located in low limestone hills near the northern bank of the Missouri River. The middle Ordovician bedrock of the Quarry Area includes, in descending order, Kimmswick Limestone, Decorah Formation, and Plattin Limestone. These units are predominantly limestone and dolomite. Massive quaternary deposits of Missouri River alluvium cover the bedrock to the south and east of the Quarry.

3.1.3 Surface Water System and Use

The former Chemical Plant and Raffinate Pits areas are located on the Missouri/Mississippi River surface drainage divide. Elevations on the site range from approximately 608 ft above mean sea level (msl) near the northern edge of the site to 665 ft above msl near the southern edge. (The disposal 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 Drainage, 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 Schote Creek and Dardenne Creek, which ultimately drain to the Mississippi River. The manmade lakes in the August A. Busch Memorial Conservation Area, which are used for public fishing and boating, are located within these surface drainages. No water from the lakes or creeks is used for irrigation or for public drinking water supplies.

Before remediation of the former Chemical Plant and Raffinate Pits areas 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. The 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 within a bluff of the Missouri River valley about 1 mile northwest of the Missouri River at approximately River Mile 49. A 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 groundwater. All water pumped from the Quarry before remediation was treated before it was released. Bulk waste removal, which included the 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 700 ft south of the Quarry, is a 1.5-mile section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri redirected the creek channels between 1960 and 1963 during the construction of a levee system around the University experimental farms (DOE 1990b). The slough is essentially landlocked. The slough is not used for drinking water or irrigation.

3.1.4 Ecology

The Weldon Spring Site is surrounded primarily by state conservation areas that include the 6,988-acre Busch Conservation Area to the north, the 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 2,548 acres (Figure 2).

The wildlife areas are managed for multiple uses, including timber, fish and wildlife habitat, and recreation. Fishing constitutes 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 1992c). 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 Biological Assessment conducted for the Chemical Plant Area of the site in 1992 (DOE 1992e) identified several endangered species in the vicinity of the Weldon Spring Site. The species list was reviewed during the last (2011) Five-Year Review based on current species lists for St. Charles County, Missouri. That review indicated that two species identified in 1992 had been delisted, and two additional species were identified as endangered. For the current (2016) Five-Year Review, the 2011 species list was compared with those currently identified as threatened or endangered (http://www.fws.gov/midwest/endangered/lists/missouri-cty.html). Three additional species have been identified as threatened and one species as endangered. One formerly identified species is no longer listed as occurring in St. Charles County. Table 2 lists all those species and their status and compares the 2011 and current status of threatened and endangered species for St. Charles County, Missouri.

Table 2. 2011 and Current Threatened and Endangered Species, St. Charles County, Missouri

Species	Group	2011 Status	Current Status
Decurrent false aster (*Boltonia decurrens*)	Flowering plants	Threatened	Threatened
Indiana bat (*Myotis sodalis*)	Mammals	Not listed	Endangered
Interior least tern (*Sterna antillarum*)	Birds	Endangered	Endangered
Northern long-eared bat (*Myotis septentrionalis*)	Mammals	Not listed	Threatened
Pallid sturgeon (*Scaphirhynchus albus*)	Fishes	Endangered	Endangered
Piping plover (*Charadrius melodus*)	Birds	Not listed	Threatened
Rufa red knot (*Calidris canutus rufa*)	Birds	Not listed	Threatened
Running buffalo clover (*Trifolium stoloniferum*)	Flowering plants	Endangered	Endangered
Scaleshell mussel (*Leptodea leptodon*)	Clams	Endangered	Endangered, but not identified as occurring in St. Charles County

3.2 Land Use and Demography

According to the US Census Bureau, the estimated population of St. Charles County in 2014 was 379,493. The three largest communities in St. Charles County are O'Fallon (population: est. 81,979), St. Charles (population: est. 65,463), and St. Peters (population: est. 54,078) (Figure 1). The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 3.2 kilometers (2 miles) 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.

Francis Howell High School is about 1 kilometer (0.6 mile) northeast of the site along Missouri State Route 94 (Figure 2). The school employs approximately 150 faculty and staff, and about 1,780 students attend it. Approximately 50 bus drivers park their school buses in the adjacent parking lot. The school constructed a new school building, which was completed in time for the start of the 2011–2012 school year.

The St. Charles County highway maintenance facility (formerly MoDOT), located adjacent to the north side of the Chemical Plant, is unmanned. The Army Reserve Training Area is to the west of the Chemical Plant. A Naval Reserve Center was built on the site in 2008 and is currently operational. An Army Reserve Center has also recently been constructed on the Army property. About 741 acres (300 hectares) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land has been developed into a high-technology research park. The conservation areas adjacent to the Chemical Plant are operated by MDC and employ about 50 people.

3.3 History of Contamination

3.3.1 Operations History

In 1941, the U.S. government acquired 17,232 acres 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. From 1941 to 1945, the Department of the Army 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 offsite springs.

Following a considerable amount of explosives decontamination of the facility by the Army, 205 acres 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 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 Chemical Plant property. Uranium processing operations resulted in radiological contamination of the same general locations previously contaminated by former Army operations.

The 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 (both drummed and uncontained) from the former Chemical Plant and other AEC locations.

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-production 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 defoliant was manufactured, and the Army transferred 50.65 acres 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.

3.3.2 Nature and Extent of Contamination

Except for the limited decontamination effort by the Army in 1984, the Chemical Plant had been closed for 20 years when the remediation project began at the site. During this period, the infrastructure had deteriorated considerably. Many windows were broken, walls were separated from floors, floors had begun to break apart, and roofs had holes and had deteriorated to the extent that many leaked badly. There was radioactive contamination on various surfaces, polychlorinated biphenyls (PCBs) contamination of floors, and deterioration of protective coverings for asbestos-containing insulation.

On the Chemical Plant grounds, 300 utility poles supporting 150,000 linear feet of wiring were rotten, and many had fallen to the ground. There was an additional 33,000 linear feet of piping, some with deteriorating asbestos containing insulation. Active water mains leaked extensively and added to contaminated water leaving the site.

In addition to the buildings, four raffinate pits contained several hundred to several thousand picocuries per gram (pCi/g) of uranium, radium, and thorium isotopes. Chemical analysis of the sludge showed relatively homogeneous material in all of the pits except Pit 4, which also contained a large number of discarded drums, containers, and debris from the Army’s earlier partial decontamination. The sludge contained concentrations greater than background for all of the metals and anions included in the analysis. The pH of greater than 7 maintained low concentrations of heavy metals in the water. These four pits, Frog Pond, and Ash Pond all contained radionuclides, primarily thorium and uranium, metals such as arsenic and chromium, and inorganic anions such as nitrate and sulfate (Figure 3).

Chemical Plant soils generally contained low levels of radionuclides such as uranium, thorium, and radium; some heavy metals such as arsenic and lead; and inorganic ions such as sulfate. Characterization data indicated that uranium (U-238) was generally distributed at low levels across the Chemical Plant surface soils, but a few discrete areas of relatively high concentrations

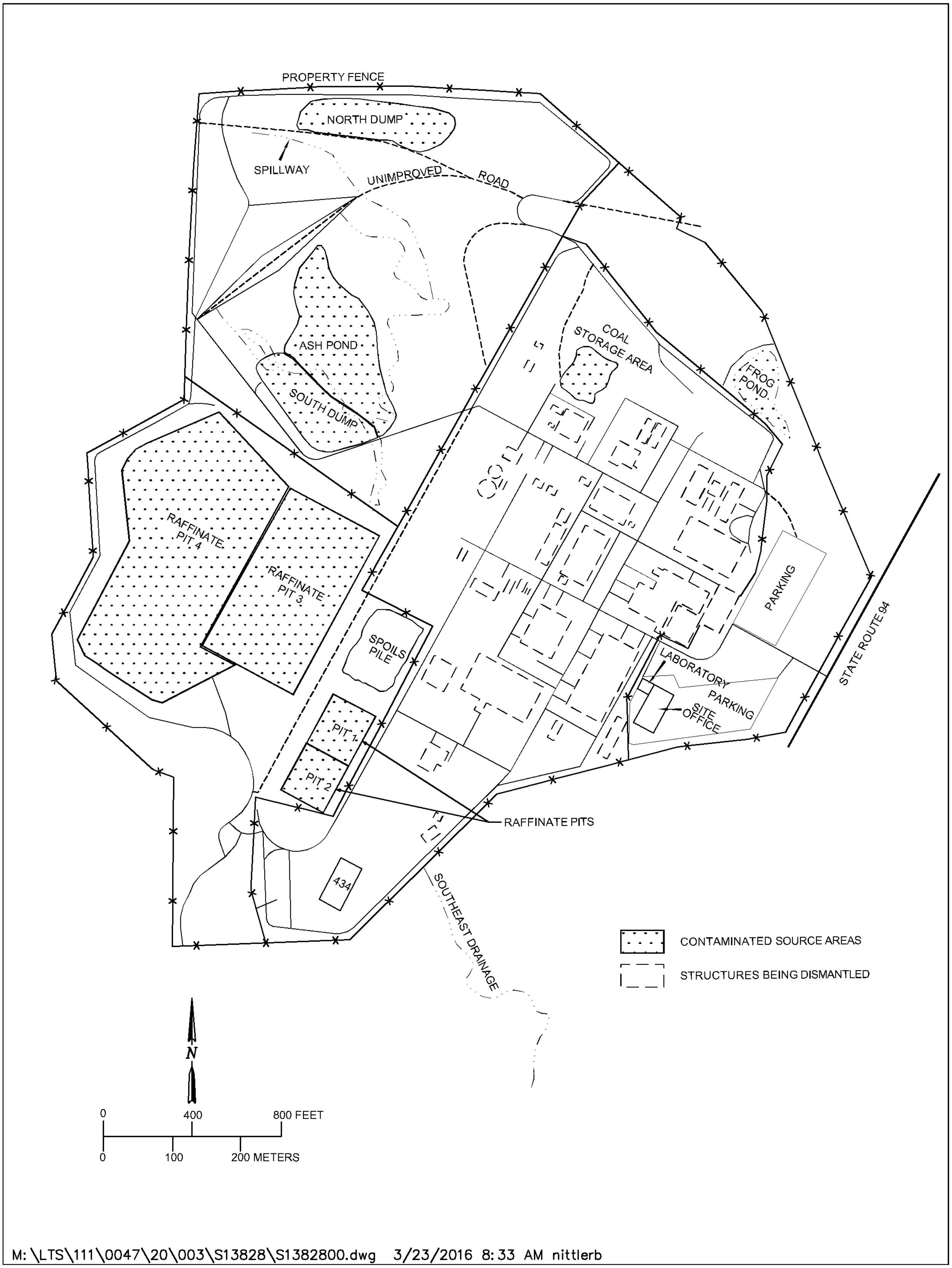

Figure 3. Location of Raffinate Pits, Frog Pond, and Ash Pond

occurred at the north dump, at the south dump, and around the process buildings. Elevated levels of radium (Ra-226 and Ra-228) were detected in a few scattered areas around the process buildings, and elevated levels of thorium (Th-230) were detected in scattered locations around the Raffinate Pits and in the south dump.

The main chemical contaminants in the soil were metals and inorganic anions. Nitroaromatic compounds were present in the soil at discrete areas associated with former ordnance works operations, and low levels of polycyclic (also called polynuclear) aromatic hydrocarbons (PAHs) were present in an area previously used for coal storage and at a concrete pad adjacent to two of the buildings. Areas adjacent to transformers and around the buildings were contaminated with low levels of PCBs. Although asbestos containing material was present throughout the Chemical Plant in buildings and overhead piping, asbestos fibers were not detected in surface or subsurface soil.

Several offsite locations were also radioactively contaminated as a result of releases from the site and were designated as vicinity properties. Low levels of radioactivity (primarily uranium and thorium) were present in several small areas of soil; in the surface water and sediments of Lakes 34, 35, and 36 in the Busch Wildlife Area; and in Burgermeister Spring and springs in the Southeast Drainage. Some higher levels of radionuclides (e.g., uranium, thorium, and radium) were present in sediment at certain locations in the Southeast Drainage because of past operational discharges.

Specific chemicals and their source areas prior to remediation are listed in Table 3.

Table 3. Specific Chemicals and Source Areas

Source Area	Chemical Contaminants	Radiological Contaminants
Chemical Plant Soils	Non-friable asbestos-containing material (ACM), PCBs, heavy metals, nitroaromatics, PAHs, nitrates, sulfates	Uranium, thorium, radium
North Dump	Non-friable ACM	Uranium, thorium, radium
South Dump	Non-friable ACM	Uranium, thorium, radium
Ash Pond	Non-friable ACM	Uranium, thorium, radium
Raffinate Pit Berms	PCBs, lead chromium, cadmium, tetrachloroethylene, nitrates	Uranium, thorium, radium
Raffinate Pit Water	Antimony, arsenic, magnesium, manganese, molybdenum, selenium, zinc, mercury	Uranium, thorium, radium
Raffinate Pit Sludge	PCBs, heavy metals, mercury	Uranium, thorium, radium
Chemical Plant Building	Friable ACM, non-friable ACM, PCBs, nitric acid, hydrofluoric acid, sodium hydroxide, tributyl phosphate, heavy metals, calcium hydroxide, potassium hydroxide, ethylene glycol, mercury, perchloric acid, magnesium, magnesium fluoride	Uranium, thorium, radium
Frog Pond Water	Arsenic, lead, chromium, mercury, magnesium, magnesium fluoride, nitroaromatics	Uranium
Frog Pond Sediment	Lead, cadmium, chromium, mercury	Uranium
Quarry Pond Water	Friable ACM, PCBs, arsenic, manganese, nitroaromatics, PAHs	Uranium, thorium, radium
Quarry Pond Sediment	Friable ACM, arsenic, manganese, nitroaromatics, PAHs	Uranium, thorium, radium
Quarry Bulk Wastes	Friable ACM, PCBs, mercury, arsenic, lead, cadmium, nickel, selenium, nitroaromatics, PAHs	Uranium, thorium, radium

3.4 Initial Response

3.4.1 Interim Response Actions

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 offsite in surface water.
- Detailed characterization of onsite 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.

Originally, 23 IRAs (Table 4) were scoped, but some of these were cancelled and others combined so that 14 were completed. Any of the IRAs cancelled were covered by other environmental documentation.

Table 4. Weldon Spring Site Interim Response Actions

Number	Description	Status
1	Electrical Transformer Removal	Complete
2	Ash Pond Isolation System	Complete
3	Material Staging Area (Moved to IRA 15)	Cancelled
4	Army Property 7	Complete
5	August A. Busch and Weldon Spring Wildlife Areas 3, 4, 5, and 6	Cancelled
6	Overhead Piping/Asbestos Removal	Complete
7	Containerized Chemicals	Complete
8	Electrical Pole/Overhead Line Removal	Complete
9	Debris Consolidation	Complete
10	Building 409 Dismantlement	Complete
11	Building 401 Dismantlement	Complete
12	Isolation Dike for Surface Water Management on the Southeast Drainage (SED)	Cancelled
13	Army Reserve Properties 1, 2, 3, and 7	Cancelled
14	Dismantlement and Removal of Non-Process Buildings, Structures, and Equipment (Moved to IRA 15-19)	Cancelled
15	Non-Process Building Dismantlement Task 1	Complete
16	Remaining Process and Non-Process Building Dismantlement (Moved to IRA 18)	Cancelled
17	Water Tower Removal (Moved to IRA 18)	Cancelled
18	Process (Contaminated Structures) Building Dismantlement	Complete
19	Decontamination Facility	Cancelled
20	Site Water Treatment Plant	Complete
21	Quarry Water Treatment Plant	Complete
22	Quarry Construction Staging Area (Incorporated into Quarry Bulk Waste ROD)	Cancelled
23	Southeast Drainage Soil Removal	Complete

EPA placed the Quarry and Chemical Plant areas on the National Priorities List on July 30, 1987, and March 30, 1989, respectively.

A Federal Facility Agreement (FFA) was signed by EPA and DOE in 1986, and it was amended in 1992. The main purpose of this FFA was to establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the site in accordance with CERCLA.

A revised FFA between EPA, DOE, and MDNR was signed by all parties by March 31, 2006. The focus of the new FFA is LTS&M activities.

Remediation of the Weldon Spring Site was administratively divided into the four OUs: the Quarry Bulk Waste Operable Unit (QBWOU), Quarry Residuals Operable Unit (QROU), Chemical Plant Operable Unit (CPOU), and Groundwater Operable Unit (GWOU). The Southeast Drainage was remediated as a separate action through an EE/CA report (DOE 1996). The selected remedies are described in Section 4.0.

3.5 Basis for Taking Actions

3.5.1 Chemical Plant Contaminants of Concern

The CPOU initial concentrations of major chemicals of concern for assessment of personnel exposure and their locations are listed in Table 5.

Table 5. Concentration and Location of Initial Chemicals of Concern at the Chemical Plant

	Onsite Concentration Range[a]			Offsite Concentration Range[b]	
Contaminant	**Soil (mg/kg)**	**Surface Water (µg/L)**	**Raffinate Pit Sludge (mg/kg)**	**Surface Water (µg/L)**	**Sediment (mg/kg)**
Antimony	6.4–110	65–400	6.0–87	70–76	ND
Arsenic	1.3–130	12–120	3.1–1,100	12–29	3.0–19
Barium	25–5,200	ND	20–7,700	78–110	10–330
Beryllium	0.51–5.5	7.0–9.0	0.59–25	ND	ND
Cadmium	0.51–11	37	0.94–14	ND	ND
Chromium III	2.0–280	28–170	4.5–150	13–23	6.3–23
Chromium VI	0.22–31	3.1–19	0.5–17	1.4–2.6	0.7–2.5
Cobalt	2.8–110	ND	5.1–44	ND	7.0–37
Copper	3.6–460	30–45	3.7–510	ND	5.0–170
Lead	1.3–1,900	22–450	2.1–640	9.5–15	9.0–48
Lithium	5.3–71	61–4,500	5.0–120	ND	-
Manganese	3.3–13,000	16–33	25–3,000	18–870	280–6,500
Mercury	0.11–2.1	0.29–0.36	0.10–15	0.35–1.3	ND
Molybdenum	4.1–120	690–4,100	16–1.600	22–42	-
Nickel	5.6–270	47–170	3.3–8,800	ND	8.0–66
Selenium	0.63–47	7.5–220	2.7–81	ND	ND
Silver	0.92–13	25–40	1.0–5.0	4.0–6.0	ND

Table 5 (continued). Concentration and Location of Initial Chemicals of Concern at the Chemical Plant

	Onsite Concentration Range[a]			Offsite Concentration Range[b]	
Contaminant	**Soil (mg/kg)**	**Surface Water (µg/L)**	**Raffinate Pit Sludge (mg/kg)**	**Surface Water (µg/L)**	**Sediment (mg/kg)**
Thallium	1.0–80	ND	1.1–58	33	ND
Vanadium	7.2–380	90–2,100	26–8,700	ND	14–75
Zinc	6.1–1,100	26–60	7.9–1,600	21–78	24–220
Fluoride	1.3–45	230–19,000	3.2–170	170–600	–
Nitrate	0.54–3,800	190–200,000	0.6–160.000	300–260.000	–
Nitrite	1.5–29	–	1.0–1,600	–	–
Acenaphthene	1.9	–	ND	–	ND
Anthracene	3.4	–	ND	–	ND
Benz*[a]*anthracene	0.41–8.2	–	ND	–	ND
Benzo*[b]*fluoranthene	4.6	–	ND	–	ND
Benzo*[k]*fluoranthene	3.9	–	ND	–	ND
Benzo*[g,h,i]*perylene	2.1	–	ND	–	ND
Benzo*[a]*pyrene	5.1	–	ND	–	ND
Chrysene	0.39–8.0	–	ND	–	ND
Fluoanthene	0.58–11	–	ND	–	ND
Fluorene	1.6	–	ND	–	ND
Indeno*[*1,2,3,-*d]*pyrene	3.2	–	ND	–	ND
2-Methylnaphthalene	0.52–4.6	–	ND	–	ND
Naphthalene	1.8	–	ND	–	ND
Phenanthrene	0.42–11	–	ND	–	ND
Pyrene	0.35–19	–	ND	–	ND
PCBs	0.28–12	–	0.15–11	ND	0.2
DNB	1.0–3.8	ND	ND	0.18–0.81	ND
2,4-DNT	0.83–6.3	ND	ND	0.3–11	ND
2,6-DNT	1.6–3.5	ND	ND	0.19–18	ND
NB	1.6–3.8	ND	ND	0.87	ND
TNB	0.63–5.7	0.04–1.4	ND	0.02–0.84	ND
TNT	1.3–32	0.80–7.5	ND	0.05–110	ND

Source: Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (DOE 1993)
Notes:
[a] The term "onsite" refers to all areas, contaminated or otherwise, within the physical boundaries of the Chemical Plant and Quarry.
[b] The term "offsite" refers to Busch Conservation Area vicinity properties, Weldon Spring Training Area vicinity properties, Weldon Spring Conservation Area vicinity properties, Burgermeister Spring, and the Southeast Drainage.

Abbreviations:
µg/L = micrograms per liter
mg/kg = milligrams per kilogram
NB = nitrobenzene
ND = not detected
TNB = trinitrobenzene

Table 6 shows the concentration ranges and locations of the radioactive contaminants of concern for the CPOU.

Table 6. Concentration Ranges and Locations of Radioactive Contaminants of Concern

Contaminant	On-Site Concentration Range[a]			Offsite Concentration Range[b]	
	Soil (pCi/g)	Surface Water (pCi/L)	Raffinate Pit Sludge (pCi/g)	Surface Water (pCi/L)	Sediment (pCi/g)
Pb-210	0.4–450	–	1.0–1,700	–	–
Ra-226	0.4–450	3.4–130	1.0–1,700	ND	0.7–220
Ra-228	0.4–450	1.5–25	4.0–1,400	ND	0.4–480
Rn-220 progeny	–	–	–	–	–
Rn-222 progeny	–	–	–	–	–
Th-228	0.4–450	1.5–25	4.0–1,400	ND	0.4–480
Th-230	0.3–97	1.4–760	8.0–34,000	1.0–8.0	1.5–10,000
Th-232	0.4–150	0.2–7.6	3.0–1,400	ND	0.7–2.5
U-234[c]	0.3–2,300	28–1,300	4.9–1,700	2.0–590	0.5–720
U-235	0.01–110	1.3–60	0.2–78	0.09–27	0.02–33
U-238	0.3–2,300	28–1,300	4.9–1,700	2.0–590	0.5–720

Source: (DOE 1993)
Notes:
[a] The term "onsite" refers to all areas, contaminated or otherwise, within the physical boundaries of the Chemical Plant and Quarry.
[b] The term "offsite" refers to Busch Conservation Area vicinity properties, Weldon Spring Training Area vicinity properties, Weldon Spring Conservation Area vicinity properties, Burgermeister Spring, and the Southeast Drainage.
[c] Estimated on the basis of expected equilibrium conditions.

Abbreviations:
ND = not detected
pCi/g = picocuries per gram
pCi/L = picocuries per liter

3.5.2 Quarry Contaminants of Concern

Table 7 shows the concentration of radionuclides in the Quarry bulk wastes.

Table 7. Concentration of Radionuclides in the Quarry Bulk Wastes

Radionuclide	Bulk Waste Concentration (pCi/g)		Average Surficial Concentration[a] (pCi/g)	Average Background Concentration (pCi/g)
	Range	Average		
Uranium-238	1.4–2,400	200	170	1.3
Thorium-232	0.7–36	26	NDA	1.0
Thorium-230	0.7–6,800	330	150	1.3
Radium-228	0.1–2,200	96	20	1.0
Radium-226	0.2–2,800	110	110	0.9

Source: Record of Decision for Management of Bulk Wastes at the Weldon Spring Quarry (DOE 1990b)
Note:
[a] Samples obtained from the top 15 centimeters (6 inches) of the Quarry bulk wastes.

Abbreviation:
NDA = No data available

Table 8 shows the concentrations of chemicals detected in the Quarry bulk wastes.

Table 8. Concentration of Chemicals Detected in the Quarry Bulk Wastes in the 1984–1985 Characterization Study and Background Concentrations in Missouri Soils

Chemical[a]	Composite Borehole Sample Concentration (mg/kg)		Number of Boreholes in Which Chemical Detected	Surface Sample Concentration (mg/kg)	Average Background Concentration[c] (mg/kg)
	Range[b]	Average[b]			
Antimony	<20[d]		0	71	<200[d]
Arsenic	73–120	100	6	100	8.7
Beryllium	0.45–0.83	0.62	6	0.61	0.8
Cadmium	1.8–98	19	6	2.0	<1
Chromium	19–49	30	6	24	54
Copper	38–160	100	6	140	13
Lead	130–410	280	6	950	20
Mercury	0.18–6.3	2.0	6	0.7	0.039
Nickel	19–120	43	6	300	14
Selenium	17–28	23	6	22	0.28
Silver	5.8–8.3	7.0	3	7.5	0.7
Thallium	3.0–6.2	4.7	6	5.1	<50[d]
Zinc	68–870	340	6	39	49
Cyanide	0.2–0.6	0.38	5	0.2	NA
PCBs (Aroclor 1254)	0.56–46	12	5	1.00	NA
PCBs (Aroclor 1260)	9.0	9.0	1	–	NA

Source: (DOE 1990b)

Notes:

[a] All compounds that had one or more positive results above detection limits are listed; concentrations are rounded to two significant figures. Samples were taken from six boreholes in the bulk wastes and from a surface waste pile.

[b] Ranges and averages are for detected values only and do not necessarily indicate the average concentrations for the entire waste material.

[c] Concentration in Missouri agricultural soils.

[d] Lower limit of detection.

Abbreviations:

mg/kg = milligrams per kilogram

NA = not applicable

3.5.3 Quarry Residuals

See Table 9 for a summary of contaminant data collected for the QROU.

Table 9. Summary of Contaminant Data Collected for the QROU[a]

Contaminant	Quarry Proper		Femme Osage Slough/Creeks		Groundwater	Background			
	Soil	Fractures	Surface Water	Sediment		Soil	Surface Water	Sediment	Groundwater
Radionuclides	*(pCi/g)*[b]	*(pCi/g)*[b]	*(pCi/L)*	*(pCi/g)*	*(pCi/L)*	*(pCi/g)*	*(pCi/L)*	*(pCi/g)*	*(pCi/L)*
Radium-226	0.28–50	0.20–96	–[c]	–	–	0.69–1.2	0.060–0.24	0.56–1.2	0.040–1.4
Radium-228	0.16–23	0.22–84	–	–	–	0.70–1.4	0.060–0.86	0.28–2.1	0.20–7.3
Thorium-230	0.81–570	0.77–630	–	–	–	0.72–1.2	0.080–1.3	0.54–2.2	0.040–9.7
Thorium-232	0.45–25	0.21–60	–	–	–	0.60–1.2	0.040–0.32	8.2–1.1	0.010–1.0
Uranium-238[d]	0.44–21	1.3–200	0.47–53	1.0–180	0.020–4,200	0.94–1.6	2.5–2.9	0.64–0.69	0.20–11
Chemicals	*(mg/kg)*	*(mg/kg)*	*(µg/L)*	*(mg/kg)*	*(µg/L)*	*(mg/kg)*	*(µg/L)*	*(mg/kg)*	*(µg/L)*
Metals									
Aluminum	4,200–20,000	4,000–31,000	67–200	1,100–20,000	22–26,000	1,300–12,000	67–200	1,100–13,000	18–4,800
Antimony	–	–	–	6.9–36	–	ND	33	ND	86
Arsenic	–	–	3.1–6.8	–	–	3.5–15	ND	2.5–6.8	2.0–8.8
Barium	–	–	–	–	29–1,200	9.3–210	56–97	27–150	75–700
Beryllium	–	–	–	0.27–1.6	–	0.44–0.74	ND	0.27–0.85	0.7–1.7
Cadmium	–	–	–	0.20–3.5	0.26–4.3	0.46–0.98	ND	ND	ND
Chromium	–	–	ND	2.8–24	0.72–150	3.3–13	ND	2.8–16	3.0–54
Cobalt	–	–	–	–	1.4–15	2.0–9.1	ND	2.2–9.5	4.3–6.6
Copper	–	–	–	2.9–30	2.2–120	11–19	16–17	2.9–14	2.2–49
Lead	–	–	ND	–	–	9.2–27	ND	2.7–15	1.0–77
Manganese	–	–	240–1,300	58–1,100	4.3–5,000	170–1,000	270–370	58–810	16–790
Mercury	–	–	–	0.060–0.10	0.16–2.4	0.090–0.10	ND	0.10	0.040–0.40
Molybdenum	–	–	–	0.80–3.9	–	0.59–1.3	ND	ND	17–19
Nickel	–	–	ND	12.3–28	4.2–66	15–28	ND	12–22	12–43
Selenium	0.21–6.0	23–150	–	0.77–2.7	–	0.62–2.0	ND	0.99	2.6–8.9
Silver	0.36–11	10–39	ND	–	–	0.97	ND	ND	22
Strontium	–	–	120–260	–	–	ND	100–110	5.5–17	250–1,200
Thallium	–	–	–	–	1.1–8.3	0.61–2.0	ND	1.5–14	2.9–6.1

Table 9 (continued). Summary of Contaminant Data Collected for the QROU[a]

Contaminant	Quarry Proper		Femme Osage Slough/Creeks		Groundwater	Background			
	Soil	Fractures	Surface Water	Sediment		Soil	Surface Water	Sediment	Groundwater
Uranium, total	1.4–63	3.9–600	0.70–80	3.0–540	0.03–10,000	0.72–3.0	3.7–4.3	1.6–3.7	0.45–17
Vanadium	–	–	–	4.8–44	1.2–67	6.2–20	10–14	4.8–31	3.2–41
Zinc	24–810	60–820	8.9–78	–	2.4–160	18–66	8.9–13	8.9–69	4.7–53
Organic Compounds									
1,3,5-TNB	0.0030–3.8	1.3	ND	0.14	0.015–270	NA	NA	NA	NA
1,3-DNB	0.002	ND	ND	ND	0.045–3.5	NA	NA	NA	NA
2,4,6-TNT	0.00020–0.69	0.0010–1.2	ND	ND	0.014–60	NA	NA	NA	NA
2,4-DNT	0.0003–0.05	0.00040–1.2	ND	0.0070	0.011–4.6	NA	NA	NA	NA
Nitrobenzene	–	ND	ND	ND	ND	NA	NA	NA	NA
PAHs	0.0075–1.4	0.009–1.4	ND	ND	ND	NA	NA	NA	NA
PCBs	0.031–4.5	0.036–1.5	ND	ND	ND	NA	NA	NA	NA

Source: Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site (DOE 1998a)

Notes:

[a] The range of detected concentrations for contaminants of potential concern (COPCs) identified for each medium is provided. Contaminants identified as COPCs are those contaminants with concentrations exceeding the statistically determined background concentration. The identification of COPCs was performed by using all the data collected for each medium (i.e., since 1987). For groundwater and surface water, the ranges of reported concentrations are for recent data collected from 1995 to 1997. These recent data are considered more representative of current conditions and indicate a decreasing trend as a result of bulk waste removal from the Quarry. Sources: Weldon Spring Remedial Action Project Database 1997; DOE 1998d.

[b] The majority of the samples from Quarry soil and fractures indicate low concentrations for radionuclides, as reflected by low mean concentrations. Mean Quarry concentrations for Quarry soil and fractures are as follows:

Soil	Mean	Fractures	Mean
Radium-226	2.4	Radium-226	4.5
Radium-228	2.3	Radium-228	4.6
Thorium-230	30	Thorium-230	58
Thorium-232	1.5	Thorium-232	5.7
Uranium-238	4.8	Uranium-238	17

[c] A dash denotes that the contaminant was not identified as a COPC.

[d] For groundwater and surface water, reported concentrations are for total uranium.

Abbreviations:

NA = not applicable; (background concentrations of organic compounds that are considered anthropogenic are assumed to be zero)

ND = not detected

3.5.4 Southeast Drainage

Initial soil characterization for the Southeast Drainage was conducted by Oak Ridge Associated Universities (ORAU) from July 1984 through September 1985. During the survey, surface beta and gamma measurements, surface and subsurface soil samples, water samples, and sediment samples were collected. Both vicinity properties that make up the Southeast Drainage (DA 4 and MDC 7) were surveyed separately. During the soil and sediment sampling of MDC 7, five samples were analyzed for Th-230 in addition to Ra-226, Th-232, and U-238. The ORAU data for the Southeast Drainage (both surface and subsurface sediment and soil) are summarized in Table 10.

Table 10. Summary of ORAU Data for Southeast Drainage

Southeast Drainage Area	Ra-226 Concentration Range (pCi/g)	Th-230 Concentration Range (pCi/g)	Th-232 Concentration Range (pCi/g)	U-238 Concentration Range (pCi/g)	Primary Contaminant	Estimated Volume (yd^3)
DA 4	0.76–210	Not Analyzed	0.43–69.1	<1.56–1,010	Ra-226 Th-232 U-238	3,270
MDC 7	2.57–130	570–10,100	0.51–240	9.58–810	Ra-226 Th-230 Th-232 U-238	6,997

Source: Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7 (DOE 1999a)
Abbreviation:
yd^3 = cubic yards

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4.0 Remedial Actions

4.1 Chemical Plant Operable Unit

4.1.1 Chemical Plant Operable Unit Remedy Selection

The Remedial Investigation/Feasibility Study (RI/FS) process was conducted for the Weldon Spring Chemical Plant Operable Unit in accordance with the requirements of CERCLA, as amended, to document the proposed management of the Chemical Plant area as an operable unit for overall site remediation and to support the comprehensive disposal options for the entire cleanup. Documents developed during the RI/FS process included the following:

- *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (DOE 1992a)
- *Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site* (DOE 1992d)
- *Feasibility Study for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1992b)
- *Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1992f)

In September 1993, DOE finalized the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1993) for managing contaminated materials (except groundwater) at the Chemical Plant. The CPOU addressed the various sources of contamination in the Chemical Plant, including soils, sludge, sediment, and materials placed in short-term storage as a result of previous response actions. The remedial action included in the Chemical Plant Record of Decision (ROD) was the major component of site cleanup and addressed comprehensive disposal options for the project. The primary focus was the contaminated material in the Chemical Plant, including that generated as a result of previous response actions, but it also addressed the disposal of materials generated by the other OUs in order to facilitate a disposal decision that would integrate all of the OUs. The three key components of the remedy or remedial action objectives (RAOs) were:

- Remove the contaminated materials.
- Treat the wastes as appropriate by chemical stabilization/solidification.
- Dispose of the wastes in an engineered disposal facility constructed onsite.

These RAOs were all met as discussed below and documented in the *Chemical Plant Operable Unit Remedial Action Report* (DOE 2004b).

The remedy included remediation of 17 offsite vicinity properties affected by Chemical Plant operations. The vicinity properties were remediated in accordance with Chemical Plant ROD cleanup criteria. Appendix A to the LTS&M Plan includes a summary of the vicinity property remediation projects and references to the close-out reports. Contaminant of concern (COC) information is discussed in Section 3.5.

4.1.2 Chemical Plant Operable Unit Remedy Implementation

The *Conceptual Design Report for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1994) was issued in December 1994 and comprised the Remedial Design Work Plan. The *Remedial Action Work Plan of the Chemical Plant Area of the Weldon Spring Site* (DOE 1995b) was issued in November 1995.

The majority of the activities and components of the Chemical Plant remedial action were discussed in the second Five-Year Review (DOE 2001a). The cell was close to completion at the time of the report, which was dated August 2001. The cell cover was completed in October 2001. The components of the remedy that have been ongoing since the time of the second, third and fourth review are the Leachate Collection and Removal System (LCRS), leachate monitoring, disposal cell groundwater monitoring, and LTS&M activities, such as inspections, monitoring and maintenance, and ICs. The description of the remedial action is detailed in the *Chemical Plant Operable Unit Remedial Action Report* (DOE 2004b).

The *Post-Remediation Risk Assessment for the Chemical Plant Operable Unit Weldon Spring Site, St. Charles, Missouri* (DOE 2002b) documents the risk estimates for residual soil after the remedial action was completed. The document concluded that on the basis of the results presented in this report, the remediation performed for the Chemical Plant and its vicinity properties has resulted in residual chemical risks that are well within the acceptable risk range for the hypothetical resident and recreational visitor scenarios evaluated. Future use of these areas or properties in a manner similar to the scenarios assumed in the report should be protective of human health. The hazard indices estimated also indicate that potential systemic toxicity would not be a concern in these areas.

4.1.2.1 Disposal Cell Design and Leachate Collection and Removal System

The disposal cell is located on the northeastern portion of the Chemical Plant property, and the overall cell encompasses an area of approximately 41 acres. The five-sided cell has 4:1 side slopes over the clean-fill dike, and cover slopes of approximately 13:1 over the waste. The maximum width of the cell footprint, including the rock-covered apron, is approximately 1,500 ft, and the maximum height above grade is approximately 91 ft. The cell contains approximately 1.48 million cubic yards of contaminated waste, with a total activity of 6,570 curies. The waste column has a maximum thickness of 63 ft, and the waste footprint, including the lower interior dike slopes, is approximately 24 acres.

Six primary systems were incorporated into the cell design: the cover, the waste, a surrounding clean-fill dike, a geochemical barrier, a basal liner system, and the LCRS.

Leachate from the cell is collected in primary and secondary collection systems. The primary collection system consists of perforated HDPE pipes, 4 inches (10 centimeters) in diameter, located in the drainage material which is on top of the primary liner. The pipes convey leachate by gravity to a sump north of the disposal cell. The sump consists of a 60-inch-diameter (152 centimeters) HDPE manhole with an attached HDPE storage pipe (measuring 200 ft [61 meters] long and 42 inches [107 centimeters] in diameter).

A secondary collection system consists of an HDPE geonet placed between layers of geotextile (high-tensile-strength filter fabric), which is placed between the primary and secondary liners. This system collects any leachate that leaks through the primary liner. Leakage flows through the secondary collection system to two gravel-filled sumps, one for each bay (east and west), located along the north edge of the cell. This secondary leachate is then conveyed by HDPE pipe through the same gravel-filled secondary containment as the primary leachate piping to the HDPE sump north of the cell. Flows from secondary collection system pipes can be monitored individually at the sump.

Leachate level is uploaded electronically into the System Operation and Analysis at Remote Sites (SOARS). By using SOARS, these data can be remotely monitored and tracked instead of having to be downloaded at the LCRS.

In accordance with 40 CFR 264.303(c)2 after the final cover was installed on the disposal cell the amount of liquids removed from each secondary leak detection system sump was required to be recorded at least monthly. As a reliable database continues to be generated, DOE may modify the sump level monitoring frequency in accordance with regulations in 40 CFR 264.303(c)2. Flow rates are reported in units of gallons per day (gpd) and compared to the action leakage rate of 100 gallons per acre per day established for the leachate collection system.

In 2015, the total primary and secondary leachate production, including secondary containment water, was approximately 26,441 gallons. In 2011, the total primary and secondary leachate production was approximately 34,154 gallons. This is a 22.6 percent reduction, and the trend is expected to continue.

Figure 4 shows the primary leachate monthly average flow rates for 2011 through 2015. The average monthly discharge from the primary leachate collection system has gone from an average of 83.0 gpd in 2011 to 63.0 gpd in 2015. This represents a 24 percent decrease in 5 years and shows that leachate production has decreased more slowly since the previous 5-year period (35 percent), but continues to decrease as designed.

The combined leachate from the secondary leachate collection system (east, west secondary collection and secondary containment) averaged approximately 10.2 gpd for 2011 to 9.4 gpd in 2015. This is a significant decrease (over 7.8 percent) in the flow rate since 2011. The average leak rate for the entire secondary leachate collection system for 2001 was approximately 0.96 gallons per acre (gpa) per day. The average leak rate in 2015 was approximately 0.39 gpa per day. This trend is expected to continue as the secondary leachate system flow rate decreases. This trend is also much less than 1 percent of the action leakage rate (100 gpa per day).

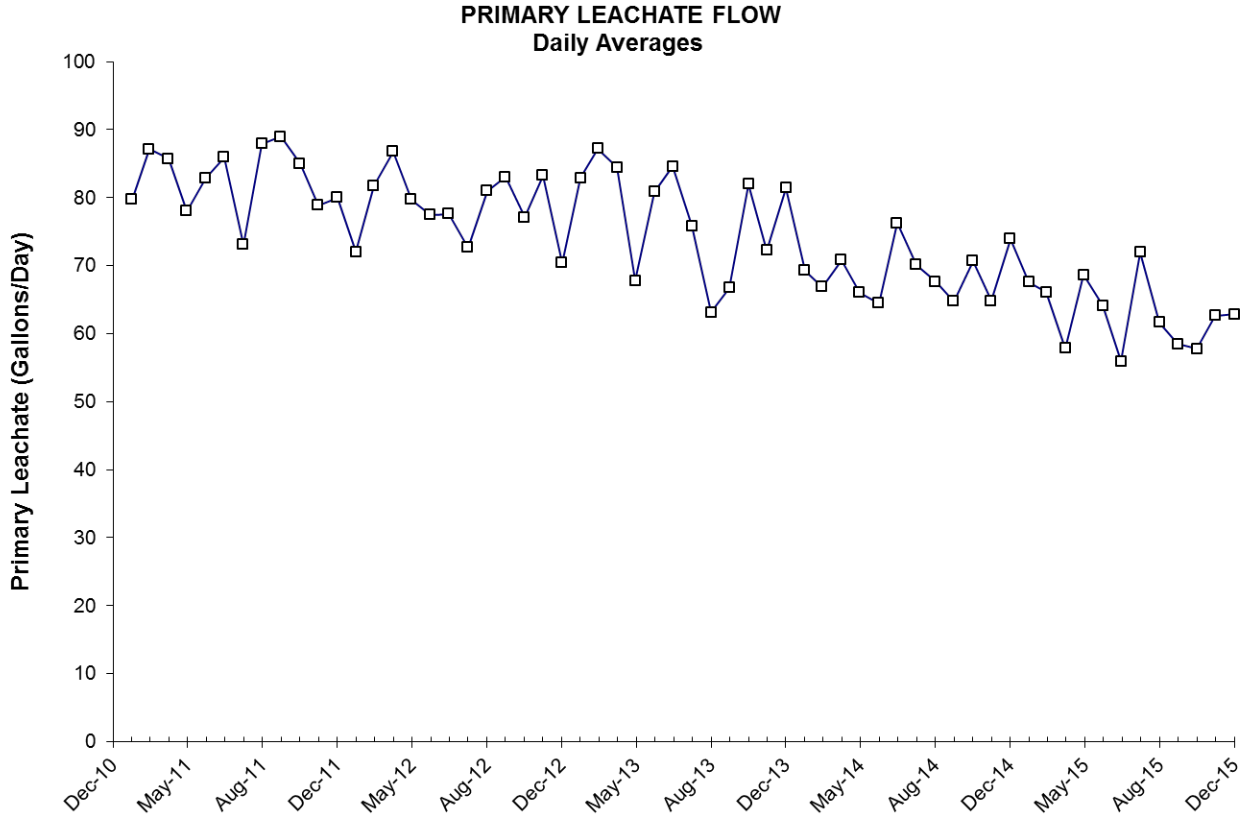

Figure 4. Primary Leachate Trends

The untreated leachate is sampled semiannually in accordance with Appendix K, Disposal Cell Monitoring Plan of the LTS&M Plan (DOE 2008c). Table 11 summarizes analytical results for untreated leachate samples collected between 2011 and 2015.

Untreated combined leachate uranium activity during 2002 typically was 50 picocuries per liter (pCi/L) and from 2011 to 2015 averaged about 22.64 pCi/L. Figure 5 shows the untreated uranium concentrations from 2011 through 2015.

The leachate is pretreated for uranium and then disposed of by hauling to the Metropolitan St. Louis Sewer District (MSD) Bissell Point Plant. The MSD and DOE established an agreement in 2001 for MSD to receive the leachate, perform the final treatment on it, and discharge it. The DOE maintains a National Pollutant Elimination Discharge permit which authorizes discharge from the LCRS to the Missouri River as a contingency option for the leachate. No water has been discharged under this permit since 2002.

Table 11. Leachate Analytical Data

Parameter	June 2011	Dec 2011	June 2012	Dec 2012	June 2013	Dec 2013	June 2014	Dec 2014	June 2015	Dec 2015
Chloride (mg/L)	51.7	53.3	50.7	46.9	48.5	39.6	49.1	44.0	45.4	45.9
Fluoride (mg/L)	0.24	0.26	0.20	ND	0.20	0.34	0.240	0.515	0.21	0.239
Nitrate (mg/L)	1.5	0.2	2.8	1.1	3.7	2.9	3.95	2.34	3.73	2.69
Sulfate (mg/L)	64.7	51.0	70.0	70.5	78.8	68.5	100	84.8	87.9	90.9
Arsenic (µg/L)	5.0	ND	3.8	3.5	3.7	ND	ND	3.89	ND	3.47
Barium (µg/L)	743	673	490	651	469	375	384	324	434	533
Chromium (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt (µg/L)	4.3	5.2	2.9	3.7	1.7	1.2	0.81	0.33	0.42	0.43
Iron (µg/L)	5240	2160	1220	3060	388	316	234	115	146	34.5
Lead (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (µg/L)	896	660	500	590	464	420	467	62.7	335	357
Nickel (µg/L)	11.5	7.8	9.4	10.2	10.2	5.9	6.47	3.38	5.34	4.72
Selenium (µg/L)	7.1	3.6	7.8	7.9	10.5	5.6	4.26	3.48	3.69	1.91
Thallium (µg/L)	ND	0.58	ND	ND	ND	ND	ND	ND	ND	0.631
COD (mg/L)	39.6	31.1	29.6	26.6	32.9	23.7	50.9	12.0	32.6	28.2
TDS (mg/L)	762	714	739	684	739	610	770	630	816	809
TOC (mg/L)	12.0	14.0	NA	13.1	12.4	10.3	12.3	12.1	11.6	11.1
1,3,5-TNB (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DNB (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-TNT (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DNT (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DNT (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrobenzene (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Radium-226 (pCi/L)	0.64	ND	0.86	0.37	ND	0.63	2.93	1.50	0.56	0.734
Radium-228 (pCi/L)	0.76	ND	1.51	0.94	ND	ND	0.720	ND	0.913	0.654
Thorium-228 (pCi/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thorium-230 (pCi/L)	0.31	0.33	ND	ND	ND	ND	ND	0.16	ND	0.36
Thorium-232 (pCi/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Uranium (pCi/L)	21.1	22.7	21.6	21.4	23.9	21.9	24	26	24	23.7
PCBs/PAHs (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Abbreviations:
COD = chemical oxygen demand
µg/L = micrograms per liter
mg/L = milligrams per liter
ND = not detected
TDS = total dissolved solids
TOC = total organic carbon

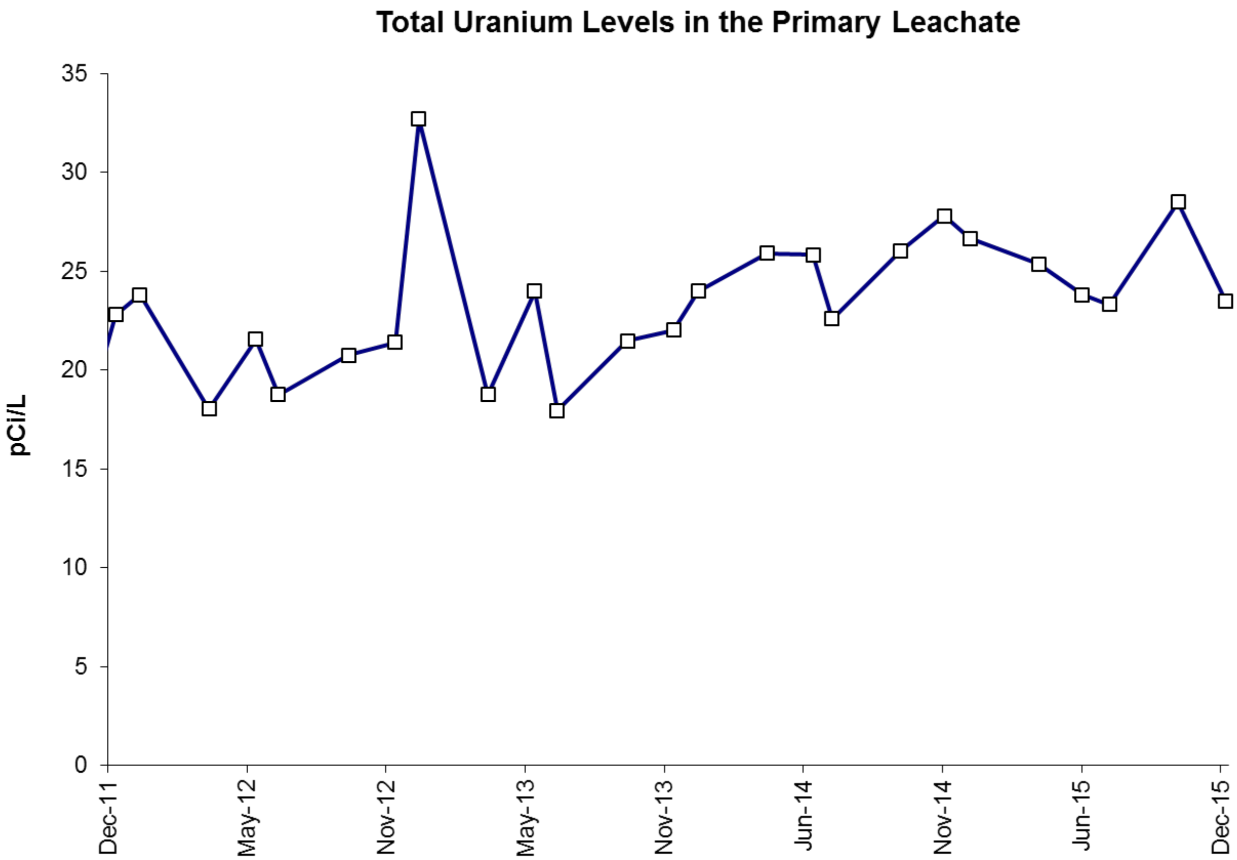

Figure 5. Leachate Uranium Concentration Trends

4.1.2.2 Disposal Cell Groundwater Monitoring

DOE established a groundwater detection monitoring network around the disposal cell to monitor cell performance, as required under 40 CFR 264 Subpart F and *Missouri Code of State Regulations* 10 CSR 25–7.264(2)(F). The network originally consisted of five wells (MW-2048, 2032, 2045, 2046, and 2047) and Burgermeister Spring. All wells are completed in the weathered portion of the Burlington-Keokuk Limestone. In 2001, monitoring well MW-2048 was damaged and replaced with well MW-2055. Also, well MW-2051 was installed to replace well MW-2045, where anomalous, elevated metal concentrations were attributed to poor hydraulic performance. Burgermeister Spring (SP-6301) is a perennial downgradient point of emergence for groundwater from the Chemical Plant area. The current wells (MW-2032, 2046, 2047, 2051, and 2055), spring, and leachate are sampled semiannually (June and December) for a specific suite of analytes. Specific procedures for evaluating monitoring results and required responses are presented in the LTS&M Plan, Appendix K, "Disposal Cell Groundwater Monitoring Plan."

4.1.3 CPOU System Operation and Maintenance

The project transferred LTS&M responsibility for the Weldon Spring Site from the DOE Oak Ridge Office to the DOE LTS&M program on October 1, 2002, and then to the Office of Legacy Management in December 2003. The LTS&M Plan for the Weldon Spring Site was finalized in

July 2005 and revised in December 2008. The following is a discussion of the LTS&M activities that took place during the last 5-year review period.

4.1.3.1 Interpretive Center

The Weldon Spring Site Interpretive Center is part of DOE's LTS&M activities at the Weldon Spring Site. The purpose of this facility is to inform the public of the site's history, remedial action activities, and final conditions. The Center provides information about the LTS&M 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 the 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 clean up the site, and the people that made it happen.
- The multi-faceted phases of the Weldon Spring Site Remedial Action Project.

These exhibits may change as appropriate due to new conditions or emerging issues at and near the site. An exhibit upgrade was completed in 2010; it included updating information in several exhibits, adding interactive and multimedia components, creating several new exhibits that address site-related topics, and improving the flow of foot traffic through the Center.
The Interpretive Center's hours of operation 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 2:00 p.m. November 1 through March 31).
- Sunday: 12:00 p.m. to 4:00 p.m.

The Interpretive Center is closed on federal holidays.

Attendance is tracked through the following types of public activities:

- Individuals that walk into the Interpretive Center from the street during normal hours of operation.
- Scheduled groups that participate in Interpretive Center educational programs.
- Community-based organizations that use the Paul T. Mydler and Howell-Hamburg meeting rooms to conduct business meetings.
- Scheduled groups who are unable to visit the site but are recipients of Interpretive Center outreach presentations.

A significant number of individuals also use site amenities (e.g., the Hamburg Trail, the disposal cell perimeter road for prairie viewing, the disposal cell viewing platform, the Native Plant

Education Garden); however, because this use does not involve entering the Interpretive Center and is often outside of normal hours of operation, it is not consistently tracked.

Attendance at the Interpretive Center has been steadily increasing (Table 12). The kindergarten-through-grade-12 educational community continues to have significant interest in Interpretive Center programs. Field trips are usually scheduled at least several months in advance, and available calendar dates fill up quickly. At times, this requires reservations to be made for the following school year. For a few school districts that have limited funding for field trips, outreach activities are scheduled, and Interpretive Center personnel give educational presentations at the school. Outreach activities usually involve several classes or the entire grade level of students.

Table 12. Interpretive Center Attendance

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002								301	224	190	40	31	786
2003	6	44	44	85	174	191	161	233	251	350	125	122	1,786
2004	52	61	166	182	104	324	192	353	379	850	556	354	3,573
2005	123	605	1,056	2,048	1,888	1,408	1,370	1,091	1,511	1,663	1,739	903	15,405
2006	542	1,136	1,595	1,874	1,685	1,226	1,465	1,431	1,176	2,215	1,735	692	16,772
2007	1,157	1,022	2,786	2,479	2,192	1,960	1,703	1,129	1,843	2,811	1,569	882	21,524
2008	1,132	1,445	2,261	3,086	2,489	1,734	1,556	1,395	2,412	2,624	1,705	1,142	22,981
2009	1,418	1,987	3,183	2,181	2,036	1,928	1,299	1,492	2,591	2,857	1,522	1,106	23,600
2010	1,440	1,441	2,465	2,378	2,968	2,002	1,904	1,117	2,615	2,696	2,396	1,534	24,956
2011	1,631	1,958	2,593	3,036	2,938	2,182	1,441	1,165	2,455	2,848	2,087	2,111	26,445
2012	1,986	1,687	2,556	2,663	2,025	2,107	1,085	1,787	2,150	2,041	1,771	1,360	23,218
2013	1,663	1,581	1,871	2,471	2,209	1,205	1,201	1,197	2,207	1,057	1,981	1,207	19,850
2014	1,168	1,401	2,478	2,298	2,891	1,379	1,491	696	2,026	3,187	1,951	1,056	22,022
2015	1,491	1,746	2,524	3,592	2,169	1,308	934	1,099	3,417	5,403	1,747	1,649	27,079
													250,002

The attendance was adversely affected in 2013 during the government shutdown and when the facility was shut down following tornado damage. The Interpretive Center continues to support community-based special events, such as mountain bike races, and is available for public meeting room usage.

On September 12, 2015, the Weldon Spring Site teamed with the Missourian's for Monarchs volunteer group to co-host the first ever Monarch Madness special event. The event was also supported with volunteers and funding by the Missouri Master Naturalists, Missouri Department of Conservation, and Great Rivers Greenway. Attendance to the event included 550 visitors from the public and 60 volunteers and exhibitors. The event hosted pollinator identification activities, kids crafts, hikes to the top of the disposal cell, hikes through the prairie, native plant sales, and even making muddy, native seed bombs for families to plant at home. The most popular activity of the event was to catch and tag live monarch butterflies as part of an international research project. An incredible 43 monarchs were captured and tagged through the course of the event, all to fly off and continue their 3,000 mile journey to the mountains of central Mexico. A primary purpose of the event was to empower visitors to take action in supporting pollinators.

LM is an important contributor to pollinator restoration. In May of 2015, The White House released a "Pollinator Research Action Plan" outlining several efforts to support and restore pollinator populations on public lands and through public and private partnerships. Specifically the plan calls for increasing monarch butterfly populations to 225 million butterflies, a significant increase from the current 60 million butterflies. LM lands, like the Weldon Spring Site, are crucial success stories in conversion of lands from WWII and Cold War era activities and factories to native habitat.

4.1.3.2 Howell Prairie/Native Plant Education Garden

The 150 acres surrounding the disposal cell have 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 before European settlement. Howell Prairie is one of the largest plantings of its kind in the St. Louis metropolitan area. Prairie maintenance included spot-spraying individual small trees and Sericea lespedeza plants with herbicide as part of ongoing efforts to reduce numbers and control encroachment of invasive weed and woody tree species throughout the prairie area.

A garden of plants native to Missouri was designed and constructed to surround the Interpretive Center and build awareness about the Weldon Spring Site. Garden maintenance consisting of manual weeding and occasional irrigation was performed throughout the growing season. Corn gluten, a cereal industry byproduct with pre-emergent herbicide qualities, was broadcast on garden beds throughout the spring to assist in weed control efforts and act as an organic fertilizer. Dried seed heads from forbs were harvested and utilized for hand overseeding in the prairie area. Locations in the prairie with erosion and less plant establishment were targeted. Volunteers continued to perform garden maintenance activities throughout this period. In September 2015, partner organizations donated native plants which were installed in numerous locations throughout the garden.

4.1.3.3 Inspections

The annual LTS&M inspections took place at the Weldon Spring Site on October 25 through 27, 2011; October 23 through 25, 2012; November 5 through 7, 2013; December 9 through 10, 2014; and December 1 through 2, 2015. The inspections were conducted in accordance with the LTS&M Plan and the associated inspection checklist. Representatives from EPA and MDNR participated in each of the inspections. Representatives from MDC, MoDOT, the MDNR Division of State Parks, the Weldon Spring Citizens Commission, and St. Charles County participated in portions of the inspections also.

The main areas inspected at the site were the Quarry, the disposal cell, the LCRS, monitoring wells, assorted general features, and areas where ICs have been established.

IC areas were inspected to ensure that restrictions on activities such as soil excavation, groundwater withdrawal, and residential use were not being violated. Each area was inspected, and no indication of violations of restrictions was observed.

The disposal cell was inspected by walking 10 transects over the cell and around the cell perimeter. No unusual settlement or other unusual observations were noted. Six areas of the cell were marked for annual observations of rock degradation. The sixth area was added during 2011 in response to a request from MDNR during the 2010 inspection. The newer plot is located on the southern face of the disposal cell. The LCRS was also inspected and found to be in good condition. A majority of the groundwater monitoring wells were inspected each year and found to be in generally good condition. Other site features, including the prairie, site markers, and roads, were also inspected.

Details of the inspections can be found in the *2011 Annual Inspection Report for the Weldon Spring Site St. Charles, Missouri*, (DOE 2012a), *2012 Annual Inspection Report for the Weldon Spring Site St. Charles, Missouri,* (DOE 2013a), *Weldon Spring Site Annual Report for Calendar Year 2012*, (DOE 2013b), *Weldon Spring Site Annual Report for Calendar Year 2013* (DOE 2014a), *Weldon Spring Site Annual Report for Calendar Year 2014*, (DOE 2015), and *Weldon Spring Site Annual Report for Calendar Year 2015* (DOE 2016). Details of the 2015 inspection, which also served as the Five-Year Review inspection, are found in Section 6.5 of this report.

4.1.3.4 Erosion

Erosion channels within the entire prairie have been mapped with GPS annually since 2007 (Figure 99). It has been noted during recent inspections that the erosion and plant growth in the erosion areas has improved over past years and is not considered an issue at this time.

4.1.3.5 Institutional Controls

Institutional controls for the Chemical Plant Operable Unit are discussed in Section 6.5.2 and Section 7.1.1.5.

4.1.3.6 Other Monitoring and Maintenance Activities

Other monitoring and maintenance activities for the CPOU include disposal cell monitoring and the collection and monitoring of the leachate, which are both discussed previously in this section.

4.1.3.7 Operation and Maintenance Costs

The FY 2011 LTS&M costs for the Weldon Spring Site were budgeted at $2,388,059.17. The actual costs were $2,236,470. 22.

The FY 2012 LTS&M costs for the Weldon Spring Site were budgeted at $3,631,136.16. The actual costs were $3,157,306.63.

The FY 2013 LTS&M costs for the Weldon Spring Site were budgeted at $3,518,624.90. The actual costs were $3,454,773.52.

The FY 2014 LTS&M costs for the Weldon Spring Site were budgeted at $3,041,380.57. The actual costs were $ 2,961,121.24.

The FY 2015 LTS&M costs for the Weldon Spring Site were budgeted at $5,032,138.45. The actual costs were $3,604,353.64.

4.2 Groundwater Operable Unit

4.2.1 Groundwater Operable Unit Remedy Selection

It was decided in 1993 to prepare separate environmental documentation regarding remediation of groundwater beneath the Chemical Plant site. Prior to that decision the groundwater was being addressed as part of the Chemical Plant Operable Unit. It also was decided at that time that DOE and the Army would work jointly to address the groundwater issues for both sites. The remedial investigation was conducted in 1995 and included a joint sampling effort of all wells in the Chemical Plant and Ordnance Works areas by DOE and the Army. The *Remedial Investigation for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1997a) and the *Baseline Risk Assessment for the Groundwater Operable Units at the Chemical Plant Area and Ordnance Works Area, Weldon Spring, Missouri* (DOE 1997c) were finalized in July 1997. The contaminants of potential concern were identified as nitrate, sulfate, chloride, lithium, molybdenum, nitroaromatic compounds, uranium, trichloroethene (TCE), and 1,2-dichloroethene. Contamination in groundwater is generally confined to the shallow, weathered portion of the uppermost bedrock unit, the Burlington-Keokuk Limestone.

The *Feasibility Study for Remedial Action for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area at the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1998c) was initiated in 1997. This study evaluated potential options for addressing groundwater contamination at both sites. The preferred alternative was long-term monitoring of groundwater in conjunction with in-situ treatment of portions of the shallow aquifer impacted by TCE. In 1998, a long-term pumping test was performed at the Chemical Plant to evaluate potential groundwater remediation methods for TCE-contaminated groundwater. Results indicated that the transmissivity of the aquifer in the area of TCE impact was higher than expected; however, due to the geology in the area, dewatering of the aquifer occurred. Evaluation of conventional pump-and-treat technologies indicated that this would not be the most effective method for possible remediation of this area. These data were evaluated in the *Supplemental Feasibility Study for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1999c) and utilized in preparation of the *Proposed Plan for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1999d).

DOE proposed active remediation of the TCE-impacted groundwater at the Chemical Plant site as presented in the proposed plan and to conduct further field studies to reexamine the effectiveness and practicability of further active remediation for the remaining contaminants of concern. An interim ROD related to the remediation for TCE contaminated groundwater at the Chemical Plant site was signed by DOE and EPA on September 29, 2000. This *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of* *the Weldon Spring Site* (DOE 2000a) authorized treatment of TCE in groundwater utilizing in-situ chemical oxidation methods.

In 2003, the document *Supporting Evaluation for the Proposed Plan for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (DOE 2003c) was prepared in conjunction with the *Proposed Plan for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (DOE 2003d). The purpose of the Supporting Evaluation was to reevaluate the feasibility of groundwater removal, in-situ chemical oxidation (ICO), and MNA technologies and options on the basis of recent information collected from the ICO pilot-phase treatment and the additional groundwater field studies.

The *Record of Decision for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (DOE 2004a) was signed by DOE in January 2004 and by EPA on February 20, 2004. The selected remedy of MNA with ICs to limit groundwater use during the period of remediation addresses cleanup of all COCs in groundwater and springs at the Chemical Plant Area. MNA relies on the effectiveness of naturally occurring processes to reduce contaminant concentrations over time. The GWOU ROD establishes remedial goals and performance standards for MNA. The selected remedy also serves as a change to the Interim ROD, which addressed TCE groundwater contamination. In-situ treatment of TCE did not perform adequately in the field and MNA is now considered the appropriate final remedy for TCE as well as the other groundwater contaminants.

The GWOU remedy and status is further described in Section 6.4.

The RAO listed in the GWOU ROD is to restore contaminated groundwater in the shallow aquifer to its beneficial use by attaining the cleanup standards. Section 4.2.2 and Section 6.4.1 give an update on the status of attaining this RAO. COC information is included in Section 3.5.

4.2.2 Groundwater Operable Unit Remedy Implementation

In July 2004, DOE initiated monitoring for MNA as outlined in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004d). This network was modified as presented in the *Interim Remedial Action Report for the Groundwater Operable Unit of the Weldon Spring Site* (DOE 2005c) and is described below.

4.2.2.1 Monitoring Program

The objectives specified in the GWOU ROD (DOE 2004a) for the MNA monitoring network are as follows:

- Objective 1 is to monitor the unimpacted water quality at upgradient locations in order to maintain a baseline of naturally occurring constituents from which to evaluate changes in downgradient locations. This objective will be met by using wells upgradient of the contaminant plume.
- Objective 2 is to verify that contaminant concentrations are declining with time at a rate and in a manner that cleanup standards will be met in approximately 100 years as established by predictive modeling. This objective will be met using wells at or near the locations with the highest concentrations of contaminants, both near the former source areas and along

expected migration pathways. The objective will be to evaluate the most contaminated zones. Long-term trend analysis will be performed to confirm downward trends in contaminant concentrations over time. Performance will be gauged against long-term trends. It is anticipated that some locations could show temporary upward trends due to the recent source control remediation, ongoing dispersion, seasonal fluctuations, analytical variability, or other factors. However, concentrations are not expected to exceed historical maximums.

- Objective 3 is to ensure that lateral migration remains confined to the current area of impact. Contaminants are expected to continue to disperse within known preferential flow paths associated with bedrock lows (paleochannels) in the upper Burlington-Keokuk Limestone and become more dilute over time as rain events continue to recharge the area. This objective will be met by monitoring various downgradient fringe locations that either are not impacted or are minimally impacted. Contaminant impacts in these locations are expected to remain minimal or nonexistent.
- Objective 4 is to monitor locations underlying the impacted groundwater system to confirm that there is no significant vertical migration of contaminants. This will be evaluated using deeper wells screened and influenced by the unweathered zone. No significant impacts at these locations should be observed.
- Objective 5 is to monitor contaminant levels at the impacted springs that are the only potential points of exposure under current land use conditions. The springs discharge groundwater that includes contaminated groundwater originating at the Chemical Plant area. Presently, contaminant concentrations at these locations are protective of human health and the environment under current recreational land uses. Continued improvement of the water quality in the affected springs should be observed.
- Objective 6 is to monitor for hydrologic conditions at the site over time in order to identify any changes in groundwater flow that might affect the protectiveness of the selected remedy. The static groundwater elevation of the monitoring network will be measured to establish that groundwater flow is not changing significantly and resulting in changes in contaminant migration.

The monitoring network is designed to collect data to either show that natural attenuation processes are acting as predicted or trigger the implementation of contingencies when these processes are not acting as predicted (i.e., unexpected expansion of the plume or sustained increases in concentrations within the area of impact). The data analysis and interpretation will satisfy the following:

- Baseline conditions (Objective 1) have remained unchanged.
- Performance monitoring locations (Objective 2) indicate that concentrations within the area of impact are decreasing or remaining stable, as expected.
- Detection monitoring locations (Objectives 3, 4, and 5) indicate when a trigger has been exceeded, indicating unacceptable expansion of the area of impact.
- Hydrogeologic monitoring locations (Objectives 1, 2, 3, 4, and 6) indicate any changes in groundwater flow that might affect the protectiveness of the MNA remedy at the site over time.

The guidance documents *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tanks Sites* (EPA 1999) and the *Technical Guidance for the*

Long-Term Monitoring of Natural Attenuation Remedies at Department of Energy Sites (DOE 1999b) were used during the development of this monitoring program.

The monitoring network consists of 46 wells, four springs, and one surface water location. The locations and the objectives they satisfy are summarized in Table 13 and are depicted in Figure 6. COCs for groundwater and springs at the Chemical Plant area are TCE, nitrate, uranium, and nitroaromatic compounds. The set of COCs measured for each of the monitoring locations presented in Table 13 depends on the proximity of the particular well or spring to the contaminant plumes.

4.2.2.2 Baseline Concentrations and Data Evaluation

The *Baseline Concentrations of the Chemical Plant Groundwater Operable Unit Monitored Natural Attenuation Network at the Weldon Spring Site* (Baseline Concentrations Report) (DOE 2008d) was updated and revised in July 2008. The primary objective of the report was to evaluate monitoring data collected from the baseline monitoring period of July 2006 through May 2008 to establish baseline concentrations for the COCs for each well and spring in the MNA network. Baseline monitoring was performed as outlined in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit* (DOE 2004d) to acquire a comprehensive set of data to reevaluate the MNA remediation time frames developed in 2002 during the remedial design phase of the GWOU and assess the long-term monitoring program. Also, this report presented the methodology for review and evaluation of future MNA data. Contingency actions associated with upward trends and trigger exceedances are outlined in the LTS&M Plan and were developed in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit* (DOE 2004d).

The initial modeling to evaluate remediation time frames using MNA was performed in 2002 and is documented in the *Supporting Evaluation for the Proposed Plan for the Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (DOE 2003c). It was determined that the desired concentrations of COCs in groundwater could be attained within 100 years. A comparison of the initial concentrations used in 2002 and the baseline concentrations indicates that the values were relatively similar for most of the COCs. A review of the contaminant distribution in the shallow groundwater at the Chemical Plant from 2002 and the baseline period (2004 through 2006) shows that the areal distribution of the COCs is essentially unchanged. The modeling performed in 2002 to evaluate MNA was not revised, and the projected cleanup times resulting from that earlier evaluation were considered applicable. The projected cleanup time for most contaminants in the GWOU is less than 100 years. The exception is the increasing uranium concentrations in the unweathered bedrock in the former Raffinate Pits area since 2004. Until the increasing trend reverses, it is not possible to project a cleanup time for this area.

Table 13. Monitoring Locations Retained for MNA Monitoring for the GWOU

Location	Objective	Unit	TCE	Nitrate	Uranium	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2017	1	Weathered				✓	✓	✓	✓	✓
MW-2035	1	Weathered	✓	✓	✓			✓		
MW-4022	1	Unweathered		✓	✓					
MW-4023	1	Weathered		✓	✓					
MW-2012	2	Weathered				✓	✓	✓	✓	✓
MW-2014	2	Weathered						✓	✓	
MW-2038	2	Weathered		✓				✓		
MW-2040	2	Weathered		✓						
MW-2046	2	Weathered					✓			
MW-2050	2	Weathered						✓	✓	
MW-2052	2	Weathered						✓	✓	
MW-2053	2	Weathered					✓	✓	✓	
MW-2054	2	Weathered						✓	✓	
MW-3003	2	Weathered		✓	✓					
MW-3024	2	Unweathered			✓					
MW-3026	2	Unweathered								
MW-3030	2	Weathered	✓		✓			✓		
MW-3034	2	Weathered	✓	✓				✓		
MW-3039	2	Weathered						✓		
MW-3040	2	Unweathered		✓	✓					
MW-4013	2	Weathered		✓						
MW-4029	2	Weathered	✓	✓						
MW-4031	2	Weathered		✓						
MW-4040	2	Unweathered		✓	✓					
MW-2032	3	Weathered				✓	✓	✓	✓	✓
MW-2051	3	Weathered				✓	✓	✓	✓	✓
MW-3037	3	Weathered	✓		✓			✓		
MW-4013	3	Weathered						✓	✓	✓
MW-4014	3	Weathered		✓		✓	✓	✓	✓	✓
MW-4015	3	Weathered						✓	✓	✓

Table 13 (continued). Monitoring Locations Retained for MNA Monitoring for the GWOU

Location	Objective	Unit	TCE	Nitrate	Uranium	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-4026	3	Alluvium/SED			✓					
MW-4036	3	Weathered	✓	✓	✓					
MW-4039	3	Weathered				✓	✓	✓	✓	✓
MW-4040	3	Unweathered	✓					✓		
MW-4041	3	Weathered	✓	✓	✓	✓	✓	✓	✓	✓
MWS-1	3	Weathered	✓	✓	✓			✓		
MWS-4	3	Weathered	✓	✓	✓					
MW-2021	4	Unweathered		✓						
MW-2022	4	Unweathered				✓	✓			
MW-2023	4	Unweathered				✓	✓	✓	✓	✓
MW-2056	4	Unweathered				✓	✓	✓	✓	✓
MW-3006	4	Unweathered	✓	✓	✓			✓		
MW-4007	4	Unweathered	✓	✓						
MW-4042	4	Unweathered		✓	✓					
MW-4043	4	Unweathered	✓	✓	✓		✓	✓		✓
MWD-2	4	Unweathered		✓	✓					
SP-5303	5	Spring/SED			✓					
SP-5304	5	Spring/SED			✓					
SP-6301	5	Spring	✓	✓	✓	✓	✓	✓	✓	✓
SP-6303	5	Spring	✓	✓	✓	✓	✓	✓	✓	✓
SW-2007	5	Stream			✓					

Notes:
Objective 1 = Upgradient locations.
Objective 2 = Area of groundwater impact.
Objective 3 = Downgradient and lateral locations.
Objective 4 = Locations beneath the area of groundwater impact.
Objective 5 = Springs or surface water locations.

Abbreviations:
DNT = dinitrotoluene
DNB = dinitrobenzene
NB = nitrobenzene
SED = Southeast Drainage
TNT = trinitrotoluene

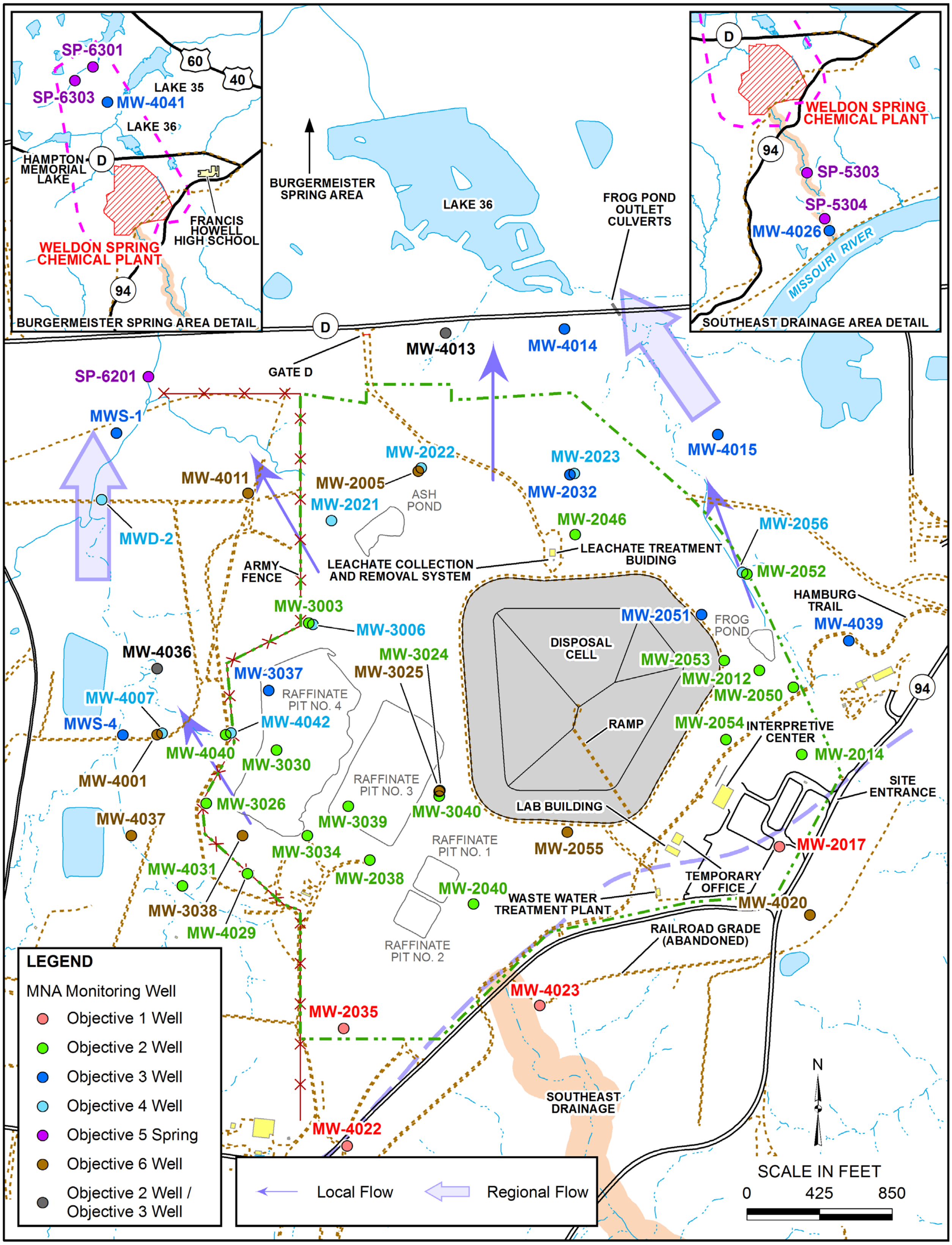

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Figure 6. GWOU MNA Monitoring Locations

The monitoring network was designed to provide data to show that natural attenuation processes are acting as predicted or to trigger the implementation of contingencies. Methods to review and interpret data that will satisfy the monitoring objectives were defined in the revised Baseline Concentrations Report (DOE 2008d). Performance of the MNA remedy will be gauged against long-term trends in the Objective 2 wells. This progress will be reviewed and documented every 5 years in conjunction with the CERCLA Five-Year Review. This review includes trending analysis for the past 5 years of data.

4.2.2.3 Uranium Concentrations in the Unweathered Bedrock

Uranium levels in three impacted area unweathered unit wells (MW-4040, MW-3040, and MW-3024) currently exceed the uranium fixed trigger level for Objective 2 wells. Uranium levels in these wells have also demonstrated a gradual increasing trend. A 2-year special study was conducted from February 2012 to February 2014 where thirteen locations (wells and springs) were sampled at an increased frequency of six times a year. Results of the special study and recommendations were reported in *Optimization for the Groundwater Operable Unit Monitored Natural Attenuation Network for Uranium Impact in the Unweathered Unit of the Burlington-Keokuk Limestone at the Weldon Spring, Missouri, Site* (DOE 2014).

The primary objective of the report was to evaluate historical data along with data collected during the special study sampling period to establish an MNA monitoring program for the unweathered bedrock unit of the Burlington-Keokuk Limestone at the Weldon Spring site. The study recommended establishing a separate uranium fixed trigger value for the unweathered unit impacted area (i.e., former source/raffinate pit areas). It was determined that the 100 pCi/L fixed trigger level for uranium in Objective 2 wells was established prematurely, before data from recently installed unweathered unit wells MW-4040 and MW-3040 was available.

Sampling frequencies of monitoring network wells were determined to be adequate to detect any significant changes that might occur. The relatively high unweathered unit uranium concentrations will attenuate much more slowly than contamination in the weathered unit. Subsequent to the study, it has been decided to expand the network to include the 16 wells screened in the unweathered unit, advantageously located weathered unit wells, and 3 downgradient springs in the unweathered unit uranium monitoring network. The inclusion of historically low concentration downgradient wells expands the monitoring network to detect potential future migration in the unweathered unit.

DOE and the regulators are currently working to resolve this issue.

4.2.2.4 Modification to Sampling Frequencies

As part of the Baseline Concentrations Report (DOE 2008d), an evaluation was performed to determine the appropriateness of the network to fulfill the intended objectives and the adequacy of the sampling frequencies that were initially specified for the MNA monitoring program. The following changes were recommended in the Baseline Concentrations Report and implemented through the LTS&M Plan in 2009:

- Objective 1: Reduced the sampling frequency to annual because concentrations in these upgradient wells were stable.
- Objective 2: Maintained semiannual sampling in the Objective 2 wells due to continued variability in the data.

- Objective 3: Reduced the sampling frequency to annual because concentrations have been behaving as expected.
- Objective 4: Reduced the sampling frequency to annual because concentrations have been behaving as expected.
- Objective 5: Increased the sampling frequency to quarterly due to variability in the springs and in some Objective 2 wells.

4.2.3 Groundwater Operable Unit System Operation and Maintenance

The long-term monitoring and maintenance activities discussed in the CPOU section also apply to the GWOU. This includes the LTS&M Plan (DOE 2008c), inspections, and ICs. Other maintenance activities include maintenance of the wells, which are inspected during each sampling event and maintained regularly. Institutional controls for the Groundwater Operable Unit are discussed in Section 6.5.2 and Section 7.2.1.5.

4.3 Quarry Bulk Waste Operable Unit

4.3.1 Quarry Bulk Waste Operable Unit Remedy Selection

The RI/FS process was conducted for the Weldon Spring Quarry Bulk Waste Operable Unit in accordance with the requirements of CERCLA, as amended, to document the proposed management of the Chemical Plant area as an operable unit for management of the bulk wastes from the Quarry. Documents developed during the RI/FS process included: (1) *Remedial Investigation for Quarry Bulk Wastes* (DOE 1989); (2) *Baseline Risk Assessment for Exposure to Bulk Wastes at the Weldon Spring Quarry* (DOE 1990d); (3) *Feasibility Study for the Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (DOE 1990c); and (4) *Proposed Plan for the Management of Bulk Wastes at the Weldon Spring Quarry, Weldon Spring Missouri* (DOE 1990a).

Remedial activities under the QBWOU were performed under the *Record of Decision for Management of Bulk Wastes at the Weldon Spring Quarry* (QBWOU ROD) (DOE 1990b). The QBWOU ROD was signed by EPA on September 28, 1990, and by DOE on March 7, 1991. The primary activities or RAOs established were to:

- Excavate and remove bulk waste (i.e., structural debris, drummed and uncontained waste, process equipment, sludge, soil).
- Transport the waste along a dedicated haul road to the Temporary Storage Area (TSA), which was within the boundary of the CPOU.
- Stage bulk wastes at the TSA for ultimate disposal in the onsite disposal cell.

These RAOs were completed as discussed below. COC information is discussed in Section 3.0.

4.3.2 Quarry Bulk Waste Operable Unit Remedy Implementation

Removal of the bulk waste was performed in a multi-tiered process similar to the one used at the Chemical Plant. In the first tier, the Quarry Water Treatment Plant, which was designed to treat contaminated water from the Quarry sump, was constructed. In the second tier, the basic infrastructure, including decontamination facilities, a haul road, and the utilities needed to excavate and transport the waste from the Quarry to the Chemical Plant, was built. In the final tier, the waste was excavated.

The waste was removed with conventional equipment and excavation techniques, placed in covered trucks, and hauled via the haul road to the Temporary Storage Area (TSA) at the Chemical Plant. The waste was retained in the TSA until it could be placed in the disposal cell. From May 1993 to October 1995, approximately 144,000 cubic yards (110,000 cubic meters) of soil and waste material were removed from the Quarry, transported to the Chemical Plant area, and placed in the TSA. All of the wastes were directly placed, or treated and placed, in the disposal cell by March 1999.

The Quarry Bulk Waste Operable Unit activities are documented in the *Quarry Bulk Waste Excavation Remedial Action Report* (DOE 1997d).

4.3.3 Quarry Bulk Waste Operable Unit System Operation and Maintenance

The QROU addresses residual contamination and long-term monitoring and maintenance for the Quarry.

4.4 Quarry Residuals Operable Unit

4.4.1 Quarry Residuals Operable Unit Remedy Selection

The QROU was the second of two operable units established for the Quarry Area of the Weldon Spring Site. An RI/FS process was conducted for the QROU in accordance with the requirements of CERCLA, as amended, to document the proposed management of the Quarry proper, the Femme Osage Slough and nearby creeks, and groundwater north of the Femme Osage Slough. Documents developed during the RI/FS process included the:

- *Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1998b)
- *Baseline Risk Assessment for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1997b)
- *Feasibility Study for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1998d)
- *Proposed Plan for Remedial Action at the Quarry Residuals Operable Unit of the Weldon Spring Site* (DOE 1998e)

The QROU remedy was described in the *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri* (QROU ROD) (DOE 1998a). The QROU 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 or RAOs included:

- Long-term monitoring of groundwater in the Missouri River alluvium to ensure that water quality in the public water supply remains protective of human health and the environment.
- Long-term monitoring of contaminated groundwater north of the Femme Osage Slough until levels are attained that pose a negligible potential impact on the groundwater in the Missouri River alluvium.
- ICs to prevent exposure to the contaminated groundwater north of the Femme Osage Slough.

The long-term monitoring status is discussed in Sections 4.4.2, 6.4 and 7.3. The ICs for the QROU have been implemented and are reviewed annually during the annual inspection.

The selected remedy in the QROU ROD (DOE 1998a) outlined the performance of two field studies to support the decision for long-term monitoring of groundwater and reliance on natural conditions to limit potential migration of uranium south of the slough. These field studies consisted of the installation and operation of an interceptor trench and hydrologic/geochemical sampling within the area of uranium impact to verify the effectiveness of uranium removal by groundwater extraction methods and support the conceptual fate and transport model for the Quarry. The interceptor trench study was performed from 2000 through 2002, and results indicated that modeled prediction for active removal of uranium from groundwater was optimistic and that further evaluation of groundwater treatment was not warranted (DOE 2003b). The result of the hydrologic and geochemical field studies performed from 2000 through 2002 provided a better understanding of the natural geochemistry of the alluvial aquifer north of the slough and led to the inclusion of this area in the ICs for the QROU (DOE 2002a).

Reclamation of the Quarry was completed on September 6, 2002. Backfilling of the Quarry was designed to reduce physical hazards associated with an open Quarry, eliminate the ponding of water, and reduce infiltration of precipitation water into the groundwater system. Fill material was placed and compacted to design elevations within the Quarry proper. During backfilling of the Quarry, selected wall and floor fractures were sealed to prevent infiltration of water and reduce the likelihood of later subsidence of the backfill. COC information is discussed in Section 3.0.

4.4.2 Quarry Residuals Operable Unit Remedy Implementation

DOE implemented long-term monitoring at the Quarry in October 2002. Monitoring is conducted in accordance with the *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit* (DOE 2000b), which was finalized in January 2000. Long-term groundwater monitoring for the QROU consists of two separate programs. 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 a predetermined target level indicating negligible potential to affect groundwater south of the slough is attained.

Groundwater monitoring is necessary to continue to ensure that uranium contaminated groundwater has a negligible potential to affect the Public Water Supply District #2 well field. 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 maximum measured in 1999) 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 microgram per liter (µg/L), the Missouri Water Quality Standard. Upon attainment of these target levels, it will be determined that the goal for the monitoring program has been met, and the long-term monitoring activities for the QROU will be concluded. Following attainment of the long-term monitoring target levels in groundwater north of the slough, an assessment of the residual risks based on actual groundwater concentrations will be performed to determine the need for future ICs.

To implement the two monitoring objectives, the wells were categorized into monitoring lines (Figure 7). Each line provides specific information relevant to long-term goals at the Quarry:

- 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. Well MW-1012 is monitored as a background location.
- The second line of wells monitors the area of impact within the alluvial materials and shallow bedrock north of the slough. These wells (MW-1006, MW-1007, MW-1008, MW 1009, 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) 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.

The sampling frequency for each location was selected to provide adequate reaction time on the basis of travel times from the residual sources and areas of impact to potential receptors. Monitoring wells on the Quarry rim (Line 1) are sampled semiannually, and wells north of the Femme Osage Slough (Line 2) are sampled quarterly. Locations south of the slough are sampled semiannually (Line 3) or annually (Line 4). All locations in the Quarry Area are sampled for uranium, sulfate, and dissolved iron. A selected group of wells north of the slough was sampled for nitroaromatic compounds.

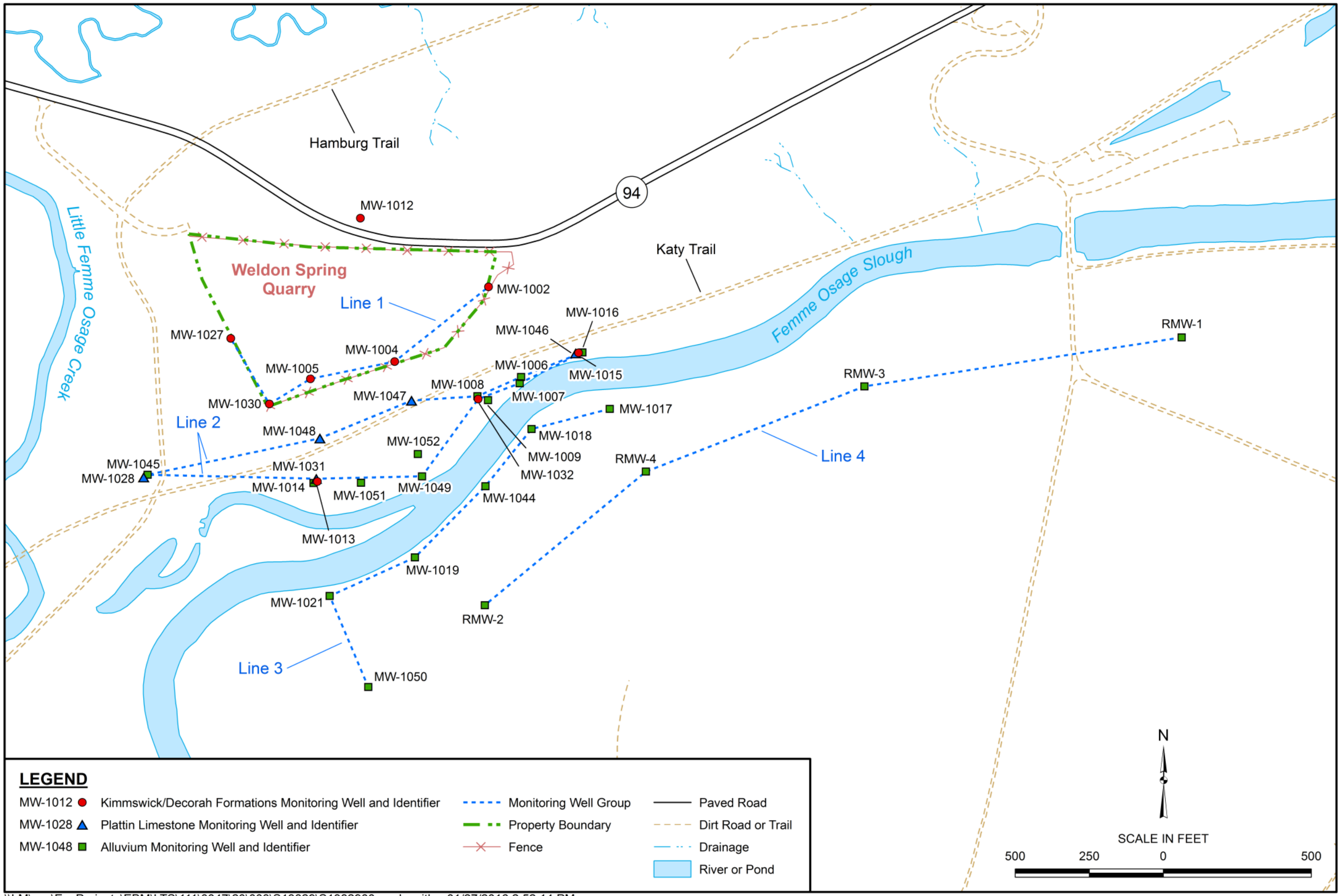

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Figure 7. QROU Monitoring Locations

The production wells south of the Quarry Area have had a separate 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 well field was originally owned and operated by St. Charles County; however, in 2005 the well field was sold to Public Water Supply District #2 (PWSD #2). The monitoring program has been continued by PWSD #2 and consists 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 PWSD #2.

The Quarry Residuals Operable Unit activities are documented in the *Quarry Residuals Operable Unit Interim Remedial Action Report* (DOE 2003a).

4.4.3 Quarry Residuals Operable Unit System Operation and Maintenance

The long-term monitoring and maintenance activities discussed in the CPOU section also apply to the QROU. This includes the LTS&M Plan (DOE 2008c), inspections, and ICs. Other maintenance activities include maintenance of the wells, which are inspected during each sampling event and maintained regularly. Institutional controls for the Quarry Residuals Operable Unit are discussed in Section 6.5.2 and Section 7.3.1.5.

4.5 Southeast Drainage

4.5.1 Southeast Drainage Remedy Selection

Cleanup for the Southeast Drainage was addressed as a removal 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) evaluated options for addressing contaminated soils and sediments in the Southeast Drainage. The EE/CA recommended that sediment in accessible areas of the drainage should be removed. The excavated materials would be stored temporarily at an onsite storage area until final disposal in the disposal cell.

The RAO for the Southeast Drainage was source removal. This was completed as discussed below in Section 4.5.2.

4.5.2 Southeast Drainage Remedy Implementation

The Southeast Drainage is a natural drainage area with intermittent flow that traverses both the Army property and the Weldon Spring Conservation Area from the Chemical Plant site to the Missouri River (Figure 2). Both the Army and AEC used the drainage to discharge water from sanitary and process sewers to the Missouri River. Also, contaminated liquids in the Raffinate Pits were decanted to the plant process sewer and subsequently discharged to the Southeast Drainage; overflow from the Raffinate Pits continued to discharge into the drainage after plant operations ceased. As a result, sediments and soils in the Southeast Drainage were contaminated. Radioactive contaminants of concern were uranium-238, radium-226, thorium-232, and thorium-230. Spring water in the Southeast Drainage (Springs SP-5303 and SP-5304) was contaminated with uranium and low concentrations of nitroaromatic compounds from the contaminated sediment.

Soil removal was in two phases: 1997 through 1998, and in 1999. A total of 1,931 cubic yards (1,476 cubic meters) was excavated in the first phase, and about 22.5 cubic yards (17.2 cubic meters) was excavated in the second phase.

Post-remediation soil sampling was conducted at Southeast Drainage locations after the soil was excavated. The purpose of this sampling was to determine the remaining concentrations of radionuclides within the soil and sediment and to calculate the risk reduction achieved from soil removal. Sampling was conducted in accordance with the *Post-Remediation Sampling Plan for the Southeast Drainage* (DOE 1997e). All post-remediation data results were used by Argonne National Laboratory to calculate risk reduction achieved by the removal action.

Complete details of the remediation as well as the post-cleanup risk assessment of the Southeast Drainage are in the *Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7* (DOE 1999a).

The Southeast Drainage post-cleanup risk assessment is detailed in the above document, which states that the remediation met the post-cleanup risk assessment for the hypothetical child. The hypothetical child is based on the future land-use scenario that a home would be built in the vicinity of the drainage, allowing a child to access the drainage for use as a play area. The post-cleanup risk assessment also states that the results indicate the removal action accomplished the goals presented in the Decision Document for the Southeast Drainage (DOE 1996).

4.5.3 Southeast Drainage System Operation and Maintenance

The long-term monitoring and maintenance activities discussed in Section 4.1 (CPOU) also apply to the Southeast Drainage. This includes the LTS&M Plan, inspections, and ICs. Institutional controls for the Southeast Drainage are discussed in Section 6.5.2 and Section 7.1.1.5.

4.6 Post-ROD Changes

CERCLA contains provisions for addressing changes to a remedy that occur after the ROD is signed. No changes were made to the RODs during this Five-Year Review period.

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5.0 Progress Since Last Review

Since the second Five-Year Review, remedial activities at the Chemical Plant and the Quarry have been completed with the exception of long-term groundwater monitoring at both locations. Since the site has reached physical completion, the LTS&M activities have become the main focus of the project. Major activities since the last Five-Year Review for the project include establishment of the IC with MoDOT—the last remaining IC required by the ESD, monitoring the groundwater, monitoring erosion activity, conducting annual surveillance inspections, continuing to operate and expand programs for the Interpretive Center, and establishing Howell Prairie.

The issues noted in the previous Five-Year Review and a discussion of each is included in Table 14:

Table 14. Status of Issues from Fourth Five-Year Review

Issue (From 2011 Five-Year Review Report)	Recommendations and Follow-Up Actions (From 2011 Five-Year Review Report)	Status
Erosion areas have been identified on the Chemical Plant Property	Have repaired erosion areas identified in past inspections. Will continue to inspect for erosion and repair as needed.	See Sections 4.1.3.4 and 6.5.5 for a complete discussion and update on erosion issues.
Small depressions and bulges have been identified on the disposal cell	These types of areas are not unexpected for a disposal cell of this type and are not a cause for concern. DOE will continue to monitor the area.	It was determined that visually delineating these surface anomalies has been subjective in the past. An aerial survey utilizing the LiDAR technology was flown in December 2014. It is planned to conduct the LiDAR survey of the disposal cell every 2 years (at least initially) and for this to take the place of walking the transects. The EPA and MDNR agreed with this plan. A discussion of the use of LiDAR is included in Sections 6.5.3 and 7.1.1.3.
Uranium levels in the GWOU Objective 2 wells screened in the unweathered unit have been greater than the trigger of 100 pCi/L since installation. A specific monitoring program for COCs in the unweathered unit has not been established as this impact was identified after design and implementation of the remedy.	The MNA program regarding uranium impact in the unweathered unit should be evaluated and possibly modified, which could include new trigger values and additional monitoring locations.	The MNA program regarding the uranium impact in the unweathered unit was evaluated during a 2-year special study (2012 to 2014). The study recommended establishing a separate uranium fixed trigger value for the unweathered unit. Additional monitoring locations have been added to the unweathered unit uranium monitoring network that now includes the 16 wells screened in the unweathered unit, advantageously located weathered unit wells, and 3 downgradient springs.
Vandalism issues exist	Continue security patrols. Place signs on the disposal cell stating that video surveillance is in use (or a similar type action).	Have increased security patrols over the past five years. Placed the sign at the top of the disposal cell that states video surveillance is in use. Have also upgraded the use of security cameras. The vandalism issues have been minimized.
DOE is working to obtain an easement with MoDOT	Work with MDNR and MoDOT to resolve landowner and other issues. Reevaluate whether IC is necessary.	The easement with MoDOT was finalized on May 24, 2012.

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6.0 Five-Year Review Process

6.1 Administrative Components of the Five-Year Review Process

The official kick-off date for the Five-Year Review process for the Weldon Spring Site, as provided by EPA, was August 12, 2015. The process will be completed with issuance of the final report in September 2016. The Five-Year Review process included notifying regulatory agencies, the community, and other interested parties of the start of the Five-Year Review; reviewing relevant documents and data; reviewing past and updated guidance; conducting site inspections; conducting site interviews; and developing and reviewing this fifth Five-Year Review Report. Each of these elements is discussed below.

EPA and MDNR were formally notified that the Five-Year Review process had begun in a letter dated October 28, 2015. The letter, which is included in Appendix A, notified them that the annual LTS&M inspection was to take place from December 1 through 2, 2015, and stated that the Five-Year Review would be a topic of discussion during a meeting on December 3, 2015. During the meeting, the Five-Year Review was discussed with all participants, including Ken Starr of DOE; Terri Uhlmeyer, Rex Hodges, and Yvonne Deyo, of Navarro Research and Engineering, Inc. (Navarro); Hoai Tran of EPA Region 7; and Patrick Anderson of MDNR. Other contributors to the development of the Five-Year Review included Laura Cummins of Navarro.

6.2 Community Notification and Involvement

Activities to involve the community in the Five-Year Review were initiated in October 2015. On October 20, 2015, DOE sent a letter to its distribution list, which includes many members of the public. The letter notified the recipients that DOE had initiated the fifth Five-Year Review, discussed the purpose of the Five Year Review, and stated that community involvement is an integral part of the Five-Year Review process, and requested input or suggestions, via a survey that DOE posted online. The survey included questions that EPA had suggested for community interviews in the Five Year Review guidance. Appendix A includes a copy of the letter and survey questions. On November 16, 2015, the *St. Louis Post Dispatch* published an announcement from DOE that the Five-Year Review process would be initiated. The announcement discussed the purpose of the Five-Year Review, the history of the Weldon Spring Site, the remedy, and COCs. The announcement also included information on the Administrative Record and the collection of records housed at the Middendorf-Kredell Library in O'Fallon, Missouri. Website and contact information were included, and the online survey was discussed. A copy of the public notice is included in Appendix A. One individual responded to the online survey, and their response are included in Appendix A. Also during the annual inspection, several stakeholders are contacted regarding the inspection and to inquire if there are any concerns or questions about the project.

The stakeholders contacted included:

- St. Charles County Sheriff
- Cottleville Fire District
- Francis Howell High School
- St. Charles County

The IC contacts also were notified in regard to the inspection and to maintain annual contact with the representatives relevant to ICs and to ensure that each representative is knowledgeable of the ICs, requirements, and restrictions. The following representatives were contacted:

- John Vogel, MDC
- Audrey Beres, MDC
- Danny Lyskowski, MDNR Division of State Parks
- Quinn Kellner, MDNR Division of State Parks
- John Downing, 88th Regional Support Command, U.S. Army
- Tom Blair, MoDOT
- Jim Wright, MoDOT
- Stowe Johnson, MoDOT

The stakeholders listed above were notified of the upcoming Five-Year Review, and several were asked questions recommended by the Five-Year Review guidance. The interview forms are included in Appendix B. The general questions asked from the Five-Year Review guidance are listed as follows:

- What is your overall impression of the project (general sentiment)?
- What effects have site operations had on the surrounding community?
- Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
- Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
- Do you feel well informed about the site’s activities and progress?
- Do you have any comments, suggestions, or recommendations regarding the site’s management or operation?

There were no negative concerns expressed by any of the interviewees. An additional interview was conducted during the Five-Year Review process with a representative from the MDNR – Hazardous Waste Program.

6.3 Document Review

The following sections list the documents assessed as part of this Five-Year Review.

6.3.1 Basis for Response Actions

The documents listed in Table 15 identify the background and goals of the remedies and any changes in laws and regulations that may affect the response action. These documents also provide background information on the remedial actions, basis for action, cleanup levels, and applicable or relevant and appropriate requirements (ARARs), and address community concerns and preferences.

Table 15. Documents Supporting Basis for Response Actions at the Site

Document	Purpose	Use for Review
Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri (DOE 1990c)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Remedial Investigation for Quarry Bulk Wastes (DOE 1989)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Baseline Risk Assessment for Exposure to Bulk Wastes at the Weldon Spring Quarry (DOE 1990d)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Record of Decision for the Management of the Bulk Wastes at the Weldon Spring Quarry (DOE 1990a)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site (DOE 1992d)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Feasibility Study for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site (DOE 1992b)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Remedial Investigation for the Chemical Plant of the Weldon Spring Site (DOE 1992a)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (DOE 1993)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri (DOE 1996)	Record removal action decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs

Table 15 (continued). Documents Supporting Basis for Response Actions at the Site

Document	Purpose	Use for Review
Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri (DOE 1998b)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Baseline Risk Assessment for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri (DOE 1997b)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Feasibility Study for Remedial Action for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri (DOE 1998d)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Record of Decision for the Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri (DOE 1998a)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Baseline Risk Assessment for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site (DOE 1997c)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Remedial Investigation for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site, Weldon Spring, Missouri (DOE 1997a)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Feasibility Study for Remedial Action for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site, Weldon Spring, Missouri (DOE 1998c)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Supplemental Feasibility Study for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site (DOE 1999c)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Supporting Evaluation for the Proposed Plan for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site (DOE 2003c)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs

Table 15 (continued). Documents Supporting Basis for Response Actions at the Site

Document	Purpose	Use for Review
Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site (DOE 2000a)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Record of Decision for the Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site (DOE 2004a)	Record selected remedial decision	Remediation goals Background Basis for action Community concerns Cleanup levels ARARs
Explanation of Significant Differences, Weldon Spring Site (DOE 2005b)	Records significant changes from the original remedy	Remediation goals

6.3.2 Implementation of the Response

The documents listed in Table 16 furnish information about design assumptions, design plans or modifications, and documentation of the response at the site.

Table 16. Documents Supporting Implementation of the Response at the Site

Document	Purpose	Use for Review
Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7 (DOE 1999a)	Documents removal action completion	History Chronology Whether cleanup levels were met
Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit (DOE 2000b)	Documents planned remedial design and activities	Background Remediation goals Remedial activities
Completion Report for Radon Flux Monitoring of the WSSRAP Disposal Facility (DOE 2001b)	Documents results of monitoring	Monitoring results
Quarry Bulk Waste Excavation Remedial Action Report (DOE 1997d)	Documents that construction activities are complete	History Chronology Effectiveness of remedial action
Conceptual Design Report for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (DOE 1994)	Documents planned remedial design and activities	Background Remediation goals Remedial activities
Chemical Plant Operable Unit Remedial Action Report (DOE 2004b)	Documents that construction activities are complete	History Chronology Effectiveness of remedial action
Quarry Residuals Operable Unit Interim Remedial Action Report (DOE 2003a)	Documents that construction activities are complete	History Chronology Effectiveness of remedial action
Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site (DOE 2004d)	Documents planned remedial design and activities	Background Remediation goals Remedial activities

6.3.3 Operation and Maintenance

The operation and maintenance documents listed in Table 17 describe the ongoing measures at the site to ensure that the remedy remains protective. They provide the structure for operation and maintenance at the site and confirm that operation and maintenance are proceeding as planned.

Table 17. Documents Supporting Operations and Maintenance at the Site

Document	Purpose	Use for Review
Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy, Weldon Spring, Missouri, Site (DOE 2008c)	Contains technical information necessary to operate and maintain the remedy	History Operation and maintenance requirements

6.3.4 Remedy Performance

The monitoring data, progress reports, post-remediation risk assessments, and performance evaluation reports listed in Table 18 provide information that can be used to determine whether the remedial actions continue to operate and function as designed and have achieved, or are expected to achieve, cleanup levels and are protective.

Table 18. Documents Supporting Remedy Performance at the Site

Document	Purpose	Use for Review
Weldon Spring Site Remedial Action Project Second Five-Year Review (DOE 2001a)	Records status and protectiveness of remedies	History Update status
Post-Remediation Risk Assessment for the Chemical Plant Operable Unit Weldon Spring Site St. Charles, Missouri (DOE 2002b)	To document risk estimates	Site status Monitoring Results
Weldon Spring Site Cell Groundwater Monitoring Demonstration Report for the December 2004 Sampling Event (DOE 2005a)	Document sampling results and explanation for exceedances. Includes plan of action	Site status Monitoring results Required actions
Weldon Spring Site Remedial Action Project Third Five-Year Review (DOE 2006)	Records status and protectiveness of remedies	History Update status
2006 Annual Inspection Report for the Weldon Spring Site, St. Charles, Missouri (DOE 2007a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Weldon Spring Site Environmental Report for Calendar Year 2006 (DOE 2007b)	Summarize activities and monitoring data annually	Site status Monitoring results
2007 Annual Inspection Report for the Weldon Spring, Missouri, Site (DOE 2008a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Baseline Concentrations of the Chemical Plant Operable Unit Monitored Natural Attenuation Network at the Weldon Spring, Missouri, Site (DOE 2008d)	Summarize environmental data	Site status Monitoring results Required actions
Weldon Spring Site Environmental Report for Calendar Year 2007 (DOE 2008b)	Summarize activities and monitoring data annually	Site status Monitoring results
2008 Annual Inspection Report for the Weldon Spring, Missouri, Site (DOE 2009a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Weldon Spring Site Environmental Report for Calendar Year 2008 (DOE 2009b)	Summarize activities and monitoring data annually	Site status Monitoring results

Table 18 (continued). Documents Supporting Remedy Performance at the Site

Document	Purpose	Use for Review
2009 Annual Inspection Report for the Weldon Spring, Missouri, Site (DOE 2010a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Weldon Spring Site Environmental Report for Calendar Year 2009 (DOE 2010b)	Summarize activities and monitoring data annually	Site status Monitoring results
2010 Annual Inspection Report for the Weldon Spring, Missouri, Site (DOE 2011a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Weldon Spring Site Environmental Report for Calendar Year 2010 (DOE 2011b)	Summarize activities and monitoring data annually	Site status
2011 Annual Inspection Report for the Weldon Spring, Missouri, Site (DOE 2012a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Weldon Spring Site Environmental Report for Calendar Year 2011 (DOE 2012b)	Summarize activities and monitoring data annually	Site status
Weldon Spring Site Fourth Five-Year Review (DOE 2011c)	Records status and protectiveness of remedies	History Update status
2012 Annual Inspection Report for the Weldon Spring, Missouri, Site (DOE 2013a)	Document results of annual inspection of LTS&M activities and IC status	Status of LTS&M activities and IC status
Weldon Spring Site Annual Report for Calendar Year 2012 (DOE 2013b)	Summarize activities and monitoring data annually Document results of annual inspection of LTS&M activities	Status of LTS&M activities, IC and site status
Weldon Spring Site Annual Report for Calendar Year 2013 (DOE 2014a)	Summarize activities and monitoring data annually Document results of annual inspection of LTS&M activities	Status of LTS&M activities, IC and site status
Weldon Spring Site Annual Report for Calendar Year 2014 (DOE 2015)	Summarize activities and monitoring data annually Document results of annual inspection of LTS&M activities	Status of LTS&M activities, IC and site status
Weldon Spring Site Annual Report for Calendar Year 2015 (DOE 2016)	Summarize activities and monitoring data annually	*Weldon Spring Site Annual Report for Calendar Year 2014* (DOE 2015)

6.3.5 Legal Documentation

The legal documentation listed in Table 19 includes information pertinent to the site that specified responsibilities for conducting remedial action, implementing institutional and access controls, and activities.

Table 19. Documents Supporting Legal Standards Regarding Remedial Action at the Site

Document	Purpose	Use for Review
Federal Facility Agreement	Commitments and agreements regarding implementation and operation of the remedies, conduct of studies, and responsibilities of other agencies	Site status Required actions Roles of different agencies
Institutional Control documentation	Access agreements, easements, and restrictions	Status and requirements of ICs

6.4 Data Review

Monitoring data are reviewed quarterly and reported annually in the Site Environmental Reports. Historical water quality and water level data for existing wells, and water quality data for surface locations are available on GEMS (Geospatial Environmental Mapping System) at http://gems-int.lm.doe.gov in the Groundwater Quality by Location report. A link to GEMS can also be found on the DOE Office of Legacy Management website (www.lm.doe.gov). Photographs, maps, and physical features can also be viewed on this website.

The monitoring programs at the Weldon Spring Site include the sampling and analysis of water collected from wells at the Chemical Plant, the Quarry, adjacent properties, and selected springs in the vicinity of the Chemical Plant. The groundwater monitoring programs are formally defined in the LTS&M Plan (DOE 2008c).

Testing for temporal trends was performed on the following data sets using the Mann-Kendall test for the most recent 5 years of data:

- Uranium, nitrate, TCE, and nitroaromatic compounds for the GWOU using data collected between 2011 and 2015, as required in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004d). Results for the trending analysis are reported for the Objective 2 wells and the Objective 5 springs because these locations monitor the area of groundwater impact and the aquifer discharge points.
- Total uranium and 2,4-DNT data from the Quarry collected between 2011 and 2015. Results for the trending analysis for uranium and 2,4-DNT are reported for wells in Lines 1 and 2 of the Quarry monitoring network, as these wells monitor the area of groundwater impact.

The EPA maximum contaminant level (MCL) for uranium in groundwater is 30 µg/L, which is a mass unit. Uranium data for the Weldon Spring Site have consistently been reported as activity (pCi/L). The activity-to-mass conversion factor that was adopted for the Weldon Spring Site is 680 pCi/mg (equivalent to 0.68 pCi/µg). With this conversion factor, the mass MCL equates to an activity MCL of 20.4 pCi/L, which will be rounded to a more conservative 20 pCi/L. Uranium activities in pCi/L are referred to as concentrations throughout this report.

6.4.1 Groundwater Operable Unit

Contaminated groundwater remains beneath the Chemical Plant. Contaminants include uranium, nitrate, TCE, and nitroaromatic compounds. Contamination in groundwater is generally confined to the shallow, weathered portion of the Burlington-Keokuk Limestone. Some contamination exists in the deeper, unweathered portion of the bedrock, primarily beneath the former Raffinate Pits. The groundwater at the Chemical Plant has been contaminated by past operations that resulted in multiple source areas. Remediation activities have eliminated the sources for the groundwater contamination beneath the site. The distribution of contaminants in the shallow aquifer at the site is controlled by bedrock topography that influences groundwater flow and several processes, such as transformation, adsorption, desorption, dilution, or dispersion; the primary attenuation mechanisms are dilution and dispersion.

6.4.1.1 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. Subsurface flow and transport in the Chemical Plant area occurs primarily in the carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated beneath the site. These materials become saturated to the north and influence groundwater flow. The thickness of the unconsolidated materials ranges from 20 to 50 ft (DOE 1992a).

A groundwater divide is located along the southern boundary of the site. Groundwater north of the divide flows north toward Dardenne Creek and ultimately to the Mississippi River, and groundwater south of the divide flows south to the Missouri River. Localized flow is controlled largely by bedrock topography. Groundwater movement is by diffuse flow with localized zones of discrete fracture-controlled flow.

The aquifer of concern beneath the Chemical Plant is the shallow bedrock aquifer within the Mississippian Burlington-Keokuk Limestone (the uppermost bedrock unit) and the underlying Fern Glen Formation (Figure 8). The Burlington-Keokuk Limestone is described as having two different lithologic zones: a shallow, weathered zone and an underlying unweathered zone. The weathered portion of this formation is highly fractured and exhibits solution voids and enlarged fractures. These features may also be present on a limited scale in the unweathered zone, particularly in the vicinity of buried preglacial stream channels (paleochannels). Localized aquifer properties are controlled by fracture spacing, solution voids, and preglacial weathering, including structural troughs along the bedrock–overburden interface. 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.

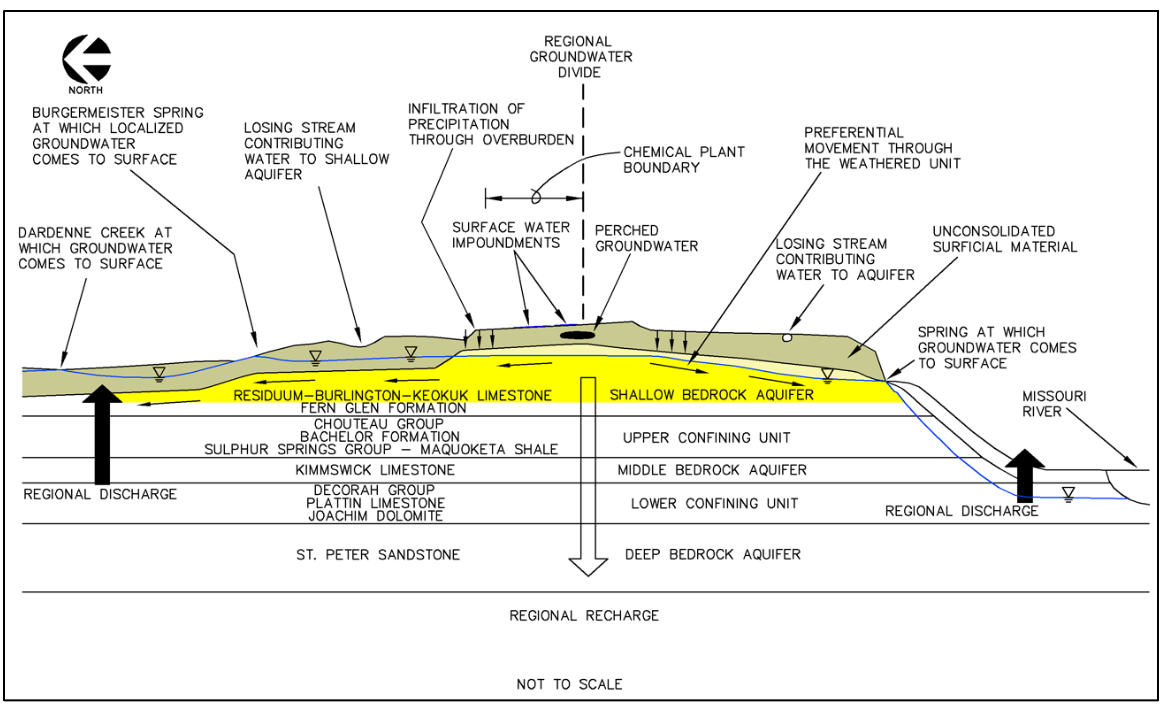

Figure 8. Conceptual Model Cross Section

All monitoring wells at the Chemical Plant are completed in the Burlington-Keokuk Limestone. Most of the wells are completed in the weathered zone of the bedrock where groundwater has the greatest potential to be contaminated. Some wells screened in the unweathered zone are used to assess the vertical migration of contaminants and monitor lateral migration within this zone. Monitoring wells within the boundaries of the Chemical Plant are located near historical contaminant sources and preferential flow pathways (paleochannels) to assess the movement of contaminated groundwater in the shallow aquifer. Additional wells are located outside the Chemical Plant boundary to detect and evaluate potential offsite migration of contaminants (Figure 9).

Numerous springs, a common feature in carbonate terrains, are present in the vicinity of the site. Four springs that are monitored routinely (Figure 10) have been historically influenced by Chemical Plant discharge water or groundwater that contained one or more of the contaminants of concern. The springs occur where surface water features intercept the water table within the weathered bedrock aquifer.

The presence of elevated total uranium and nitrate at Burgermeister Spring (SP 6301)1.2 miles north of the site, which is beyond downgradient monitoring wells with background levels, indicates that discrete subsurface flow paths are present in the vicinity of the site. Groundwater tracer tests performed in 1995 (DOE 1997a) confirmed that a discrete and rapid subsurface hydraulic connection exists between the northern portion of the Chemical Plant and Burgermeister Spring. These flow paths are associated with the preglacial stream channels (paleochannels) present beneath the site.

6.4.1.2 Chemical Plant Hydrogeologic Data Analysis

Hydrogeologic conditions at the site are being monitored using all of the wells included in the MNA network (Objectives 1, 2, 3, and 4 wells) and additional wells (Objective 6 wells) that were selected to provide adequate coverage to identify changes in groundwater flow that might affect the protectiveness of the selected remedy. The static groundwater levels of the monitoring network are measured to establish that groundwater flow is not changing significantly and causing shifts in contaminant migration.

The groundwater elevations measured in the fall of 2015 (September 28 to September 30) were used to construct potentiometric surface maps of the weathered and unweathered units of the shallow aquifer using the available wells at the Chemical Plant (Figure 11 and Figure 12). The configuration of the potentiometric surface has remained relatively unchanged during the 5-year period. However, groundwater elevations have decreased in several portions of the site, and northwest of the site, spring SP-6303 has been dry since the April 4, 2013, sample was collected. Even though the groundwater elevations vary somewhat during the year in response to wet and dry periods, the groundwater flow direction has been consistently to the north. A groundwater divide is present along the southern boundary of the Chemical Plant site. Troughs in the groundwater surfaces coincide with the location of paleochannels.

Groundwater elevations generally decreased in the weathered unit of the Burlington-Keokuk Limestone in response to the site remediation activities that began in the late 1990s and was completed in late 2001 (Figure 13 and Figure 14) but have since stabilized. Well MW-3028 was pumped during 2001 (drawdown on Figure 13) as part of the field studies on the Groundwater Operable Unit (DOE 2002a). An increase in surface water infiltration in the Frog Pond area after the remediation activities has caused a slight increase in groundwater elevations and increased seasonal variability (well MW-2013, Figure 13). Groundwater elevations in both the weathered and unweathered units decreased in the Raffinate Pits area (MW-3024, Figure 14) in response to the removal of large surface water impoundments, such as the Raffinate Pits, during site remediation.

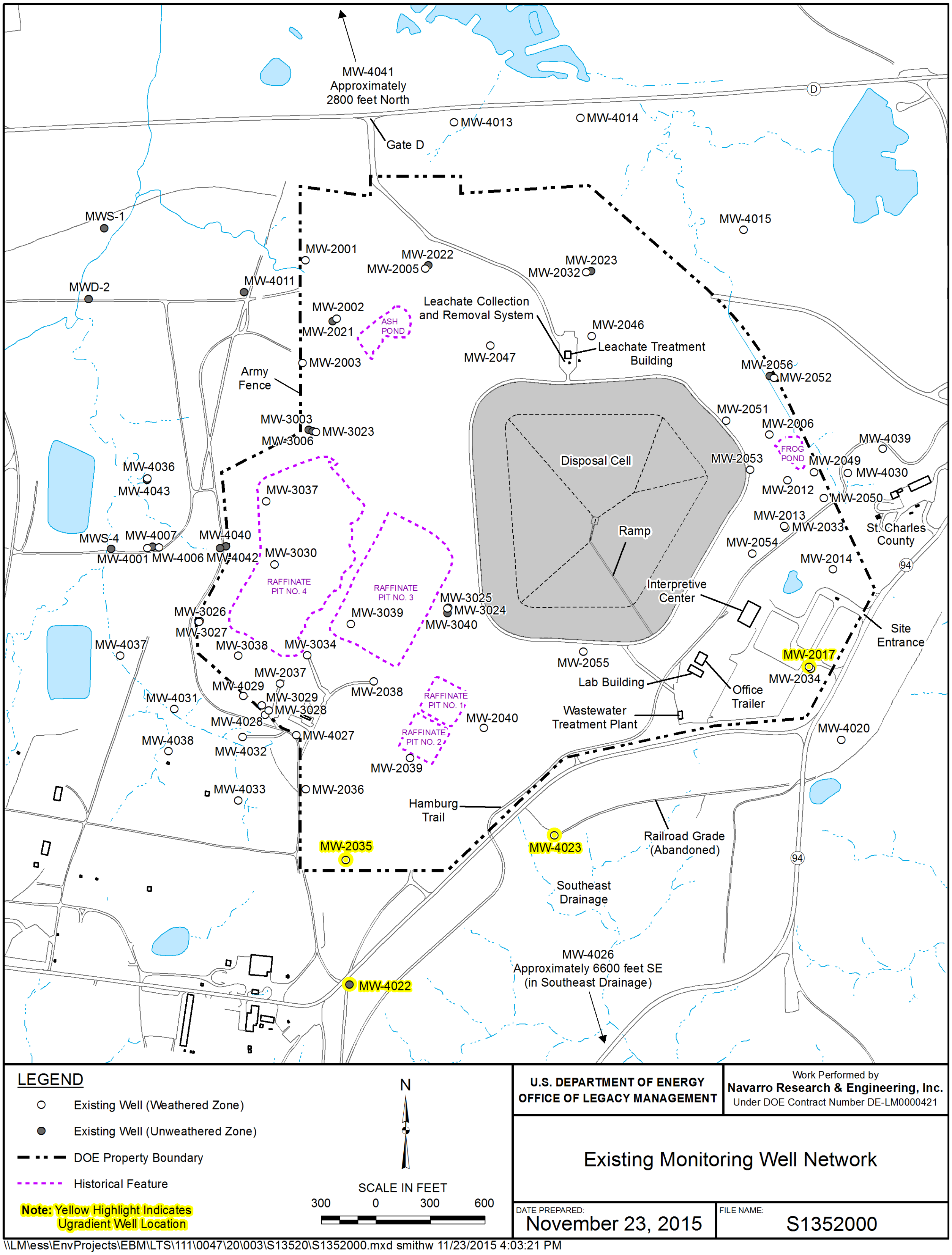

Figure 9. Existing Monitoring Well Network

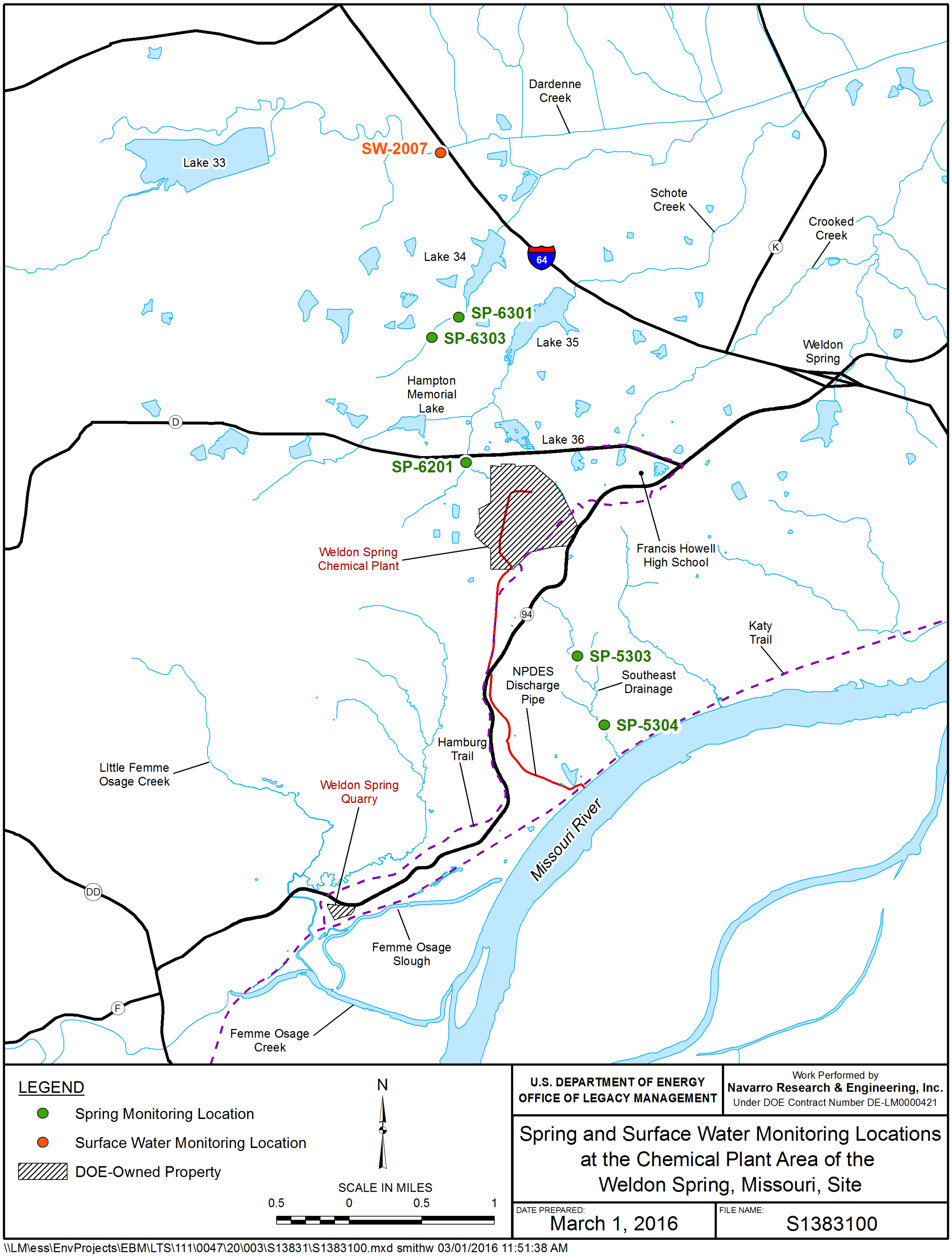

Figure 10. Spring and Surface Water Monitoring Locations at the Chemical Plant Area of the Weldon Spring, Missouri, Site

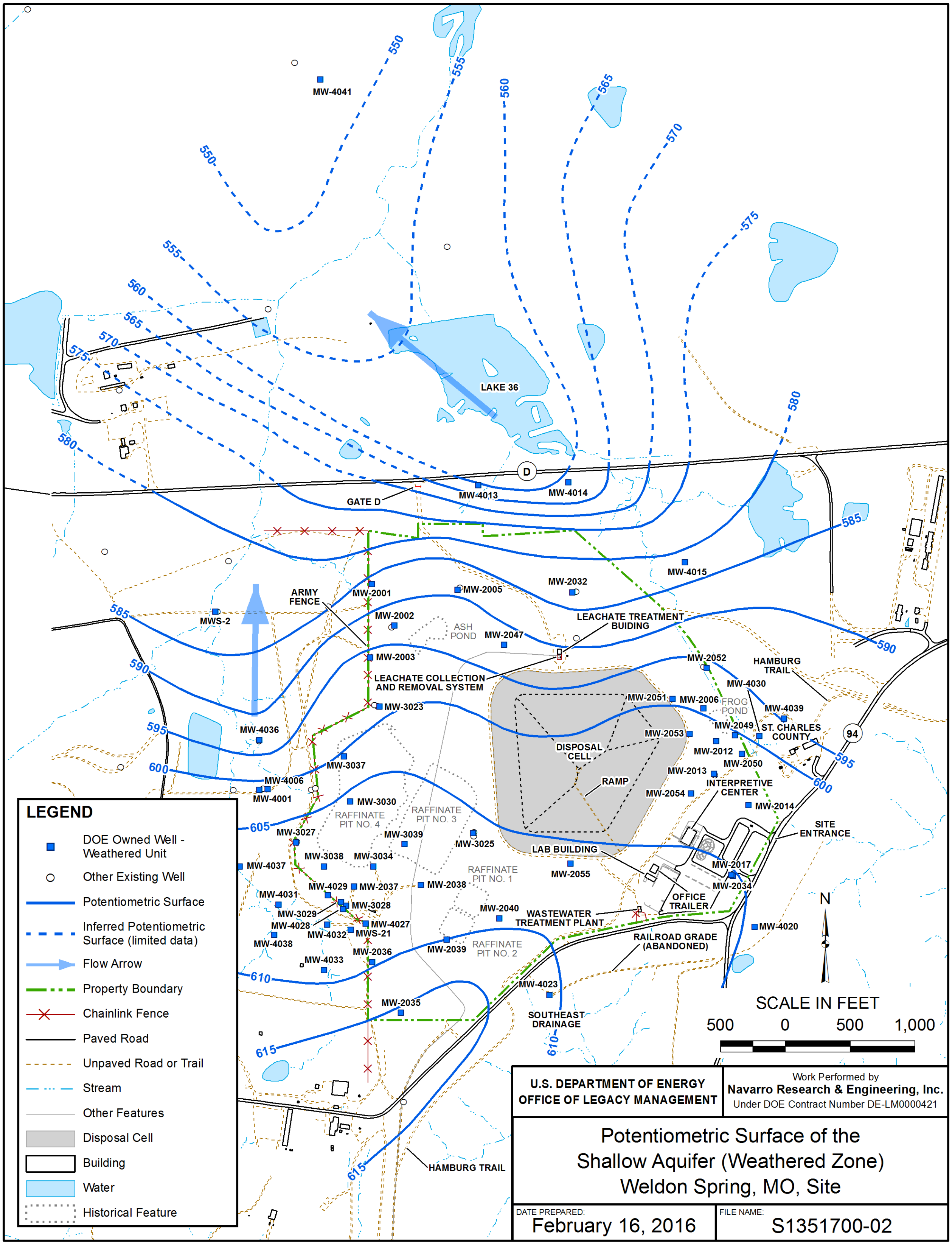

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Figure 11. Weathered Unit Groundwater Surface at the Weldon Spring Former Chemical Plant (Fall 2015)

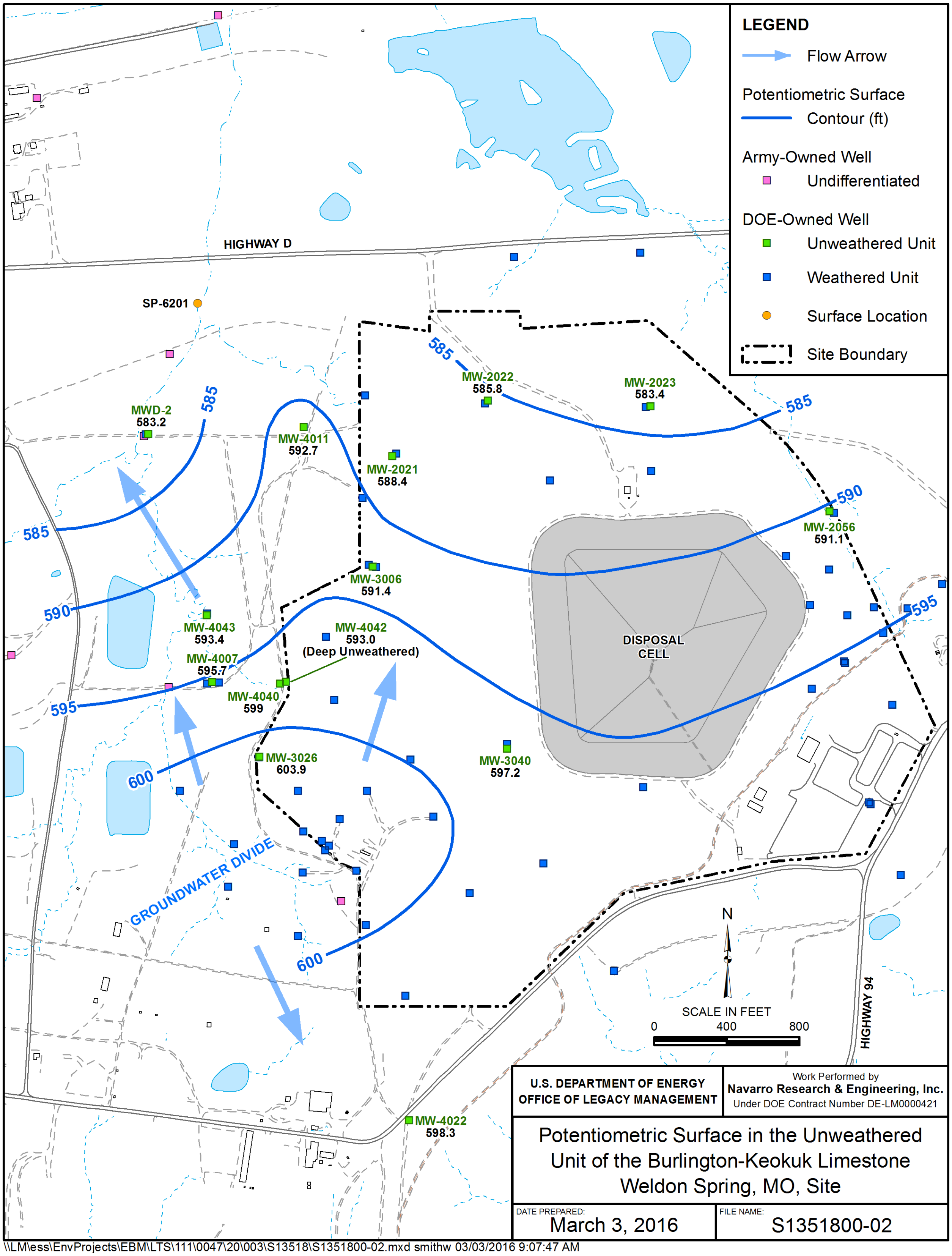

Figure 12. Unweathered Unit Groundwater Surface at the Weldon Spring Former Chemical Plant (Fall 2015)

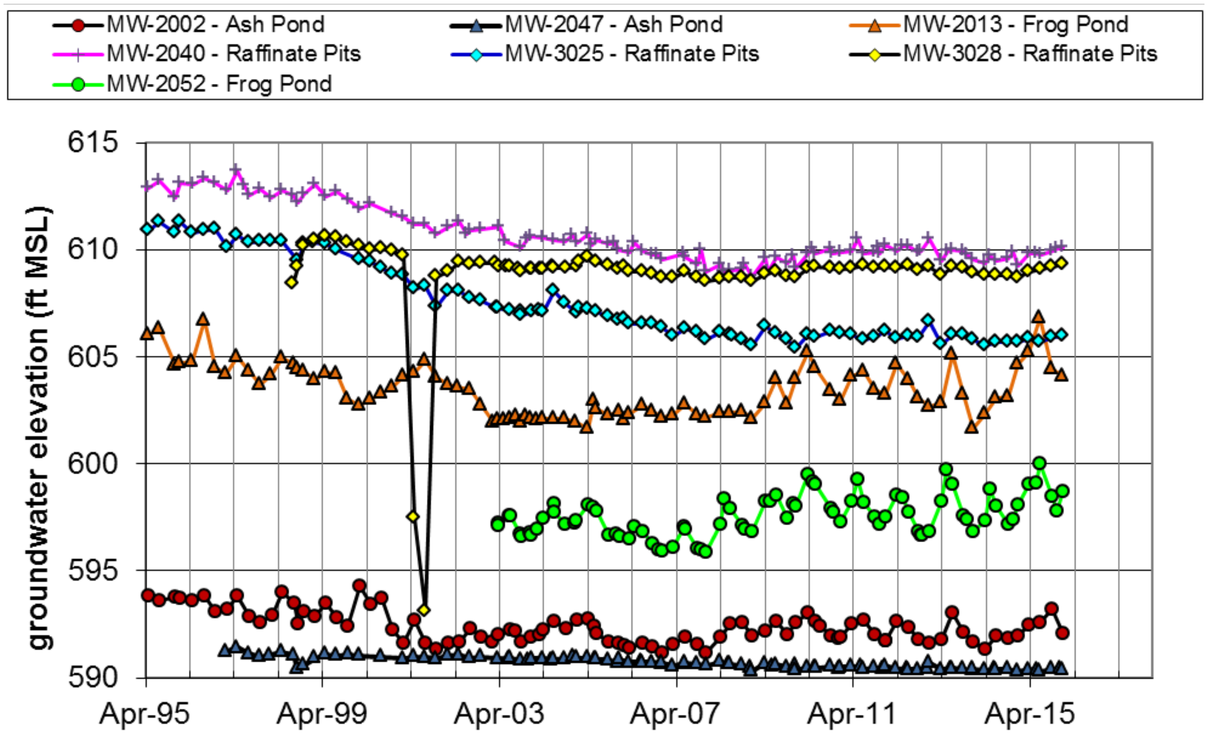

Figure 13. Groundwater Elevations in the Weathered Unit

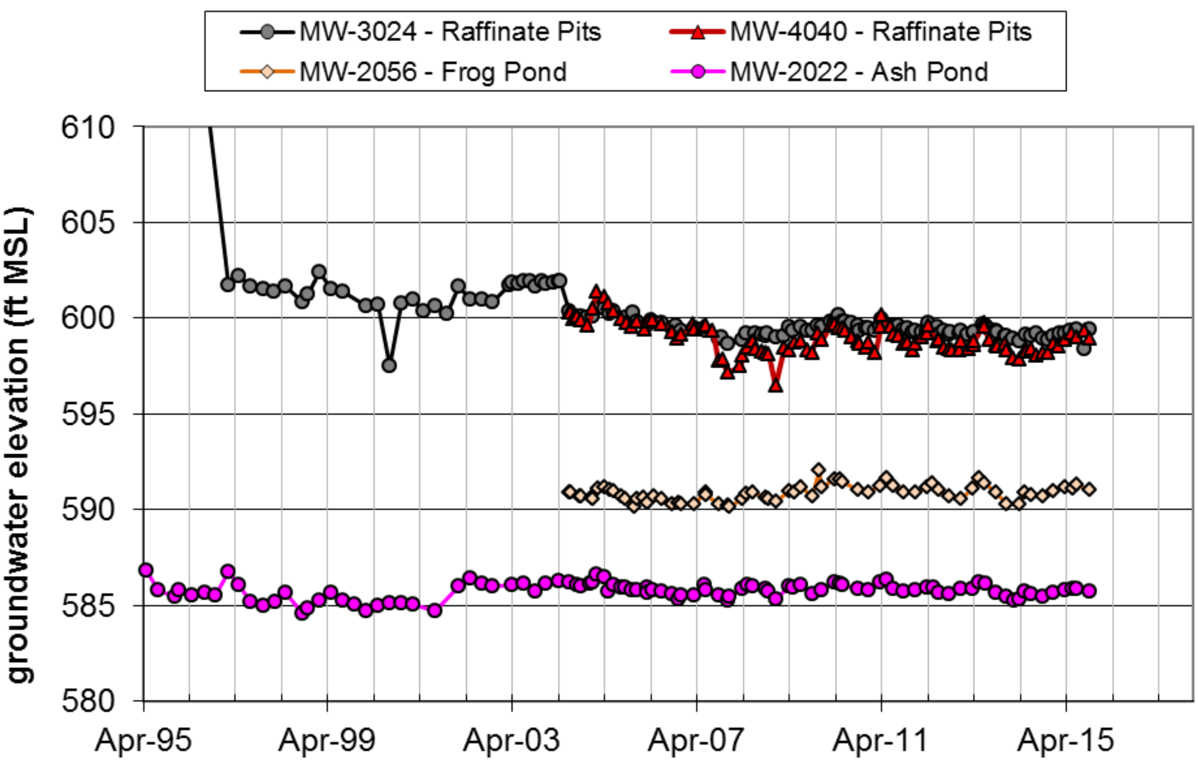

Figure 14. Groundwater Elevations in the Unweathered Unit

6.4.1.3 Contaminants of Interest

Contaminated groundwater remains beneath the former Chemical Plant. Contaminants include uranium, nitrate, TCE, and nitroaromatic compounds. Nitrate was reported from the laboratory as "Nitrate as N" prior to 2006, and as "Nitrate + nitrite as N," with "N" being nitrogen, since 2006. Nitrite is typically not detectable when measured separately. Throughout the document, "nitrate as N" will be referred to as "nitrate" except for a few locations where it is specified for the 10 mg/L MCL (equivalent to 44.3 mg/L for nitrate reported as NO_3). Contamination in groundwater is generally limited to the shallow, weathered portion of the Burlington-Keokuk Limestone. Some contamination occurs in the deeper, unweathered portion of the bedrock, primarily beneath the former Raffinate Pits. The groundwater at the former Chemical Plant has been contaminated by past operations that resulted in multiple source areas. Remediation activities at the site have removed the primary source zones for groundwater contamination. The distribution of contaminants in the shallow aquifer at the site is controlled by several processes, such as transformation, adsorption, desorption, dilution, or dispersion; the primary attenuation mechanisms are dilution and dispersion.

The Raffinate Pits were the primary historical source for uranium contamination in groundwater. Uranium entered the shallow aquifer via infiltration through the thin overburden beneath the pits. The extent of uranium in groundwater was limited, because uranium is partially sorbed to the clays in the overburden materials. At locations where uranium-contaminated water migrated beneath the overburden, it entered the limestone conduit system and subsequently discharged to springs north of the site. The oxidizing conditions of the shallow aquifer are not favorable for the precipitation of uranium from solution. Uranium-contaminated sediments were also discharged offsite during past operations. These sediments accumulated in subsurface cracks and fissures in the losing stream segments and act as residual sources of contamination to groundwater and springs.

Nitrate is present in the groundwater near the former Raffinate Pits area and the Ash Pond area, which are the historical sources of this contaminant. Nitrate is mobile in the shallow groundwater system, as it is not readily sorbed to subsurface materials. Conditions for natural denitrification have not been identified in the shallow aquifer, so nitrate persists in groundwater, enters the limestone conduit system, and subsequently discharges to springs north of the site.

Groundwater contaminated with TCE is localized in the weathered portion of the bedrock aquifer in the vicinity of Raffinate Pit 4. The source of TCE contamination was drums that were disposed of in Raffinate Pit 4. The oxidizing conditions in the shallow bedrock aquifer do not promote the biodegradation of chlorinated organic compounds.

Nitroaromatic compounds (1,3-dinitrobenzene [DNB]; 2,4,6-TNT; 2,4-DNT; 2,6-DNT; and nitrobenzene) in the groundwater system coincide with former production line locations. The presence of nitroaromatic compounds in groundwater is a result of leakage from former TNT process lines, discharges from water lines, and leaching from contaminated soils and waste lagoons. The mobility of nitroaromatic compounds in the bedrock aquifer is high due to little sorption to the bedrock materials. Microorganisms indigenous to the soils and the shallow aquifer have the ability to transform and degrade TNT and DNT.

6.4.1.4 Chemical Plant GWOU Monitoring Program

The monitoring network is designed to provide data either to show that natural attenuation processes are acting as predicted or to trigger the implementation of contingencies when these processes are not acting as predicted (e.g., unexpected expansion of the plume or sustained increases in concentrations within the area of impact). The data analysis and interpretation will address the following:

- Upgradient locations (Objective 1) indicate that baseline conditions remain unchanged.
- Performance monitoring locations (Objective 2) indicate that concentrations within the area of impact are decreasing or remaining stable.
- Detection monitoring locations (Objectives 3, 4, and 5) monitor for unacceptable expansion of the area of impact. Objective 3 locations monitor for potential lateral expansion and Objective 4 locations monitor for potential vertical expansion. Objective 5 locations are springs that are the only potential points of exposure under current land use conditions. The springs discharge groundwater that includes contaminated groundwater originating at the former Chemical Plant area. Presently, contaminant concentrations at these locations are protective of human health and the environment under current recreational land uses.
- Hydrogeologic monitoring locations (Objectives 1, 2, 3, 4, and 6) indicate any changes in groundwater flow that might affect the protectiveness of the MNA remedy at the site over time. Only monitor water levels are monitored at Objective 6 locations.

Data are evaluated as outlined in the Baseline Concentrations Report (DOE 2008d). The evaluation of data was established to satisfy the monitoring objectives for the MNA remedy.

Trigger Levels

Trigger levels were set for each contaminant at the performance and detection monitoring locations in the event that unexpected increases occur. There are two trigger levels for each contaminant, the first of which is independent of the specific contaminant. The first trigger level is set at what would be considered a statistically significant increase of a contaminant concentration at a location, and is defined as the mean of the previous eight data points plus 3 standard deviations. This trigger is designed to alert to the possibility that a contaminant plume is no longer stable and is expanding. The first response is to determine if the result is valid (resample), and if it is confirmed, to then increase sampling frequency to track possible future increases in concentration. It is most useful for downgradient wells with relatively low and stable concentrations. It is less useful for higher-concentration wells adjacent to an impacted area where results are typically more variable. Higher-concentration zones in remediated areas where contamination was previously stable could be subject to a period of unstable, increasing concentrations before the trend reverses. Contingency actions are defined in Appendix M of the LTS&M Plan.

The second trigger level is a fixed concentration established to provide a level above which increases in concentration would be considered unacceptable (Table 20). At the Weldon Spring Site, the fixed trigger levels were based on a review of data collected prior to 2004 and are used to evaluate MNA performance and to minimize risk to potential receptors. They are typically set at higher levels near impacted areas and at lower levels, such as the MCL, in downgradient, non-impacted areas. These triggers were formalized in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004d).

Table 20. Fixed Trigger Levels for Performance and Detection Monitoring for the GWOU

Analyte	Cleanup Standard	Objective 2	Objective 3 (Near)	Objective 3 (Far)	Objective 4	Objective 5
Nitrate (mg/L)	10	1,350	30	10	20	20
Uranium (pCi/L)	20	100	50	20	40	150
TCE (μg/L)	5	1,000	15	5	10	5
2,4-DNT (μg/L) – FP	0.11	2,300	1.1	0.11	0.22	0.22
2,4-DNT (μg/L) – RP		5	0.55			
2,6-DNT (μg/L)	1.3	2,000	13	1.3	2.6	1.3
2,4,6-TNT (μg/L)	2.8	500	11.2	2.8	5.6	2.8
1,3-DNB (μg/L)	1.0	20	4	1	2	1
NB (μg/L)	17	50	34	17	17	17

Abbreviations:
DNB = dinitrobenzene; DNT = dinitrotoluene; FP = Frog Pond; NB = nitrobenzene; RP = Raffinate Pits; TNT = trinitrotoluene; TCE = trichloroethene

The fixed triggers were set for each contaminant and are different for the area of impact (Objective 2), outside the area of impact (Objectives 3 and 4), or at discharge points (Objective 5). Objective 3 wells are subclassified into "near" and "far." Near wells include both close wells that delineate the plume and farther away wells that confirm no migration to that location. Far wells are those that are at a distance beyond where concentrations that might pose a risk would reasonably be expected to migrate, essentially a downgradient background well. If a fixed trigger is exceeded, consideration is given as to whether site conditions have changed unexpectedly. Exceeding a fixed trigger at a downgradient location could indicate that the contaminant plume is expanding, though not fast enough to trip the trigger of the average plus 3 standard deviations.

In impacted areas, where concentrations are expected to be variable, exceeding the fixed trigger may not be as significant when considered in context with all other data. For example, uranium levels in three wells adjacent to the former Raffinate Pits (contained within institutional controls) currently exceeds the uranium fixed trigger level for impacted areas (100 pCi/L). This trigger level was set a few years after contaminated material was removed from the Raffinate Pits and prior to installation of two of the three "high" concentration wells. The concentration in the third well later increased to exceed the trigger, in response to the nearby remediation operations that tend to mobilize remnant contamination. The 100 pCi/L trigger was set to provide a goal to judge MNA performance in the impacted area, not as a trigger that has risk implications. For instance, the average uranium concentration in two of the three wells is below the 150 pCi/L limit for downgradient discharge areas where receptors have potential access.

Data collected since 2004 indicate that the uranium fixed trigger for the impacted area was set prematurely. The 2004 to 2006 baseline study (DOE 2008d) did not include the new wells in the reevaluation of initial concentrations and suggested that additional data were needed to better establish baseline concentrations. Uranium levels in the wells are beginning to stabilize, though concentrations continued to rise slowly during 2014. Concentrations of more-mobile constituents in the Raffinate Pits, such as nitrate, initially increased in impacted area well MW-4040 but have since begun to decline. Given sufficient time, uranium concentrations should also peak and then decline. Appropriate responses to exceeding fixed triggers would be to increase sampling frequency to ensure that the trend is not seasonally affected, add additional downgradient sampling locations, or revise the trigger as warranted. A detailed discussion of the recommendations is available in the *Optimization for the Groundwater Operable Unit Monitored Natural Attenuation Network for Uranium Impact in the Unweathered Unit of the Burlington-Keokuk Limestone at the Weldon Spring, Missouri, Site* (DOE 2014b).

Groundwater data from the upgradient locations are compared with the previously collected data from each respective location. If a statistically significant increase (mean plus 3 standard deviations for the previous eight data points) is measured, then the value is evaluated for its validity. For those locations that are "nondetect," a statistically significant increase is considered to be the respective cleanup standard measured for two consecutive sampling periods. Contingency actions are defined in Appendix M of the LTS&M Plan. The data are currently being reviewed quarterly.

Non-Parametric Trend Analysis

Testing for temporal trends was performed using uranium, nitrate, TCE, and nitroaromatic compound data, as required in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004d) using data from the previous 5 years (2010 through 2014). Results for the trending analysis are reported for the Objective 2 wells and the Objective 5 springs because these locations monitor groundwater impact at discharge points. The trend analysis is conducted using the Mann-Kendall test described in Helsel and Hirsch (2002). The Mann-Kendall test is implemented in the Visual Sampling Plan (VSP) software (VSP 2013; Gilbert 1987; Hirsch et al. 1982).

The Mann-Kendall test is used for temporal trend identification because it can easily facilitate missing data and does not require the data to conform to a particular distribution (such as a normal or lognormal distribution). The nonparametric method is valid for scenarios that include a high number of nondetect data points. Data reported as trace (estimated) concentrations or as nondetects can be used by assigning them a common value that is smaller than the smallest measured value in the data set. This approach is valid because only the relative magnitudes of the data, rather than their measured values, are used in the method.

A possible consequence of this approach is that the test can produce biased results if a large fraction of data within a given time series is nondetects and if detection limits change between sampling events. Results reported below the detection limit were assigned a value of one-half of the specified detection limit. Results equal to and below the detection limit (as well as "U" qualified or rejected results) are shown on the data charts as empty or white symbols (identified in the legend as a location name preceded by an “n”, e.g., “nMW-1001”) and are the same shape as the corresponding color-filled symbol for results classified as “detect.”

Trends are calculated from sample results collected at a location during the previous 5 years, less duplicates and rejected values. Trend results are shown on the data charts with their *p*-value and slope. If the *p*-value is less than 0.05, then the trend is statistically significant and either “up” or “down,” depending on the slope. If the *p*-value is greater than 0.05, then there is no statistically significant trend (“none”). It has been shown that the false discovery rate for a *p*-value of 0.05 is close to 30% (Colquhoun 2014), or a 30% chance of concluding that a trend exists that could simply be the result of random chance. A more rigorous 2-tailed test (essentially a *p*-value of 0.025 for a 1-tailed test) for determining if a trend exists is being used to reduce the number of false trends. Trending requires 10 or more samples, especially for locations with variable results.

The data are plotted on a log-scale, since the rate of concentration increase or decrease typically slows with time and it allows changes in lower-concentration wells to be compared with changes in higher-concentration wells. A linear regression line (Isaaks and Srivastava 1989) is plotted with the data on the charts to visually show the slope and the time period of data used for trending. If concentrations increase or decrease significantly over the trend calculation time period, the linear fit line will curve (plotted on a log-scale). An example trending calculation using VSP is provided in Appendix F.

Baseline Monitoring Results for the GWOU

Baseline conditions are monitored in four upgradient wells to confirm that baseline conditions have remained unchanged and for comparison if changes occur in downgradient areas of impact. Each of the upgradient wells was sampled annually during the period from 2011 through 2015. The concentration for each parameter is presented in Table 21. The concentrations measured from 2011 through 2015 are similar to previous results and indicate no change in upgradient groundwater quality (Objective 1).

Table 21. Baseline Monitoring for the GWOU MNA Remedy (2011–2015)—Averages

Location	MW-2017	MW-2035	MW-4022	MW-4023
	Weathered	Weathered	Unweathered	Weathered
Parameters				
Uranium (pCi/L)	NR	0.42	2.9	1.9
Nitrate (mg/L)	NR	0.71	0.35	0.73
TCE (μg/L)	NR	<1	NR	NR
1,3-DNB (μg/L)	ND (<0.04)	ND (<0.04)	NR	NR
2,4,6-TNT (μg/L)	ND (<0.04)	ND (<0.04)	NR	NR
2,4-DNT (μg/L)	ND (<0.04)	ND (<0.04)	NR	NR
2,6-DNT (μg/L)	ND (<0.04)	ND (<0.04)	NR	NR
Nitrobenzene (μg/L)	ND (<0.04)	ND (<0.04)	NR	NR

Abbreviations:
DNB = dinitrobenzene; DNT = dinitrotoluene; ND = analyte not detected above reporting limit indicated in parentheses; NR = analyte not required; TNT = trinitrotoluene

6.4.1.5 Monitoring for the GWOU

The performance of the MNA remedy is assessed through the sampling of the Objective 2 monitoring wells. Objective 2 wells are within the areas of impact and monitor both the weathered and unweathered units of the Burlington-Keokuk Limestone. Objective 2 of the MNA strategy is to verify that contaminant concentrations are declining or remaining stable as expected and that cleanup standards will be met in a reasonable time frame.

Performance of the remedy is gauged against long-term trend analysis as outlined in the MNA Baseline Concentrations Report (DOE 2008d) and the LTS&M Plan. Some locations are expected to show temporary upward trends due to ongoing dispersion, analytical variability, or other factors; however, concentrations are not expected to exceed historical maximums. Concentration-versus-time graphs serve as visual indicators of MNA progress.

Detection monitoring consists of sampling to fulfill Objectives 3, 4, and 5 of the MNA strategy. Wells along the fringes and downgradient (both laterally and vertically) of the areas of impact are monitored to ensure that lateral and vertical migration remains within the current area of impact and that expected lateral downgradient migration (due to dispersion) within the paleochannels is minimal. Springs and surface water locations are also monitored, as these are the closest groundwater discharge points for the shallow aquifer in the vicinity of the Chemical Plant. These locations are monitored to ensure that concentrations remain protective of human health and the environment and that water quality continues to improve in the springs.

Uranium GWOU Performance Monitoring Results

The area of uranium impact is in the former Raffinate Pits area in the western portion of the site. Uranium levels exceed the MCL of 20 pCi/L in both the weathered and unweathered units of the Burlington-Keokuk Limestone. Table 22 presents a summary of the uranium values for the period from 2011 through 2015. Figure 15 shows performance (red) and detection (blue) monitoring locations with 2015 uranium averages. Weathered unit wells and surface locations have round symbols, and unweathered unit locations have square symbols.

Table 22. Uranium Averages from GWOU Performance Monitoring Wells

Location	Uranium (pCi/L)				
	2011	2012	2013	2014	2015
Weathered Unit					
MW-3003	3.1	2.9	3.0	2.8	2.8
MW-3030	29	29	28	25	26
Unweathered Unit					
MW-4040	306	317	336	358	350
MW-3040	104	114	126	115	129
MW-3024	116	135	132	123	136
MW-3026	NS	NS	NS	44	54

Abbreviation:
NS = not sampled

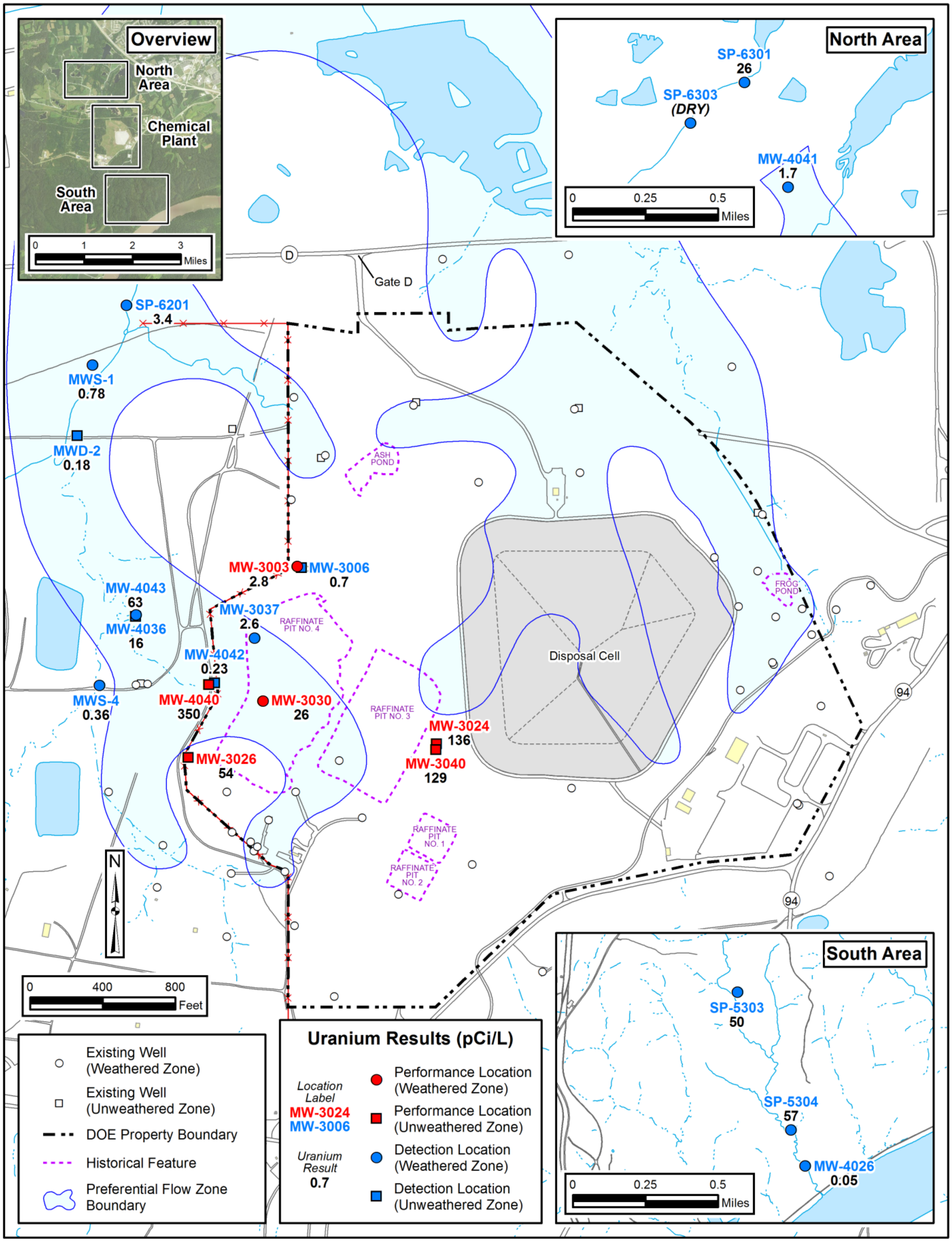

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Figure 15. Uranium Monitoring Locations with 2015 Average Concentrations

Uranium impact in the weathered unit is monitored in two wells. The highest uranium levels in this unit are measured in MW-3030 (Figure 16), installed beneath the former Raffinate Pits area. The Objective 2 wells screened in the weathered unit have generally shown gradually decreasing uranium levels since the removal of the pits. The levels in MW-3003 have consistently been less than the MCL since 2000. Well MW-3003 is screened where the weathered unit transitions to the unweathered unit. Uranium concentrations have dropped since low-flow sampling was adopted at the beginning of 2004. Uranium levels in MW-3003 have declined to low levels and are beginning to stabilize near background levels.

Uranium levels in wells screened in the weathered unit have continued to decrease over the past 5 years. A statistically significant downward trend is indicated for MW-3030. The rate of decline appears to be decreasing, but uranium levels in MW-3030 could be below the 20 pCi/L uranium MCL in the next 10 years.

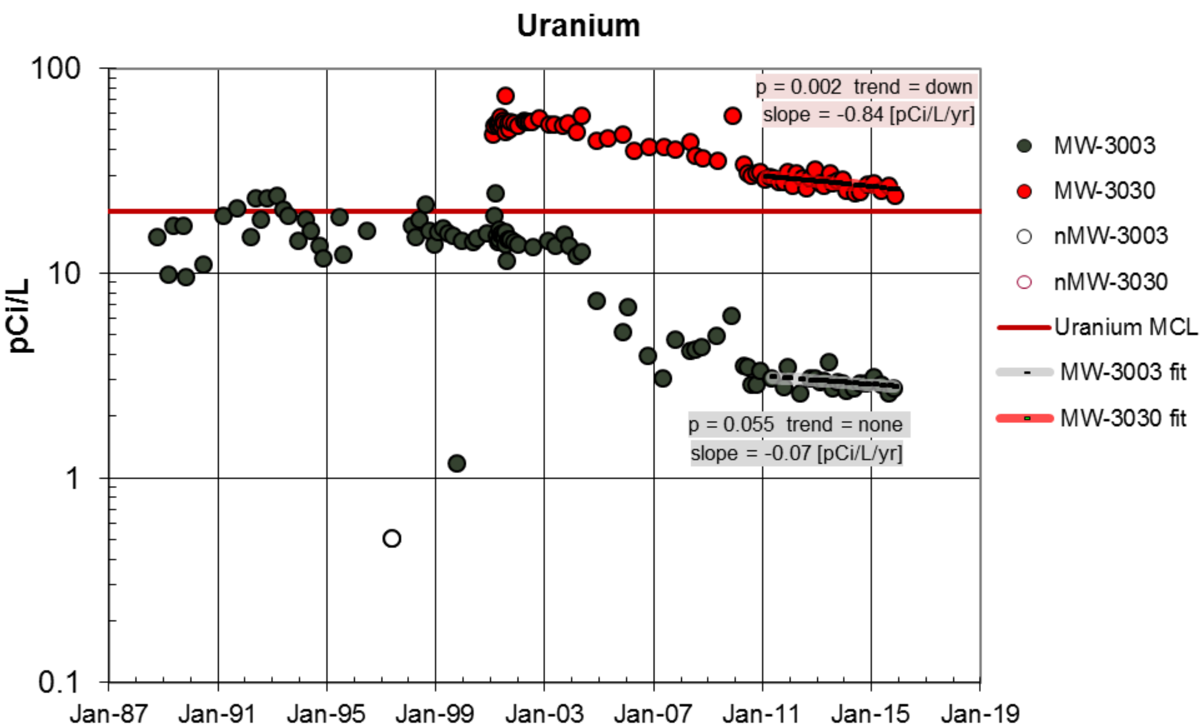

Figure 16. Uranium Concentrations in Performance Monitoring Wells—Weathered Unit

Uranium impact is greatest in the wells that are screened in the unweathered unit beneath and immediately downgradient of the former Raffinate Pits (Figure 17). Uranium results in wells MW-4040, MW-3040, and MW-3024 were consistently above the Objective 2 100 pCi/L trigger level during the previous 5 years and are currently trending upward. Well MW-3026 which had not been sampled since 2004, due to low concentrations and a downward trend, was added to the uranium monitoring network in 2014 because of its proximity to former Raffinate Pit 4. The results since 2014 have been consistently higher (around 50 pCi/L) than samples collected 10 years earlier (Figure 17). They also appear to be increasing, although there are too few samples to indicate a statistically significant trend. Data from well MW-4042 (screened deeper in the unweathered unit at the same location as high-concentration well MW-4040) indicate that significant uranium has not migrated into the deeper part of the unweathered unit.

The anomalously high values in late 2009 for each of the wells above the 100 pCi/L trigger level were lab qualified as estimated. The anomalously high result of the February 2014 sample collected from MW-4040 was not lab qualified as estimated. In response, MW-4040 was resampled; that result and later August and November sample results were in line with historical results.

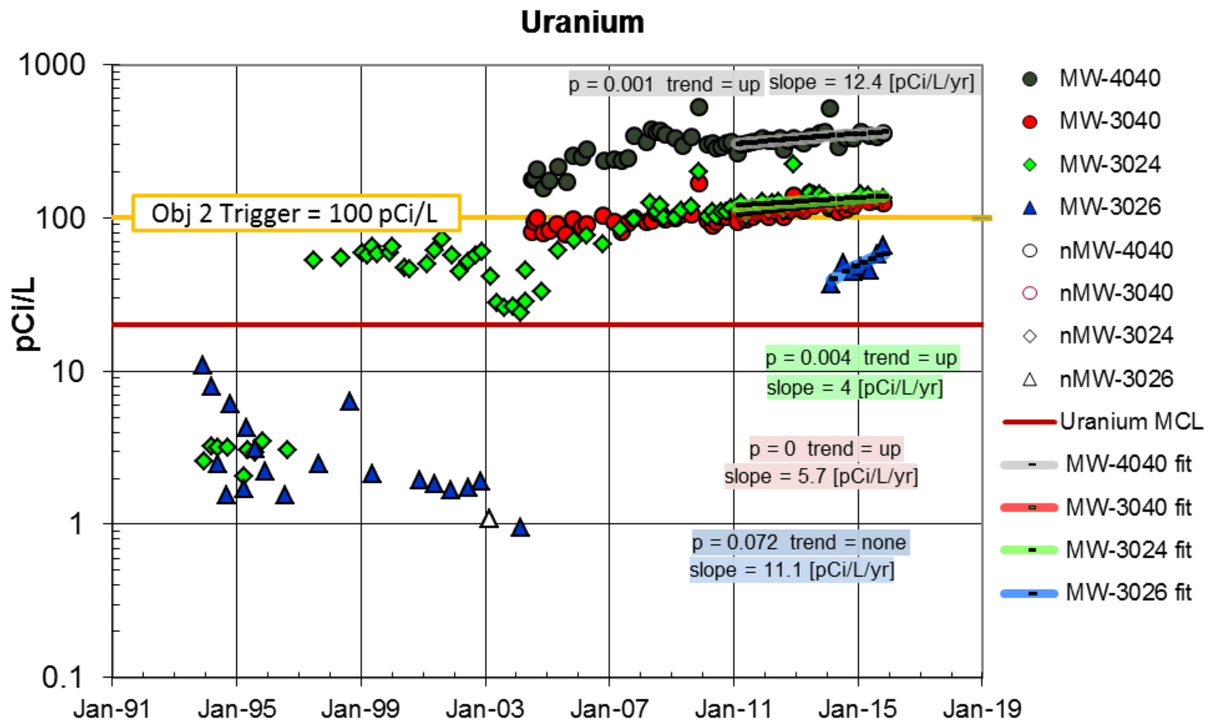

Figure 17. Uranium Concentrations in Performance Monitoring Wells—Unweathered Unit

Uranium GWOU Detection Monitoring Results

Uranium detection monitoring locations are listed in Table 23. Uranium levels have been at or below typical background levels for all weathered unit detection monitoring wells except MW-4036 (Figure 18). None of the weathered unit wells have a discernable trend. Uranium levels in MW-4036 vary seasonally, ranging from 2 to 62 pCi/L from 2011 through 2015.

Uranium levels have been at or below typical background levels for all unweathered unit detection monitoring wells except MW-4043 (Figure 19). Well MW-4043 averaged 77 pCi/L over the previous 5 years but has been trending downward, with the most recent result at 59 pCi/L. It is adjacent to weathered unit well MW-4036. Uranium levels in MW-3006 are on a recent up trend, but still below 1 pCi/L.

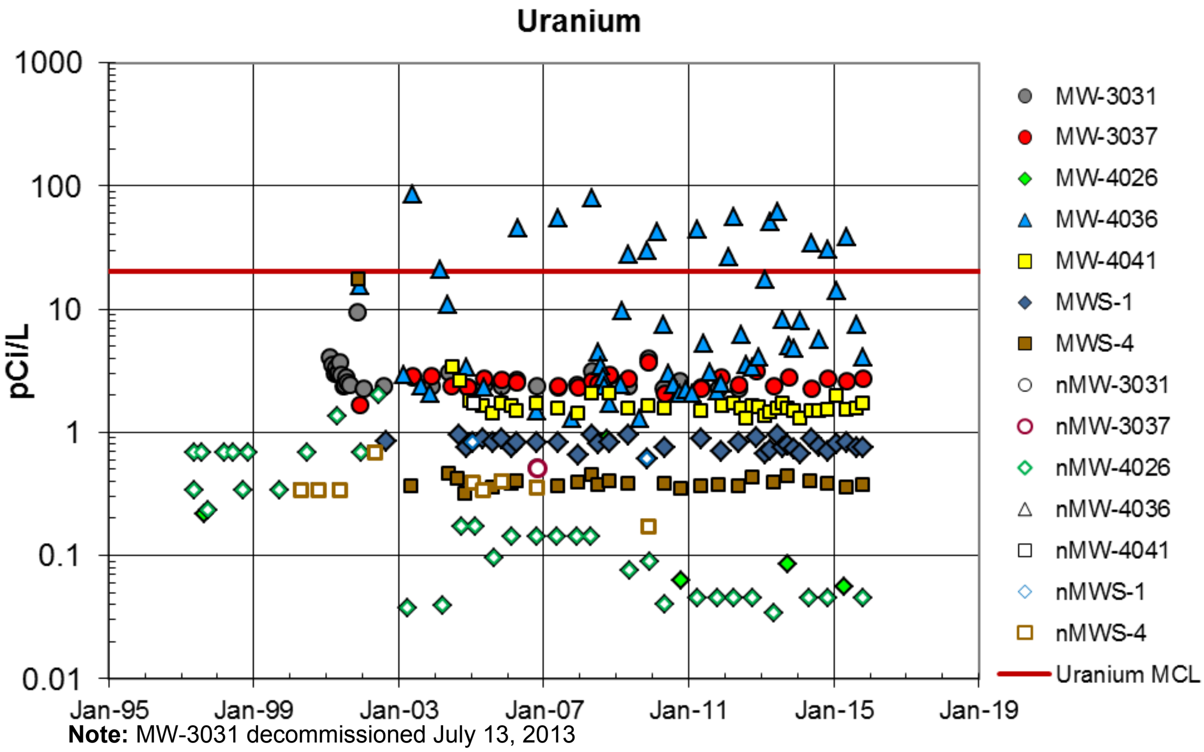

Figure 18. Uranium Levels in Detection Monitoring Wells—Weathered Unit

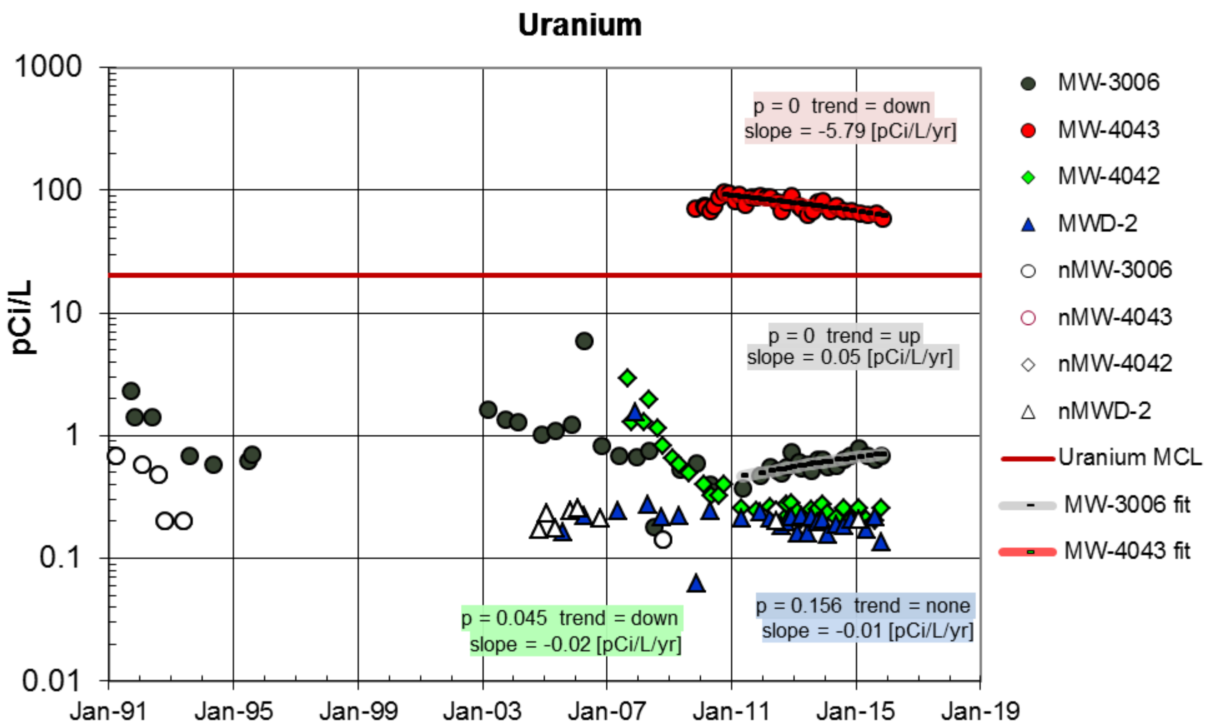

Figure 19. Uranium Levels in Detection Monitoring Wells—Unweathered Unit

Table 23. Uranium GWOU Detection Monitoring Locations

Locations	Detection Monitoring Areas
Weathered Unit	
MW-3031	Fringe
MW-3037	Fringe
MW-4026	Southeast Drainage (alluvium)
MW-4036	Downgradient
MW-4041	Downgradient
MWS-1	Downgradient
MWS-4	Downgradient
Unweathered Unit	
MW-3006	Fringe
MW-4042	Downgradient
MWD-2	Downgradient
Springs and Surface Water	
SP-5303	Southeast Drainage
SP-5304	Southeast Drainage
SP-6301	Burgermeister Spring Branch
SP-6303	Burgermeister Spring Branch
SW-2007	Dardenne Creek

The variable uranium levels in MW-4036 were part of a special study that was initiated in 2008. A new well, MW-4043 was installed in 2009 adjacent to MW-4036 and screened in the unweathered unit. The location is in the western preferential flow zone (paleochannel) that extends north northwest from Raffinate Pit 4.

Uranium concentrations in MW-4036 vary over nearly 2 orders of magnitude, ranging from above those in upgradient impacted area well MW-3030 to near background levels (about 2 pCi/L) during the year (Figure 20). The variation in this well is a response to seasonal effects that cause water levels in the unweathered unit to rise more than those in the overlying weathered unit, creating a seasonal upward vertical gradient, typically most pronounced in the winter and spring. Concentrations in weathered unit well MW-4036 can approach those in unweathered unit well MW-4043 when there is an upward gradient. When there is no upward gradient, concentrations in MW-4036 decline to near-background levels. These data indicate that uranium is migrating horizontally from the impacted area in the unweathered unit within the paleochannel.

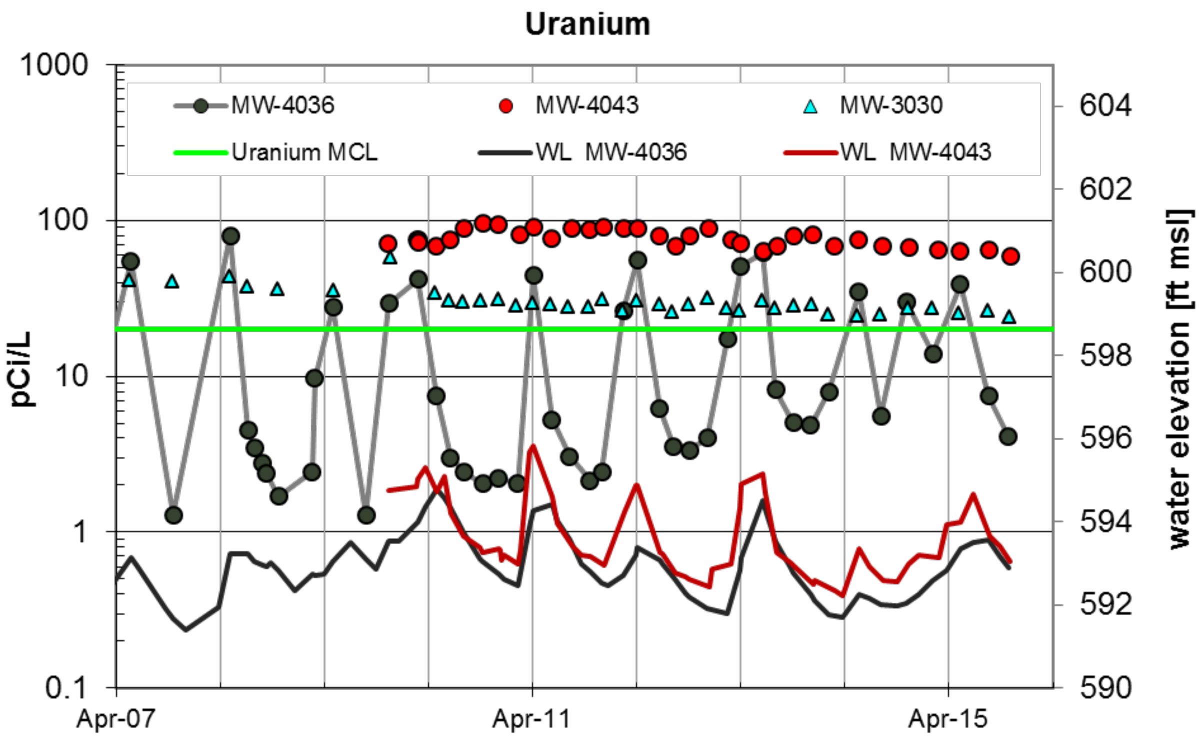

Figure 20. Seasonally Variable Uranium Concentrations in MW-4036

Well MW-4042 is a deep unweathered unit well adjacent to MW-4040, the high uranium concentration well in the upper part of the unweathered unit. It confirms that uranium has not migrated downward to the deeper part of the unweathered unit. The initial slightly higher concentrations in MW-4042 that dissipated over the next few years (Figure 19) were likely introduced during well installation as the well was drilled through the higher-concentration upper part of the unweathered unit.

In general, the distribution of uranium has expanded along the western side of the Raffinate Pits area, as indicated by the variable uranium values reported in MW-4036 and the elevated uranium levels measured in MW-4043. The presence of uranium in a downgradient spring SP-6201, at an average value of 19.4 pCi/L, also supports the conclusion of downgradient migration of uranium. Downgradient migration is expected, as the attenuation mechanisms for uranium are dilution and dispersion, which lead to some downgradient migration. Triggers for “Objective 3–near” wells were set to take into account the migration of contaminants in the paleochannels. Uranium impact is contained within the paleochannel located within the upper portion of the shallow aquifer (weathered and unweathered units of the Burlington-Keokuk Limestone).

Uranium concentrations at surface water locations north of the former Chemical Plant have not significantly changed from the previous 5-year period (Figure 21). Concentrations in Dardenne Creek have been low since monitoring resumed at location SW-2007 in 2001. Concentrations at spring SP-6303 had been declining on a long-term trend and were at background levels from 2010 until it was last sampled on April 4, 2013. It has been dry since. Uranium concentrations at Burgermeister Spring (SP-6301) continue to vary (by about an order of magnitude) but remain within historical ranges and well below the trigger level of 150 pCi/L (Figure 21).

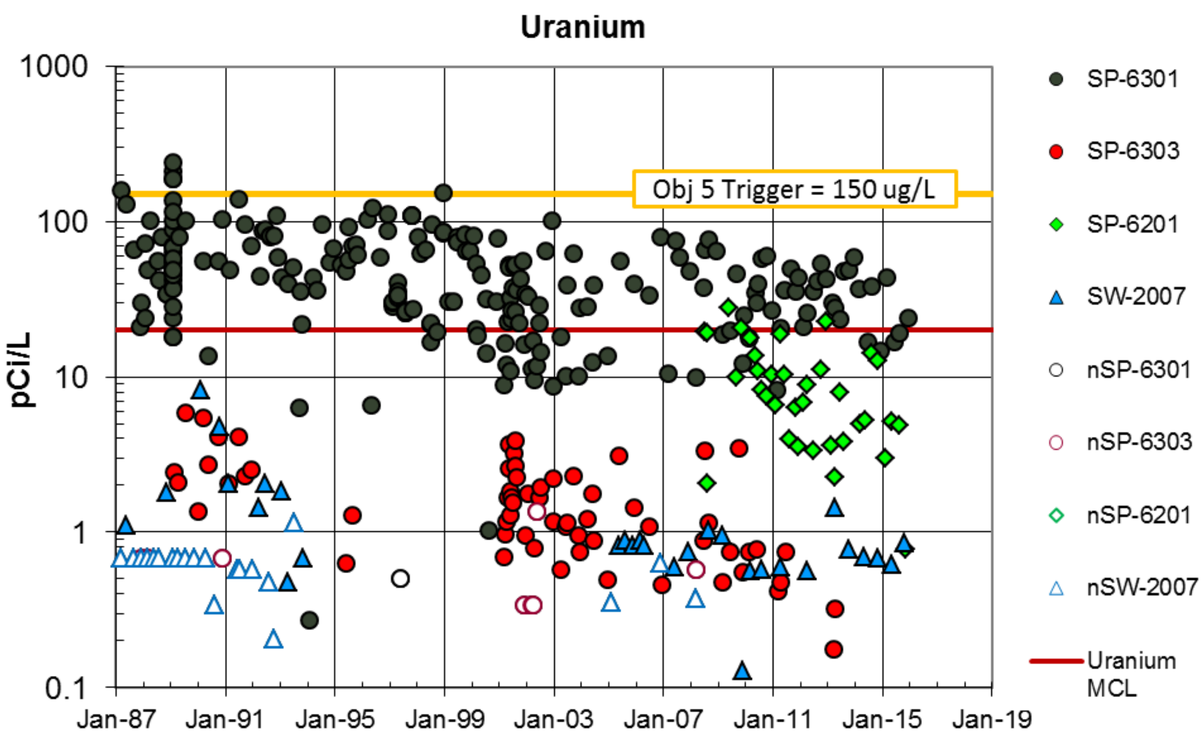

Figure 21. Uranium Levels in Surface Locations North of the former Chemical Plant

The uranium levels in Burgermeister Spring and SP-6303 are not correlated and indicate that the source contribution to SP-6303 is less than the contribution to Burgermeister Spring. The variability of uranium concentrations at Burgermeister Spring appear to be inversely related to the variability that occurs at MW-4036 (Figure 22). As water elevations increase in response to increased rainfall, uranium concentrations at Burgermeister Spring decrease, likely due to increased dilution. Groundwater travel times from the site to Burgermeister Spring are on the order of 2 to 9 days, as determined from dye tracing (DOE 1997a).

Trending of Burgermeister Spring uranium results over 5-year intervals has been problematic due to the variability of results. The period from 2009 through 2014 gives an uptrend. The period from 2010 through 2015 gives no trend. The indicated trend for a 5-year period can be controlled by just a few data points that are influenced by the weather. A longer time frame provides a more reliable trend that can be projected forward (Figure 23). The chart provides linear regression fits, Mann-Kendall trends, and slopes for three time periods. Extrapolating the "order of magnitude every 60 years" line (labeled "OM 60 yrs" on Figure 22) suggests that the highest uranium concentrations seen at Burgermeister Spring could be below the 20 pCi/L MCL in 30 to 40 years.

Uranium impact in the Southeast Drainage is the result of historical discharges to this drainage during plant operation that resulted in contaminated soil and sediment within this drainage. The source of uranium impact in the two springs (SP-5303 and SP-5304) is residually contaminated sediments within the bedrock fracture system. The uranium levels in the two Southeast Drainage springs monitored under this program have been less variable in the past few years (Figure 24), and uranium behaves similarly in both springs. Uranium levels in both springs exceed the MCL but are less than the trigger level of 150 pCi/L. Uranium in MW-4026, a monitoring well downgradient of the two springs, were at very low levels or below detection limits (Figure 24).

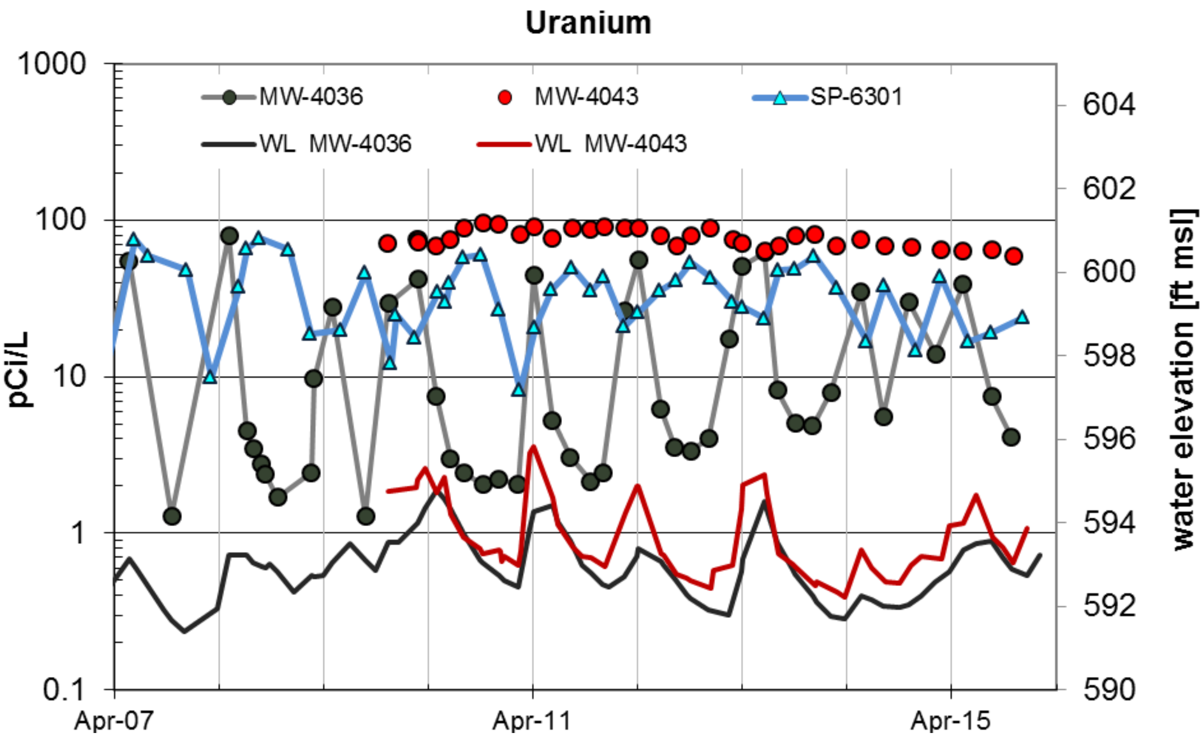

Figure 22. Variable Uranium Levels at Burgermeister Spring (SP-6301)

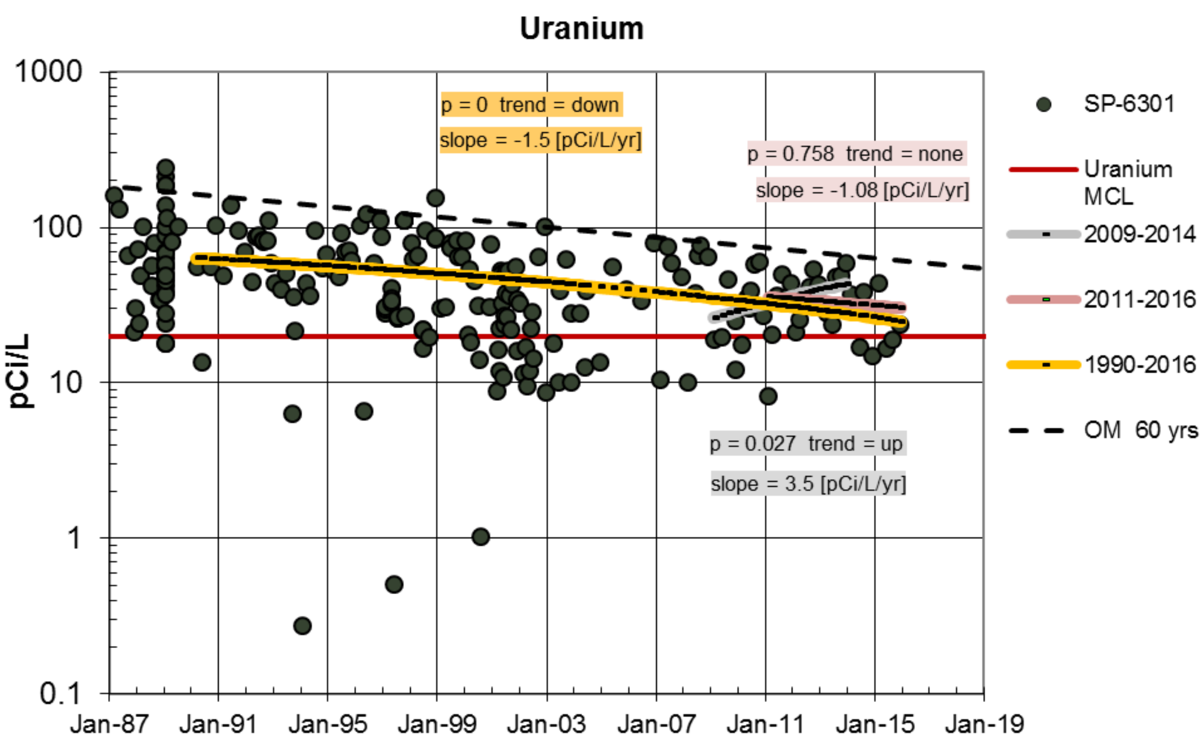

Figure 23. Trending of Uranium Levels at Burgermeister Spring (SP-6301)

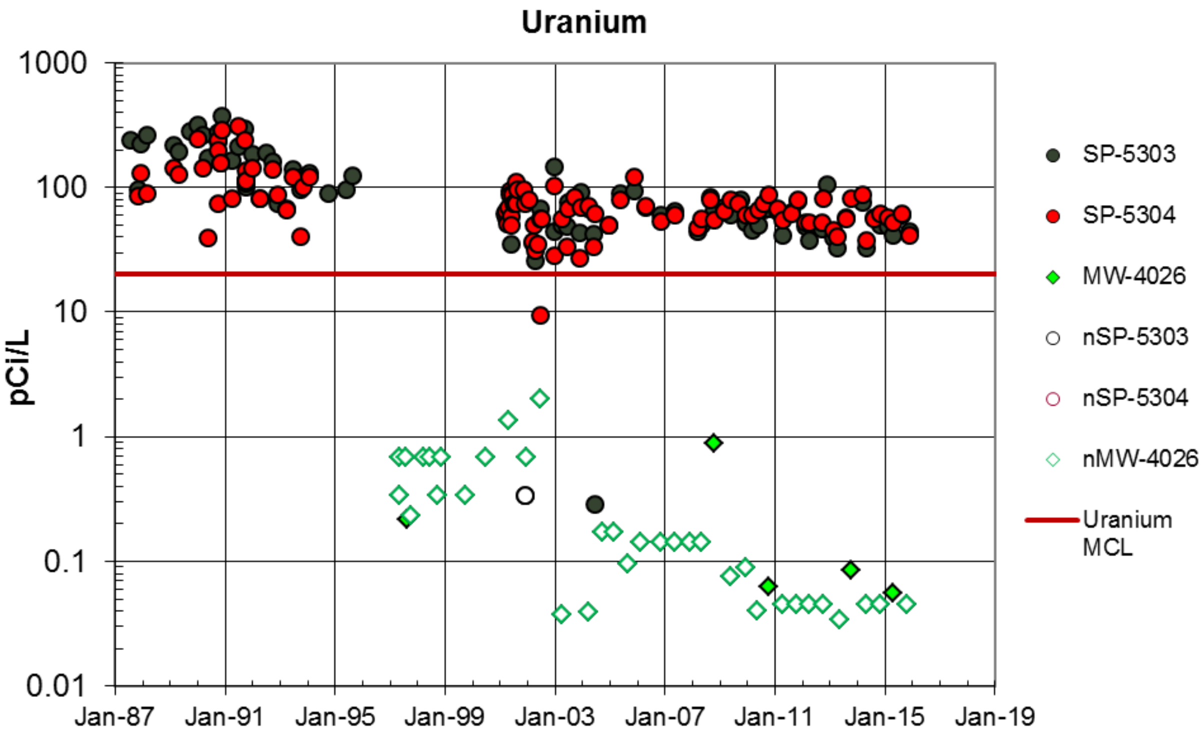

Figure 24. Uranium Levels in Southeast Drainage Springs and MW-4026

Analysis of the data from 2011 through 2015 indicated no statistically significant trends for these two springs. However, the historical data set indicates that uranium levels at SP-5303 and SP-5304 have been decreasing over the long-term (Figure 25).

While uranium levels in the Raffinate Pits area have changed since the implementation of the MNA remedy for uranium, overall, the remedy remains protective. Groundwater flow directions are unchanged in the Raffinate Pits area. Impacted groundwater is contained within the paleochannel in this area and is migrating along the expected pathways. Uranium levels are decreasing in the weathered unit due to dilution and dispersion.

The removal of the Raffinate Pits has decreased infiltration and recharge, thereby reducing the dilution and flushing of unweathered unit groundwater. Increased uranium levels are the result of residual uranium from contaminated materials that were forced deeper into the bedrock by the high hydraulic head in the former Raffinate Pits. The reduced infiltration and the relatively low permeability of the unweathered unit will slow the flushing of impacted groundwater from this unit.

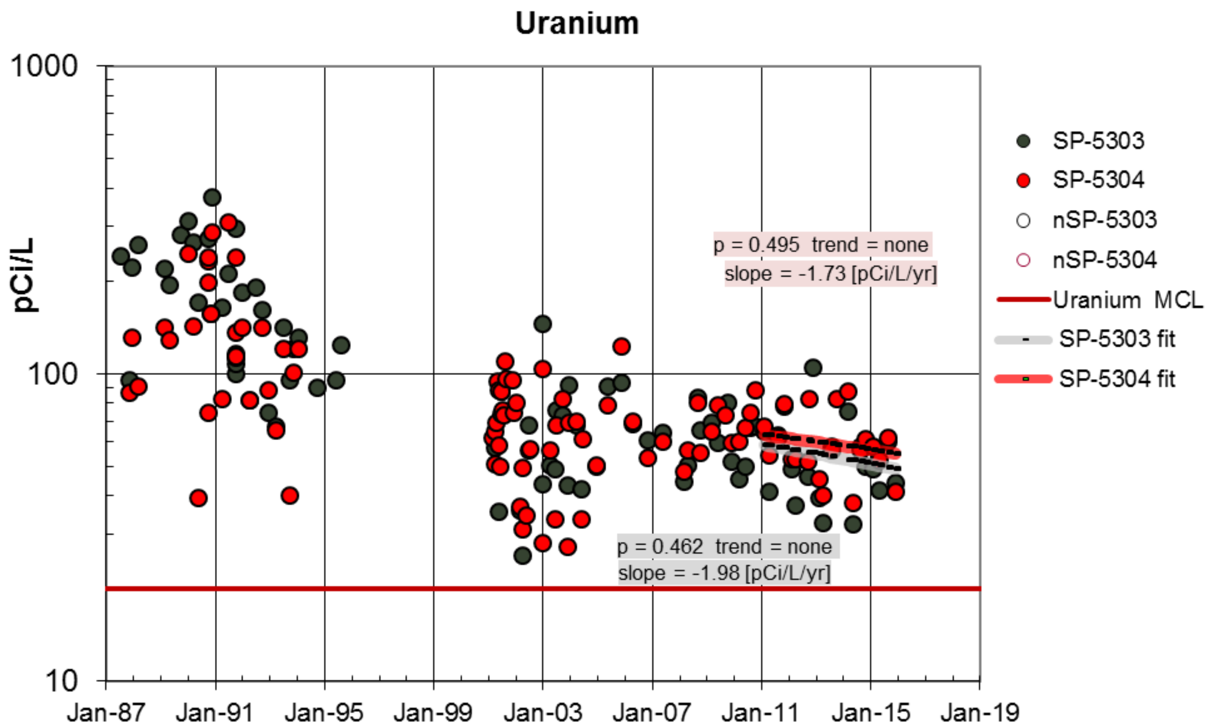

Figure 25. Trending of Uranium in Southeast Drainage Springs

Overall, uranium impact is contained within the upper portion of the shallow aquifer (weathered and upper unweathered units of the Burlington-Keokuk Limestone). Uranium levels in the weathered unit are decreasing as a result of source removal and natural attenuation (dilution and dispersion) and could attain the MCL in the next 10 years if decreases continue at the current rate. However, in areas where upward vertical gradients can seasonally occur, the lower part of the weathered unit will receive contribution from the upper part of the unweathered unit from below. Uranium levels in impacted areas within the less-permeable unweathered unit are increasing due to reduced infiltration to offset desorption of uranium from residual materials that were introduced into this zone by higher hydraulic heads in the former Raffinate Pits. Recharge that does enter the system is more likely to move horizontally through the weathered unit than vertically into the unweathered unit due to greater conductivity in the horizontal direction and the lack of a vertical driving force to move the groundwater downward as was previously exerted by water in the Raffinate Pits.

Uranium Distribution Overview

The 2011 review of the uranium distribution indicated two areas of uranium impact—one associated with former Raffinate Pit 4 and to the west, and another east of former Raffinate Pit 3. The uranium associated with former Raffinate Pit 3 is restricted to wells MW-3040 and MW-3024, both screened in the unweathered unit at essentially the same location, immediately east of the former pit. The top of the 20 ft long screened interval in MW-3024 is in the upper part of the unweathered unit near the weathered/unweathered unit interface. Well MW-3040 was installed in 2004 to isolate the lower 10 ft portion of this interval to limit contribution from the overlying weathered unit. This source location is not within a preferential flow zone (paleochannel), thereby limiting downgradient uranium migration.

The area of uranium impact associated with former Raffinate Pit 4 and the uranium to the west of Pit 4 is present in both the weathered and unweathered units. This source is located over a preferential flow zone (the western paleochannel) that permits uranium migration downgradient to the north. Unweathered unit well MW-4040 has the highest uranium concentration at the former Chemical Plant with a 2012 to 2015 average of 344 pCi/L. Downgradient, 550 ft to the northwest at well MW-4043, unweathered unit uranium concentrations decrease to 72 pCi/L. Another 1000 ft downgradient to the north, concentrations decrease to background levels at well MWD-2 (<1 pCi/L). Results from well MW-4043 (installed 2009) were not included with the 2011 uranium distribution map. With the addition of the MW-4043 results, the 2015 unweathered unit uranium distribution was extended to beyond well MW-4043 (Figure 26). The decreasing uranium concentrations at MW-4043 (Figure 19) suggest that the uranium distribution may be contracting. It appears to be decreasing at the same rate as spring SP-6301 (Figure 23) and could reach the MCL in about 30 years based on the limited 6-year data set.

Recent results from unweathered unit well MW-3026 (2012 to 2015 average of 47 pCi/L) necessitate expanding the unweathered unit uranium distribution to the south. Sampling of this well was suspended after 15 years of declining uranium concentrations that had reached background levels in 2004. Sampling was resumed in 2014 because MW-3026 is about the same distance west of Raffinate Pit 4 as high-concentration well MW-4040, which is 400 ft to the north. Even though MW-3026 is currently upgradient, mounding beneath the former Raffinate Pits would have pushed contamination both down and then outward away from the mounding, locally overwhelming the natural hydraulic gradient. The uranium concentration in MW-3026 is apparently increasing (Figure 26), but the recent data set is insufficient for trending to be statistically significant.

MW-3030 is located within the footprint of former Raffinate Pit 4 and is screened in the weathered unit. Uranium concentrations have been steadily decreasing in this well (3-year average of 27 pCi/L) and may reach the uranium MCL in the next 10 years (Figure 16). About 800 ft downgradient, 2012 to 2015 average uranium concentrations in weathered unit well MW-4036 are 20 pCi/L, an increase from the 2010 average of 15.8 pCi/L. The weathered unit distribution (20 pCi/L contour) was extended to the MW-4036 location. The apparent increase at MW-4036 is an artifact of the time periods that were averaged (2010 data versus 2012 to 2015 data) and the variability of uranium concentrations in this well, not an expanding uranium distribution.

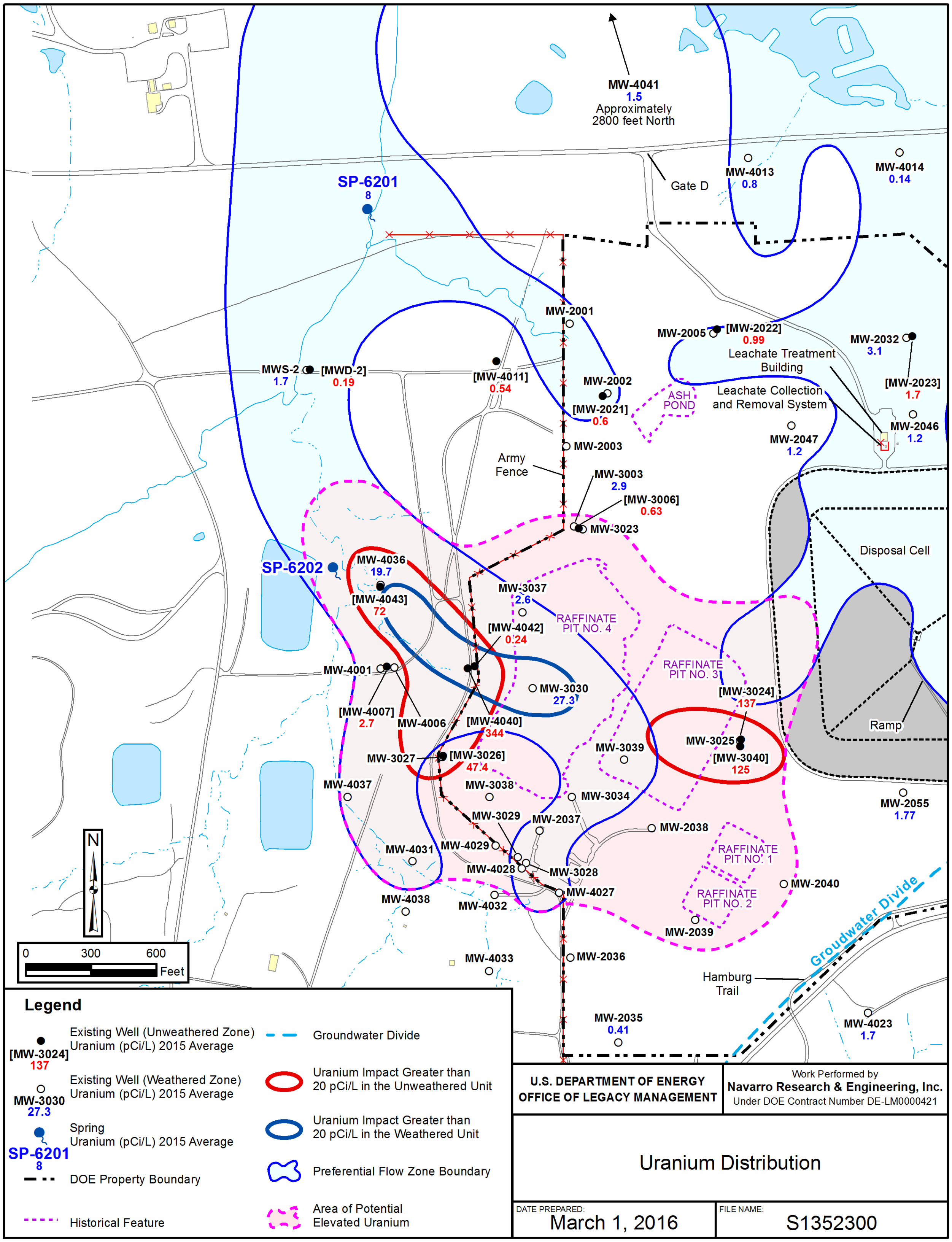

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Figure 26. Uranium Distribution in the Weathered and Unweathered Units
Average Uranium from 10/1/2012 to 10/1/2015

GWOU Special Study (2012 to 2014)—Unweathered Unit Uranium Monitoring Network

The uranium levels in the unweathered unit were evaluated from February 2012 through February 2014 in response to the three impacted area wells in which uranium concentration consistently exceed the fixed trigger level of 100 pCi/L for impacted areas and are trending upward (Figure 17). Sampling frequencies of monitoring network wells were determined to be adequate to detect any significant changes. After the study, it was decided to expand the network to include the 15 wells screened in the unweathered unit, advantageously located weathered unit wells, and 3 downgradient springs in the unweathered unit uranium monitoring network (Table 24). The inclusion of historically low concentration downgradient wells enhances the monitoring network to detect potential future migration. The inclusion of spring SP-6201 provides a downgradient location with slightly elevated but decreasing uranium concentrations (Figure 21). Past and future uranium concentrations for unweathered unit wells (Figure 17), weathered unit wells (Figure 16), and surface locations (Figure 21) in the unweathered unit uranium monitoring network will document the progression of the MNA remedy.

Nitrate GWOU Performance Monitoring Results

The highest concentrations of nitrate have been measured in the former Raffinate Pits area (Figure 27). Elevated nitrate concentrations are also present in the former Ash Pond area. Both are historical sources of this contaminant. The higher mobility of nitrate, as compared to other contaminants at the site, has resulted in a larger distribution of this contaminant in the shallow aquifer. Nitrate levels exceed the MCL of 10 mg/L (for nitrate as N) in all of the Objective 2 wells in both the weathered and unweathered units of the Burlington-Keokuk Limestone. A summary of the nitrate data for the period from 2011 through 2015 is presented in Table 25.

Nitrate concentrations are highest in the weathered unit of the Burlington-Keokuk Limestone in the former Raffinate Pits area (Figure 28). Wells MW-2038, MW-3003, MW-4029, MW-3034, and MW-4031 are all currently above 100 mg/L but below the 1350 mg/L trigger value. Wells MW-4013, MW-2040, and MW-4036 are below 100 mg/L but above the 10 mg/L cleanup standard (Figure 29).

Recent data indicate that concentrations are decreasing in the higher-concentration weathered unit wells, with statistically significant decreases in MW-4029 and MW-4031. Concentrations are relatively stable in the lower-concentration weathered unit wells with the exception of MW-4036. Nitrate concentrations vary up to an order of magnitude at MW-4036 with no discernable trend. Well MW-4036 is located within the preferential flow path that extends north from Raffinate Pit 4. Its variability is not due to contribution from the unweathered unit, as was the case for uranium, because unweathered unit well MW-4043 has a low and decreasing nitrate concentration (Figure 30). Variability in MW-4036 appears to be more related to dilution, in that concentrations are lower when water levels are high.

Nitrate concentrations in the unweathered unit (Figure 31) exceed the MCL only in the Raffinate Pits area. Nitrate concentrations in well MW-4040 (located near Raffinate Pit 4) have been relatively stable with no observable trend since it was installed. Nitrate in well MW-3040 has had a consistent decreasing trend over the long term and the past 5 years. Nitrate concentrations at this well could reach the 10 mg/L MCL in the next 15 years. Well MW-3024, located adjacent to MW-3040, is screened over the same 10 ft interval plus an additional 10 ft higher (20 ft screened interval, nearer the weathered unit). Nitrate in MW-3024 has a decreasing trend, but at a lower rate that will likely take at least 50 years to reach the 10 mg/L MCL.

Table 24. Unweathered Unit Uranium Monitoring Network Locations

Location	Objective	Unit	Average Uranium[b] 2012–2014 (pCi/L)	Recommended Frequency (samples/yr)
MW-4040	2	Unweathered	338 (14)	4
MW-3026[a]	2	Unweathered	36.8 (1)	4
MW-3040	2	Unweathered	119 (13)	4
MW-3024	2	Unweathered	132 (13)	4
MW-3003	2	Weathered[c]	2.9 (10)	4
MW-3006	2	Unweathered	0.57 (12)	4
MW-4042	4	Unweathered	0.24 (12)	4
MW-4043	3	Unweathered	76.7 (13)	4
MW-4036[a]	3	Weathered	19.6 (13)	4
MWS-2	3	Weathered	1.6 (12)	4
MWD-2	3	Unweathered	0.19 (12)	4
MW-4007	3	Unweathered	2.5 (12)	4
MW-4011[a]	3	Unweathered	0.53 (1)	2
MW-4041	3	Weathered	1.5 (12)	4
MW-2021[a]	3	Unweathered	0.53 (1)	2
MW-2022[a]	3	Unweathered	1.0 (1)	2
MW-2023[a]	3	Unweathered	NS	2
MW-2032[a]	3	Weathered	2.0 (4)	2
MW-2056[a]	3	Unweathered	NS	2 (for 2 yrs then decrease)
MW-4022[a]	1	Unweathered	2.7 (2)	1
MW-4013[a]	3	Weathered	NS	2 (for 2 yrs then decrease)
MW-4014[a]	3	Weathered	NS	2 (for 2 yrs then decrease)
SP-6201	5	Spring	7.5 (10)	4
SP-6301	5	Spring	37.8 (13)	4
SP-6303[a]	5	Spring	0.25 (2)	4

Notes:
[a] Wells and spring to be added to the unweathered unit monitoring network.
[b] Number in parentheses is number of samples used to calculate the average.
[c] MW-3003 is screened across the weathered/unweathered unit interface.

Objective 1 = upgradient locations.
Objective 2 = area of groundwater impact.
Objective 3 = downgradient and lateral locations.
Objective 4 = locations beneath the area of groundwater impact.
Objective 5 = springs or surface water locations.

Abbreviation:
NS = not sampled

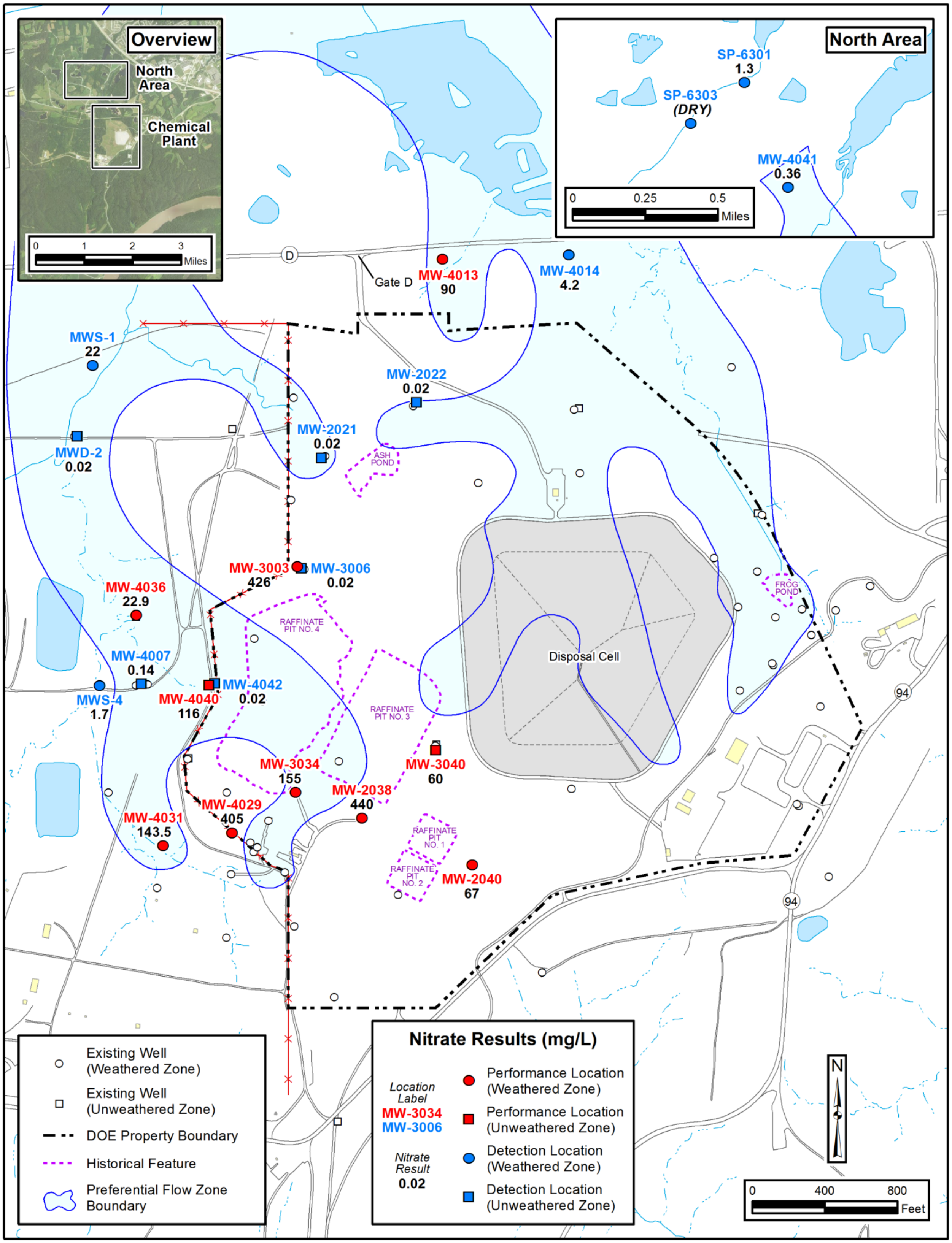

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Figure 27. Nitrate Monitoring Locations with 2015 Average Concentrations

Table 25. Average Nitrate from GWOU Performance Monitoring Wells

Location	Nitrate Concentration (mg/L)				
	2011	2012	2013	2014	2015
Weathered Unit					
MW-2038	485	460	550	450	440
MW-3003	466	449	372	457	426
MW-4029	449	440	400	410	405
MW-3034	195	184	173	165	155
MW-4031	191	160	160	149	144
MW-4013	96	76	108	85	90
MW-2040	89	82	87	86	67
MW-4036	33	45	31	18.3	23
Unweathered Unit					
MW-3040	116	89	78	65	60
MW-4040	119	113	107	120	116

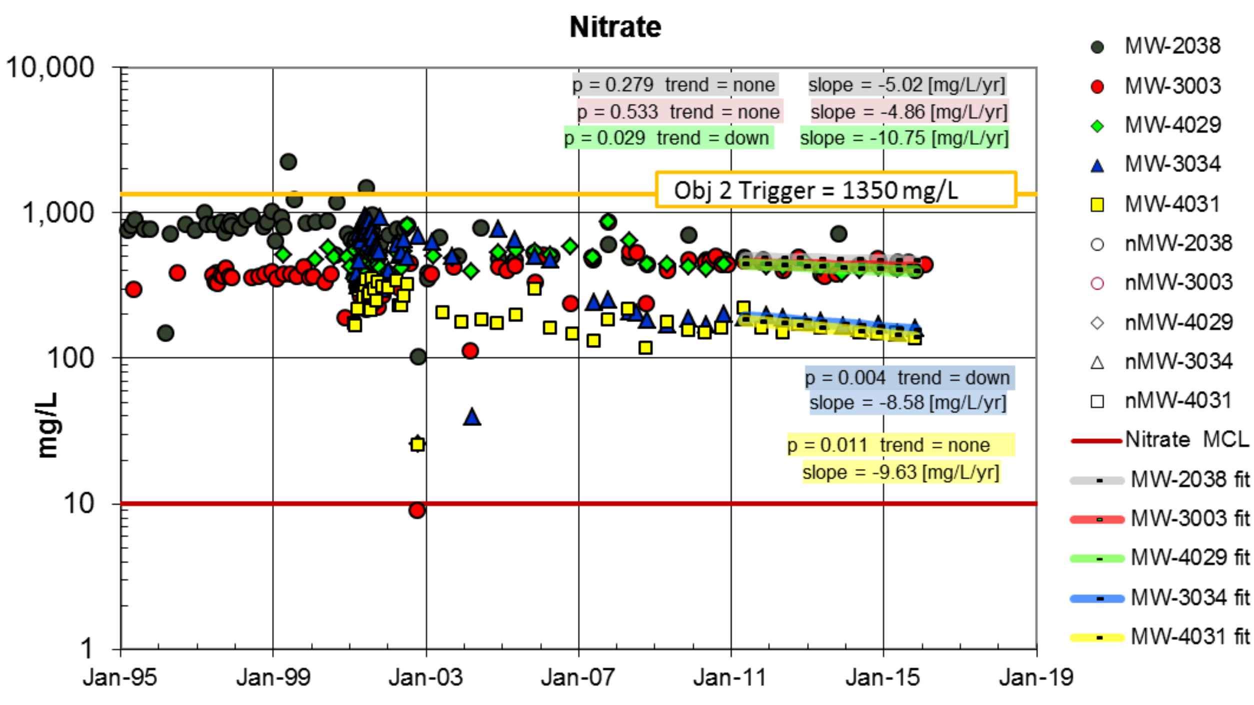

Figure 28. Nitrate Concentrations in Performance Monitoring Wells—Weathered Unit (Higher Concentration Wells)

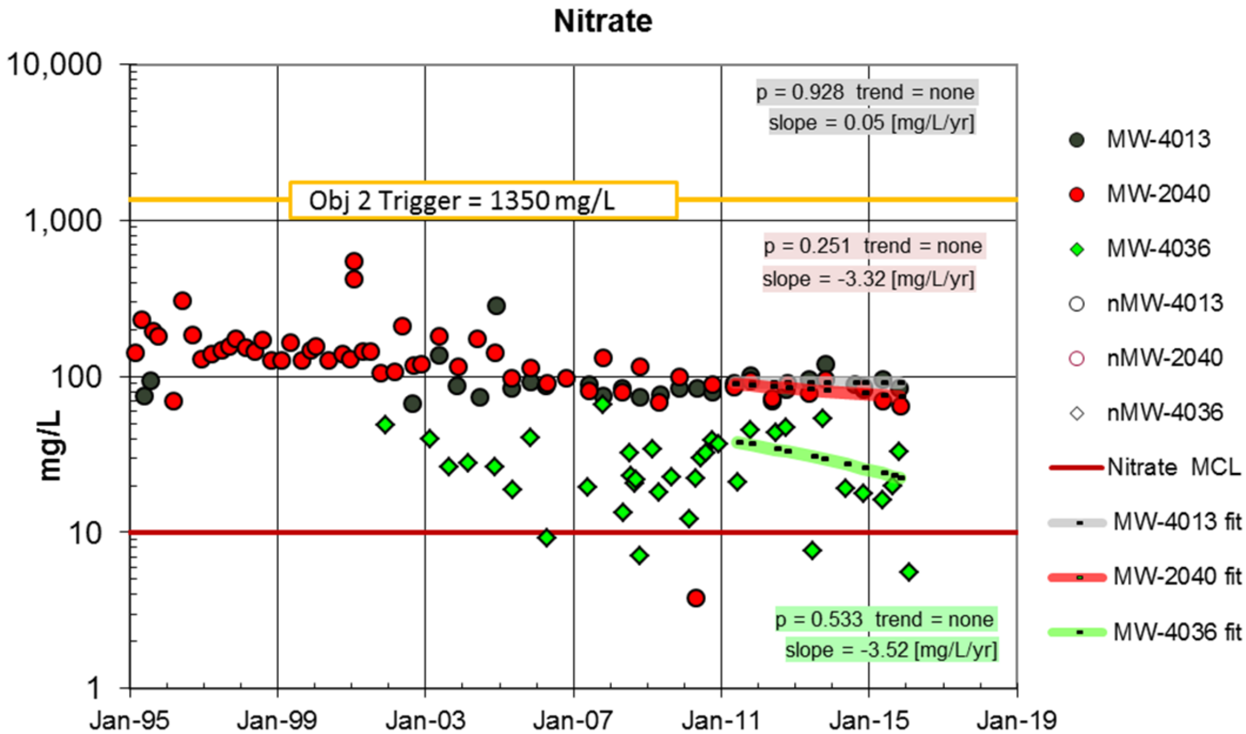

Figure 29. Nitrate Concentrations in Performance Monitoring Wells—Weathered Unit (Lower Concentration Wells)

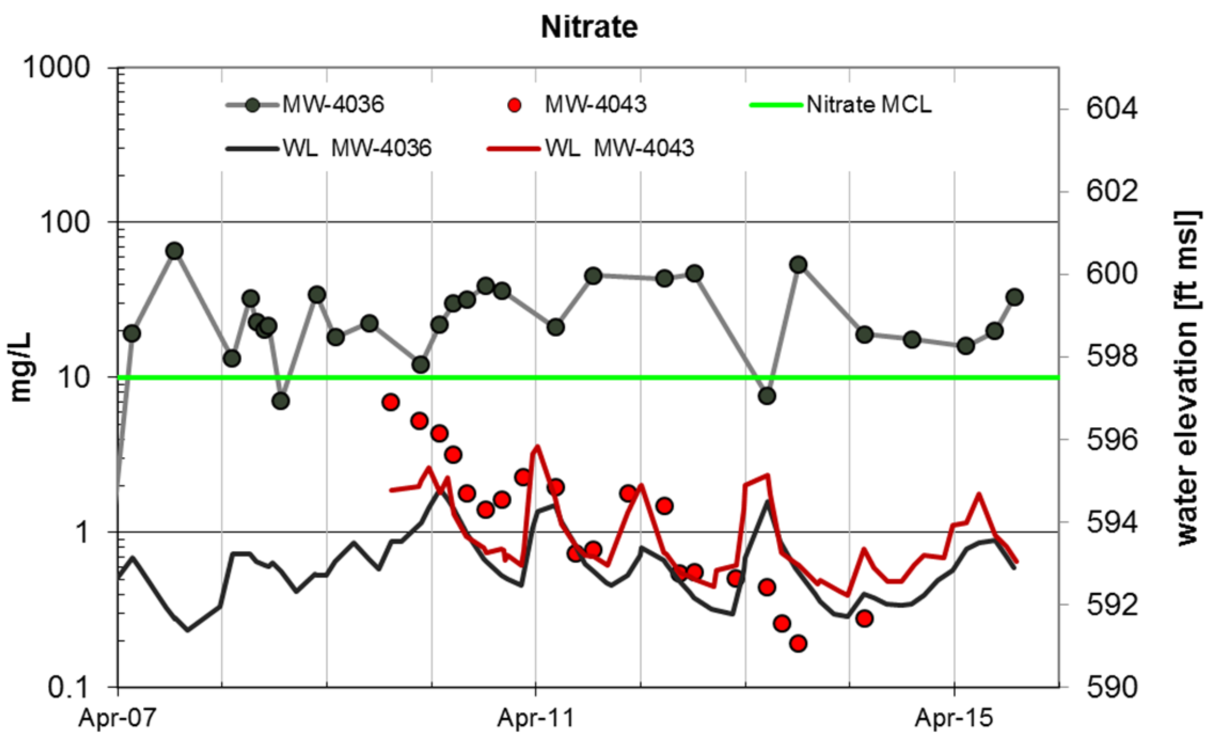

Figure 30. Variable Nitrate Concentrations in MW-4036

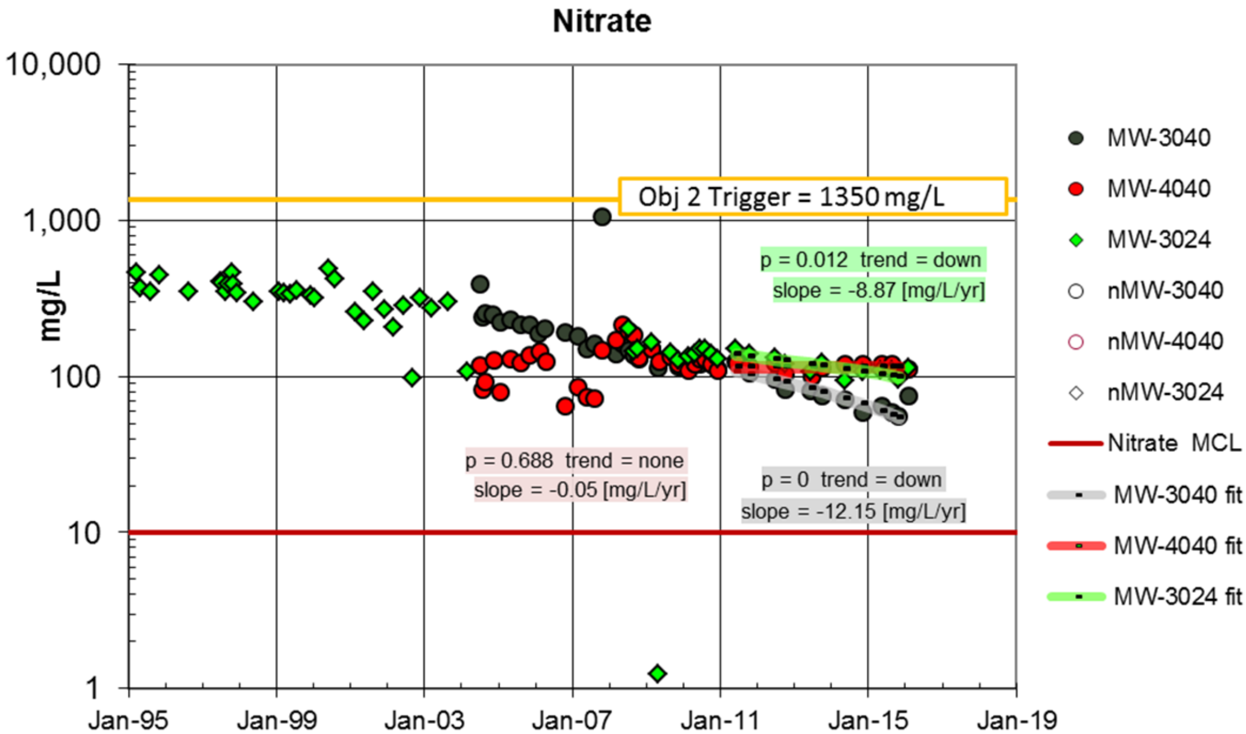

Figure 31. Nitrate Concentrations in Performance Monitoring Wells—Unweathered Unit

Overall, nitrate impact is contained within the upper portion of the shallow aquifer (weathered and upper unweathered units of the Burlington-Keokuk Limestone). Nitrate concentrations in the weathered and unweathered units are decreasing except along the leading edge of the area of impact in the weathered unit. Some locations were expected to show temporary upward trends due to ongoing dispersion; however, concentrations are not expected to exceed historical maximums seen within the areas of highest impact. The higher mobility of nitrate, as compared to other contaminants at the site, has resulted in quicker flushing of this contaminant from the aquifer system.

Nitrate GWOU Detection Monitoring Results

Results at nitrate detection monitoring locations (Table 26) indicate that nitrate migration from the area of impact is behaving as expected. Migration has been restricted to the weathered unit with only well MWS-1 exceeding the 10 mg/L MCL (Figure 32). Average concentrations of nitrate in well MWS-1 have exceeded the MCL since 2005 and have been steadily increasing. Trending of data since 2004 (there are an insufficient number of samples in the last 5 years for trending) indicate a persistent long-term uptrend. For comparison, uranium levels have remained steady at MWS-1, typically less than 1 pCi/L. Nitrate levels at far downgradient well MW-4041 have a slight increasing trend over the last 10 years, but concentrations at this well are so low, always less than 1 mg/L, that the rate of increase is currently of no concern. Nitrate is below detection in unweathered unit detection monitoring wells except for low level detections in MW-4007 and MW-4042 (Figure 33).

Table 26. Nitrate Detection Monitoring Locations for the GWOU

Location	Detection Monitoring Areas
Weathered Unit	
MW-4014	Fringe
MW-4041	Downgradient
MWS-1	Downgradient
MWS-4	Downgradient
Unweathered Unit	
MW-2021	Vertical Extent
MW-2022	Vertical Extent
MW-3006	Fringe
MW-4007	Downgradient
MW-4042	Downgradient
MWD-2	Downgradient
Springs and Surface Water	
SP-6301	Burgermeister Spring
SP-6303	Burgermeister Spring Branch

The nitrate concentrations in Burgermeister Spring ranged from 0.4 to 5.4 mg/L from 2011 through 2015—less than the MCL of 10 mg/L. All nitrate concentrations in Burgermeister Spring have been less than the MCL since 2003 (Figure 34). Nitrate concentrations in SP-6303, dry since 2013, typically track those of Burgermeister Spring when flowing.

Trend analysis of Burgermeister Spring (SP-6301) results indicates that nitrate concentrations are continuing to decrease (Figure 34). Analysis of the data collected from 2011 through 2015 indicated no statistically significant trend (because concentrations vary by about an order of magnitude), though visual inspection of data since 1987 indicates a long-term down trend.

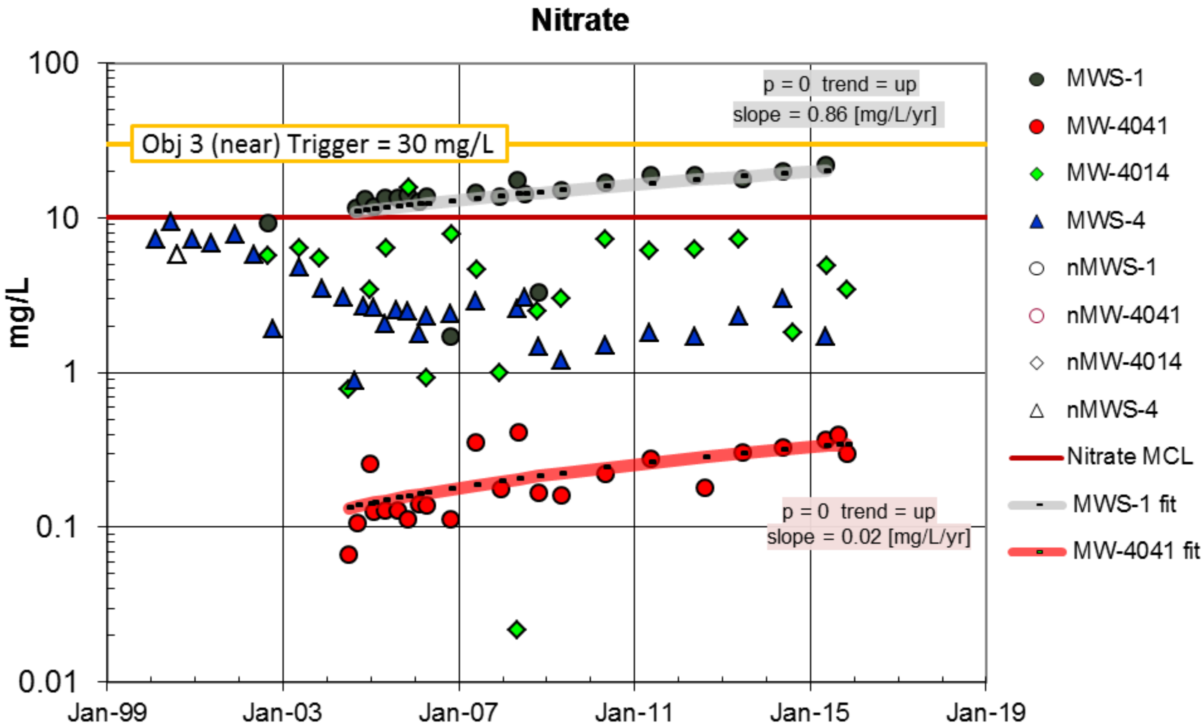

Figure 32. Nitrate Concentrations in Detection Monitoring Wells—Weathered Unit

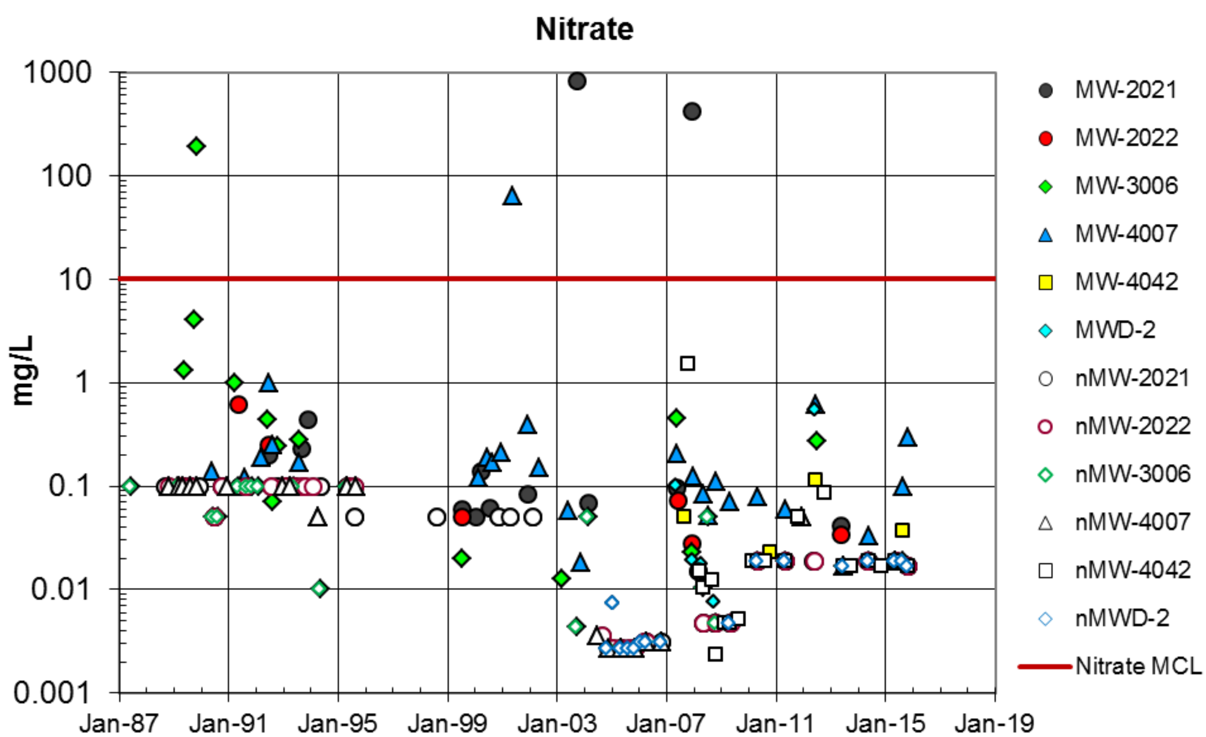

Figure 33. Nitrate Concentrations in Detection Monitoring Wells—Unweathered Unit

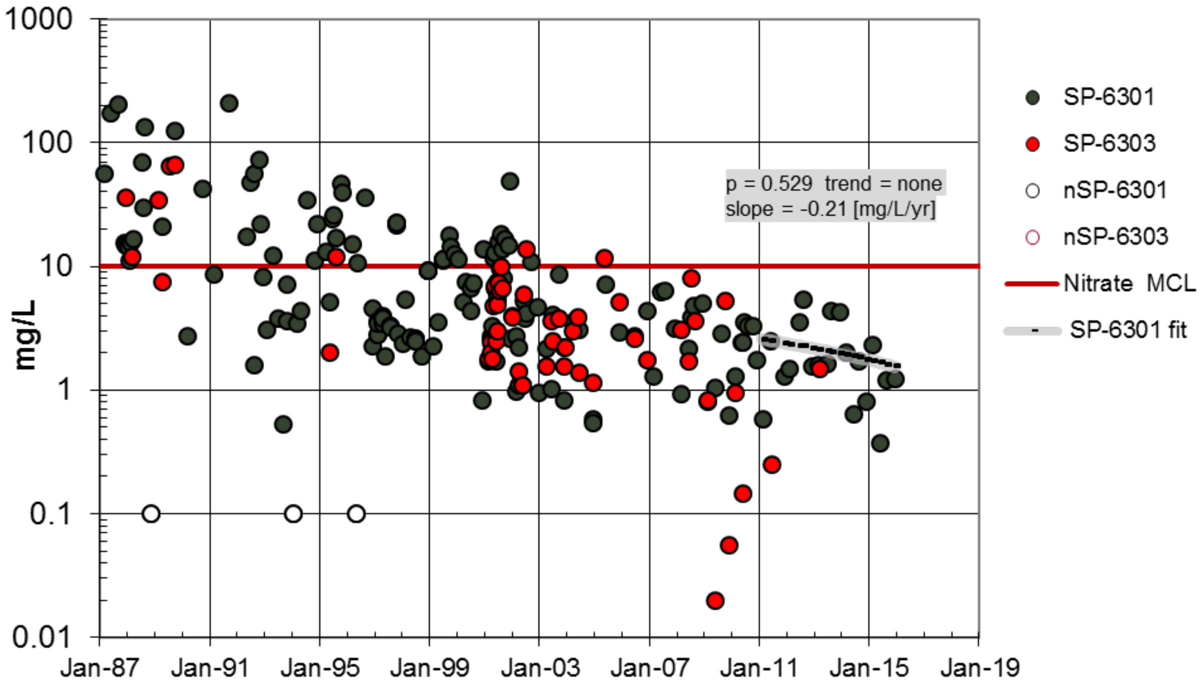

Figure 34. Nitrate Concentrations in Burgermeister Spring and SP-6303

Trichloroethene (TCE) GWOU Performance Monitoring Results

TCE contamination in the shallow groundwater is located in the vicinity of former Raffinate Pit 4, where drums containing TCE are suspected to have been discarded. TCE impact is detected only in the weathered unit of the Burlington-Keokuk Limestone. Table 27 presents a summary of the TCE data for the period from 2011 through 2015, and Figure 35 shows 2015 averages.

Table 27. Average TCE Concentrations from GWOU Performance Monitoring Wells

Location	TCE Concentration (µg/L)				
	2011	2012	2013	2014	2015
MW-3030	249	199	214	185	185
MW-3034	153	134	118	105	320
MW-4029	320	284	291	315	315

TCE impact is highest in MW-4029, along a preferential flow pathway in the area. The TCE concentrations in MW-3030 and MW-3034 (Figure 36) have varied over time (Figure 36); however, some changes are a result of rebound from field studies performed in 2001 and 2002. Data from recent years indicate decreases in TCE concentrations in these three wells.

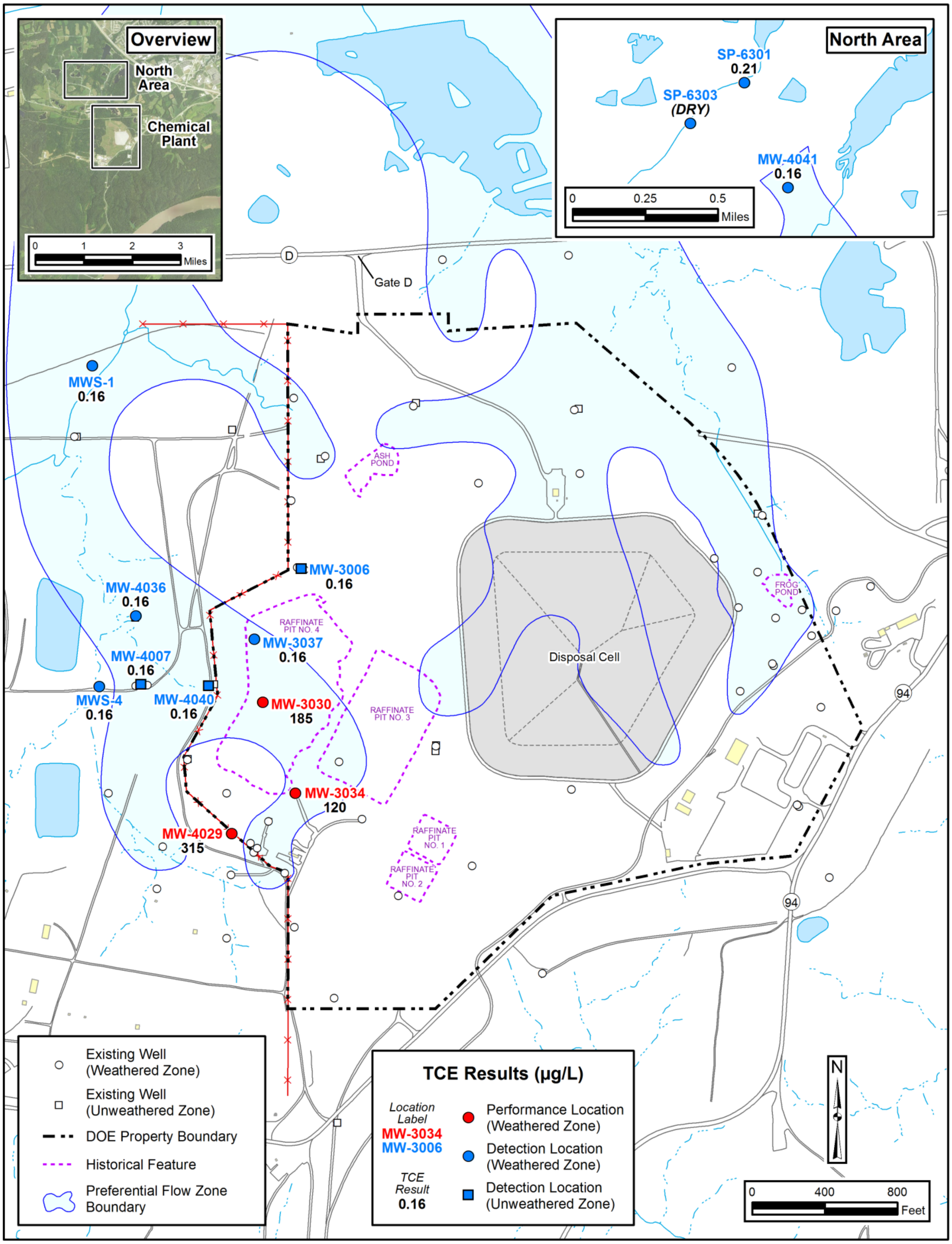

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Figure 35. TCE Monitoring Locations with 2015 Average Concentrations

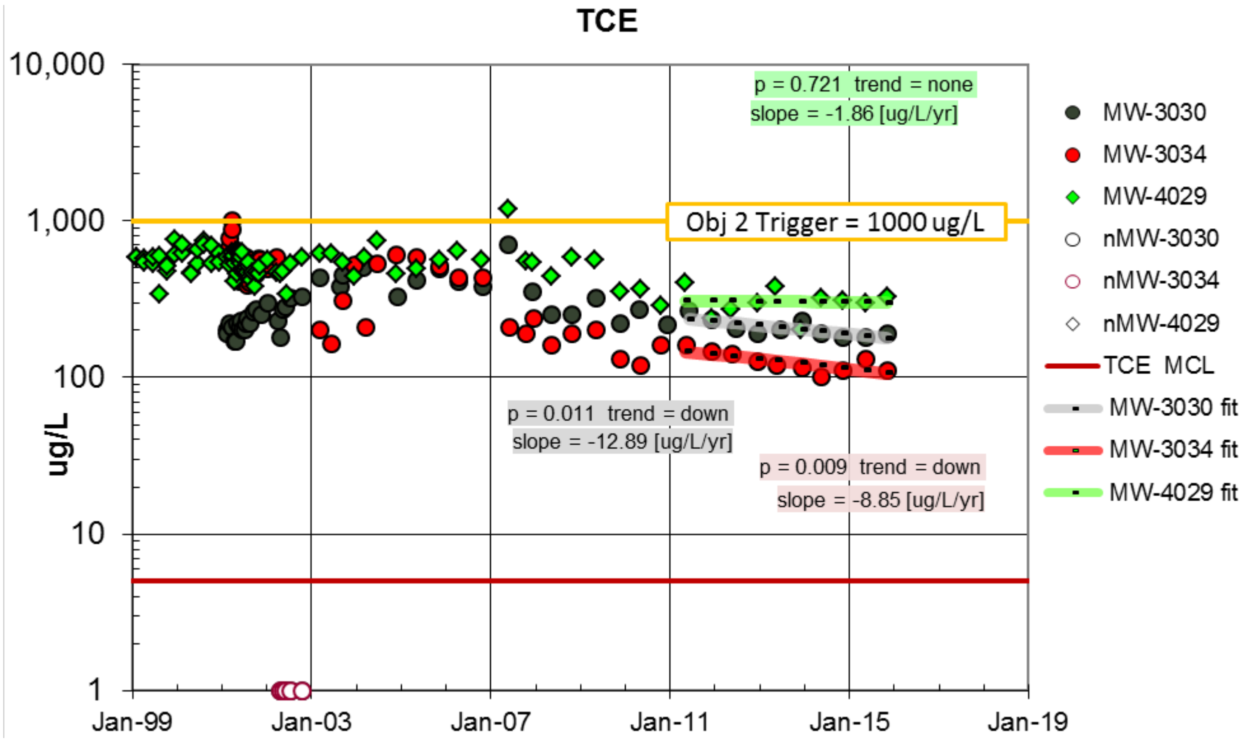


Figure 36. TCE Concentrations in Performance Monitoring Wells

Concentrations of TCE in all of the Objective 2 wells continue to exceed the 5 µg/L cleanup standard.

Results of the trend analysis indicate that TCE concentrations in groundwater are decreasing. Down trends were calculated for MW-3030 and MW-3034 using data from 2011 through 2015. TCE concentrations are trending down for all three wells using a longer dataset.

Low levels of the TCE degradation product *cis*-1,2-dichloroethene (DCE) was measured in the three Objective 2 wells with concentrations significantly less than the 70 µg/L MCL (Figure 37). Results of *trans*-1,2-DCE were all less than 1 µg/L and either reported as estimated or nondetect values in the three Objective 2 wells. No detectable concentrations of vinyl chloride were reported in any of the Objective 2 wells. The geochemistry of the groundwater at the former Chemical Plant is oxidizing; therefore, reductive dechlorination of TCE is limited. Dilution and dispersion are the primary attenuation mechanisms for TCE in groundwater.

Overall, TCE impact is confined to a discrete area of the Chemical Plant site and is limited to the weathered unit of the Burlington-Keokuk Limestone. TCE concentrations in the weathered unit are slowly decreasing in the area of impact.

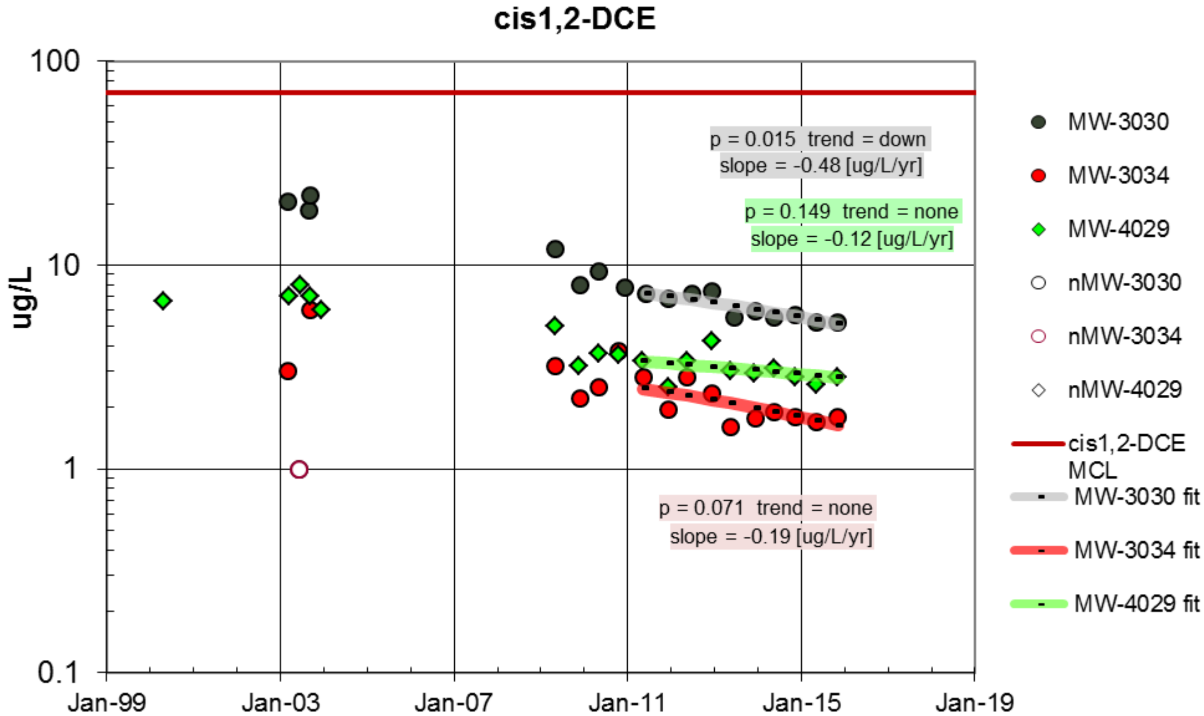
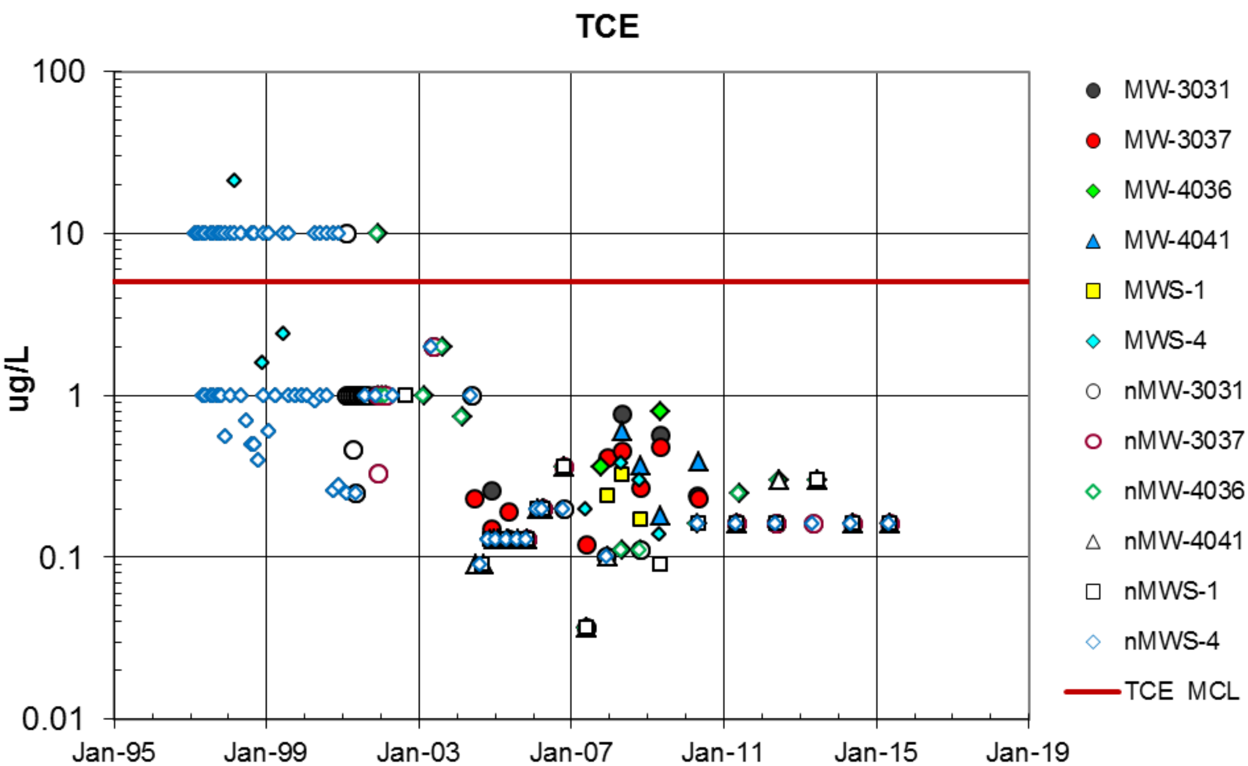


Figure 37. cis-1,2-DCE Concentrations in Performance Monitoring Wells

Trichloroethene GWOU Detection Monitoring Results

No detections or estimated values of TCE were reported in the detection monitoring wells (weathered unit, Figure 38; unweathered unit, Figure 39) or at Burgermeister Spring from 2011 through 2015. One estimated value of 0.71 µg/L was reported for the June 2011 sample from SP-6303, which has been dry since mid-2013. The data from the past 5 years indicate that the area of TCE impact has not expanded, either laterally or vertically. No detectable concentrations of the degradation products *cis*-1,2-DCE, *trans*-1,2-DCE, or vinyl chloride were reported at any of the detection monitoring locations.



Note: MW-3031 was decommissioned July 13, 2013

Figure 38. TCE Concentrations in Detection Monitoring Wells—Weathered Unit

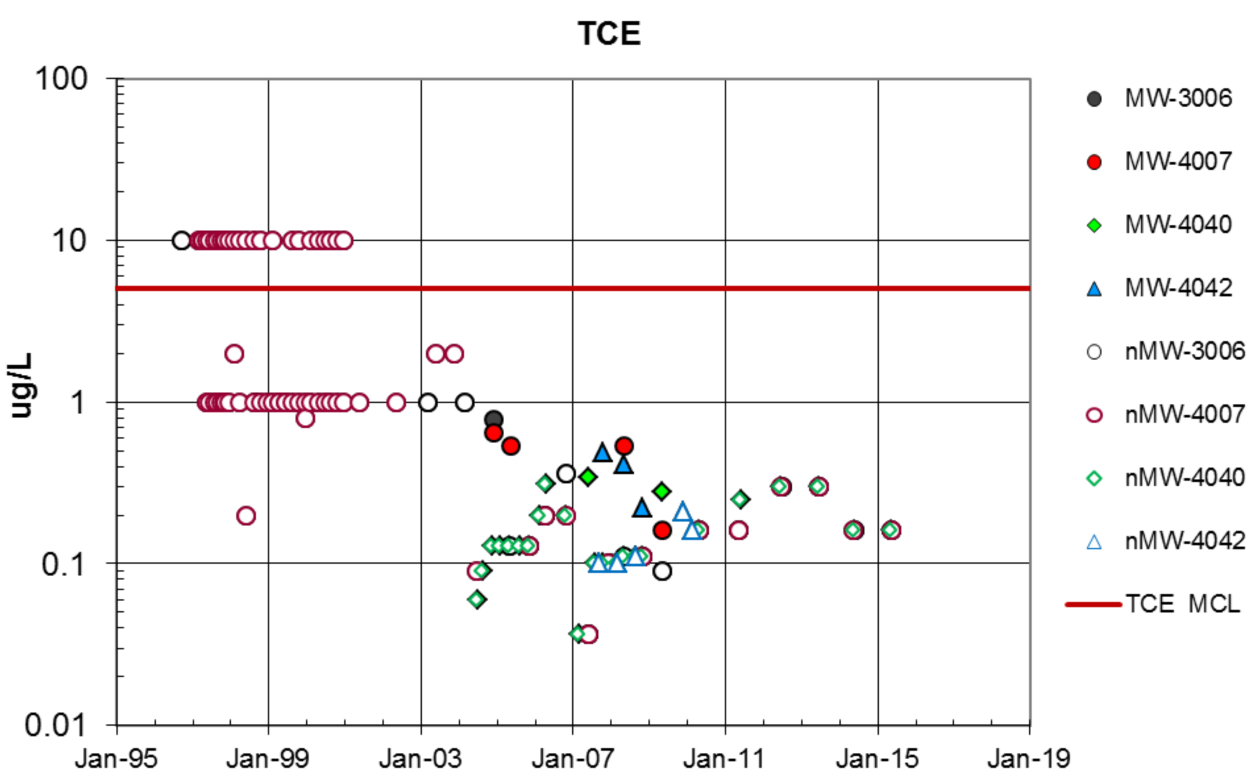


Figure 39. TCE Concentrations in Detection Monitoring Wells—Unweathered Unit

Nitroaromatic Compounds GWOU Performance Monitoring Results

Former Frog Pond Area

The former Frog Pond area is the most significant area of nitroaromatic compound impact for groundwater at the site and is limited to the weathered unit of the Burlington-Keokuk Limestone. Groundwater in this area has historically had concentrations above the cleanup standards for 1,3-DNT; 2,4,6-TNT; 2,4-DNT; 2,6-DNT; and nitrobenzene (NB). Concentrations of nitroaromatic compounds increased in this area starting in 1997. More recent data from several performance monitoring wells indicate that concentrations of some compounds have decreased to below cleanup standards.

The distribution of nitroaromatic compounds suggests that the primary source areas are Production Line 1 which was related to the former Army operations, most notably the Wash Houses (T-13) and the Wastewater Settling Tanks (T-16). Some contribution to the nitroaromatic contamination originates from former Army Lagoon 1. The preferential flow path in the vicinity of the former Frog Pond has been identified from the bedrock topography, and the contaminant distribution is controlled somewhat by topography. Nitroaromatic compound impact in the former Frog Pond area is isolated to the Burlington-Keokuk Limestone weathered unit.

Nitroaromatic compound concentrations, primarily the DNTs, have continued to be variable in the former Frog Pond area. Starting in 1997, increases in concentrations were reported, and concentrations increased dramatically during and after the completion of soil excavation in this area and remedial activities performed by the U.S. Army Corps of Engineers in nearby Army Lagoon 1. Also during this time frame, groundwater elevations steadily decreased, likely in response to the removal of Frog Pond and redirection of surface water runoff, both of which reduced the amount of infiltration into the groundwater system. Nitroaromatic compound concentrations in several wells in this area dramatically decreased in 2004.

Since 2007, DNT concentrations in MW-2012 have varied by 2 to 3 orders of magnitude. The suspected cause was the infiltration of surface water runoff into the groundwater system through a subsidence feature that formed near MW-2012. The continued influence of surface water infiltration is indicated by the fluctuation of groundwater elevations in several Objective 2 wells near the preferential flow pathway in the area (Figure 40). Large fluctuations in groundwater elevations occurred historically when Frog Pond and surface water drainage features were present. In recent years, groundwater elevations and seasonal variability have generally increased in wells along the preferential pathway, most notably in MW-2012 and MW-2052. This increase is likely attributed to surface water contribution in a natural drainage channel that is beginning to establish in this area.

The “MCL” line on the data charts for 1,3-DNB and 2,4-DNT are ROD Cleanup Standards based on Missouri Water Quality Standards. The “MCL” line on the data charts for 2,6-DNT and 2,4,6-TNT are risk based ROD Cleanup Standards. The citations for the ROD Cleanup Standards are provided in Table 54 in Section 7.2.7.

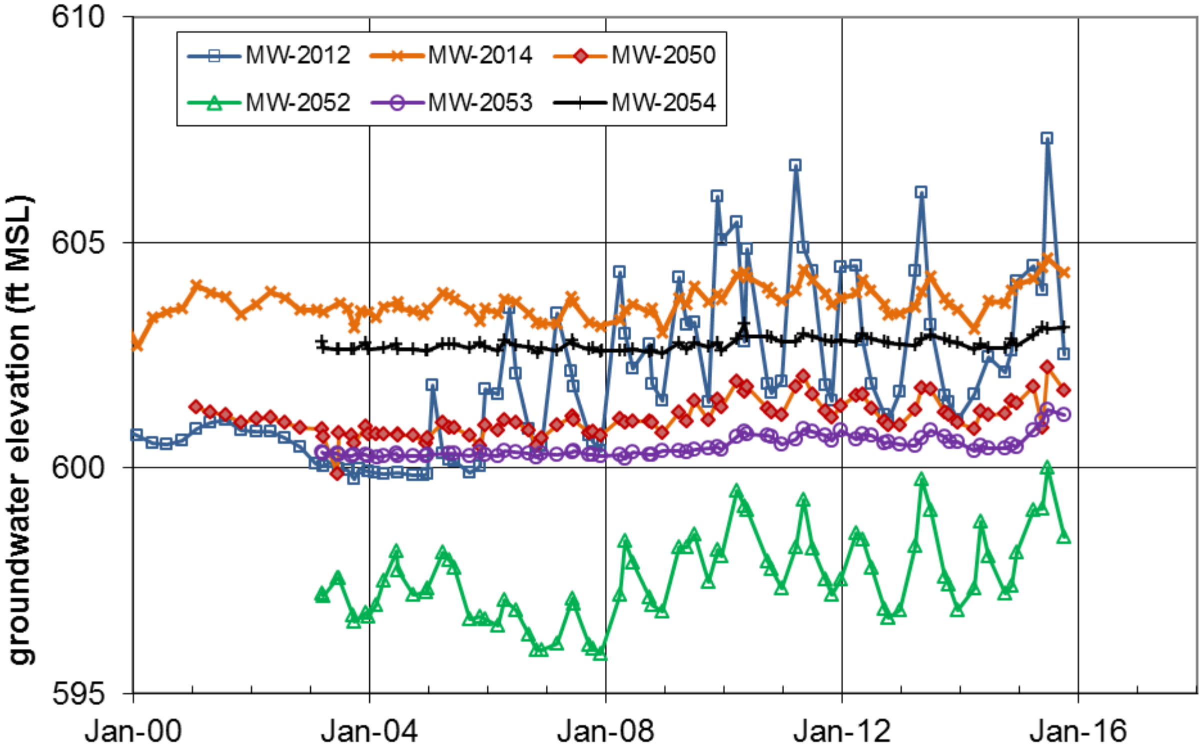


Figure 40. Groundwater Elevations in Frog Pond Area Monitoring Wells

1,3-DNB

Performance monitoring concentrations of 1,3-DNB in well MW-2012 were above the 1 µg/L cleanup standard from late 2001 to early 2006 but have remained below that level since then (Figure 41). Decreases in 1,3-DNB are expected, as this nitroaromatic compound is a photodegradation product of 2,4-DNT. Increases in concentration of this compound began during the period that 2,4-DNT-impacted soils were being excavated in this area. Exposure of impacted soil likely resulted in some photodegradation and subsequent infiltration into the aquifer system. Concentrations of 1,3-DNB in wells MW-2050, MW-2052, and MW-2053 that have not been above the 1,3-DNB MCL but are impacted by 2,4-DNT are included on Figure 41 to illustrate the decline in 1,3-DNB concentrations in MW-2012 since 2003. Concentrations of 1,3-DNB have been below the cleanup standard for more than 10 years at both performance and detection monitoring locations.

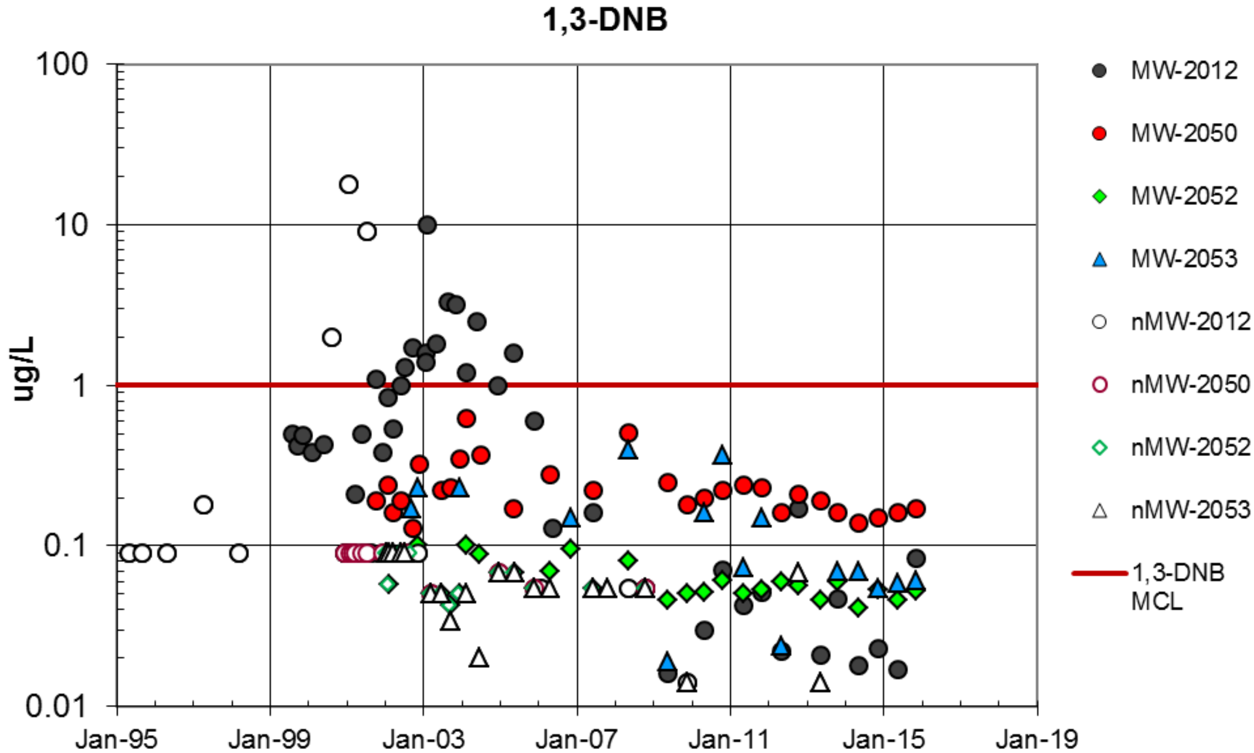


Figure 41. 1,3-DNB Concentrations in Performance Monitoring Well MW-2012

Detection monitoring location (Table 28) results for 1,3-DNB show that no downgradient migration of impacted groundwater has occurred from the area of known impact within the weathered unit (Figure 42). Fringe location MW-2051 has low concentrations of 1,3-DNB, and these concentrations are consistent with historical data. The data from the unweathered unit wells (Figure 43) indicate that the impacted groundwater in the overlying weathered unit has not moved downward. The concentrations reported in SP-6303 are negligible and consistent with historical data. None of the concentrations reported exceeded the triggers levels set for the Objective 3 or 4 wells or the Objective 5 springs.

Table 28. 1,3-DNB Detection Monitoring Locations for GWOU Detection Monitoring Locations

Locations	Detection Monitoring Areas
Weathered Unit	
MW-2032	Fringe
MW-2051	Fringe
MW-4014	Downgradient
MW-4039	Fringe
MW-4041	Downgradient—Far
Unweathered Unit	
MW-2022	Vertical Extent
MW-2023	Vertical Extent
MW-2056	Vertical Extent
Springs	
SP-6301	Burgermeister Spring
SP-6303	Burgermeister Spring Branch

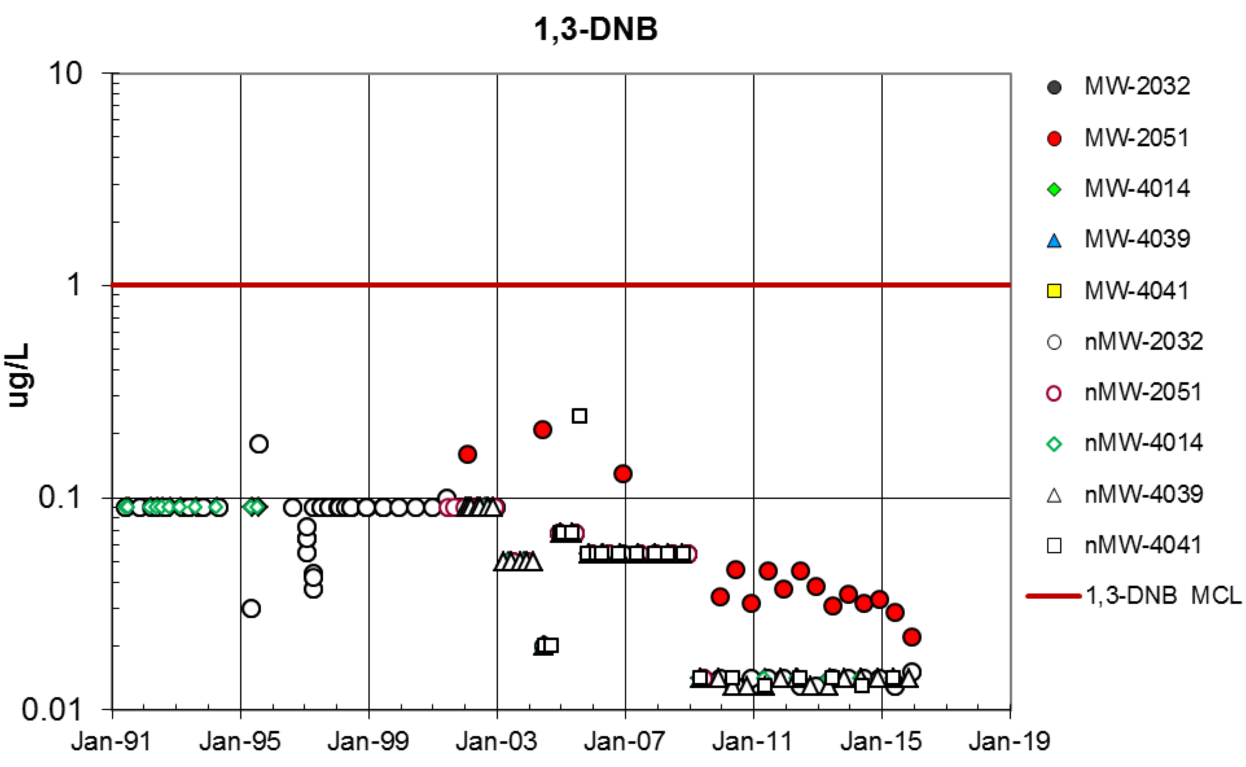


Figure 42. 1,3-DNB Concentrations in Detection Monitoring Wells—Weathered Unit

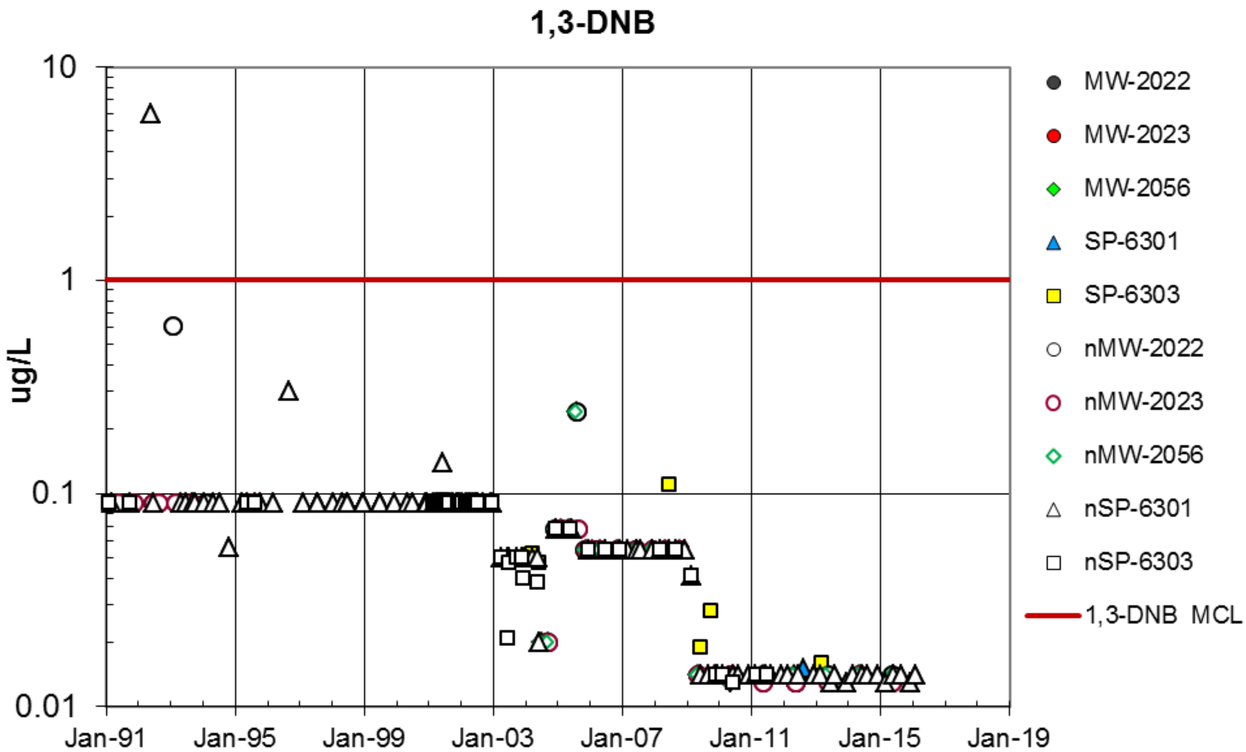


Figure 43. 1,3-DNB Concentrations in Detection Monitoring Wells—Unweathered Unit and Springs

Nitrobenzene (NB)

The nitroaromatic compound NB was not detected during the previous 5 years, except for a single estimated value of 0.044 µg/L reported at well MW-2052 in the October 15, 2012 sample. The cleanup standard for NB is 17 µg/L. It has not been detected (without validation qualifiers) in any of the Objective 3, 4, or 5 detection monitoring locations since the MNA program began in 2004.

2,4,6-TNT Performance Monitoring Results

All 2,4,6-TNT concentrations reported at monitoring locations (Figure 44) from 2011 through 2015 were below the cleanup standard of 2.8 µg/L (Table 29). Concentrations of TNT have generally been decreasing in the Frog Pond area (Figure 45) since 2003. Well MW-2046 monitors a discrete area of TNT impact in the north-central portion of the site. Trend analysis of 2,4,6-TNT data collected from 2011 through 2015 indicates that concentrations are continuing to decrease in all of the Objective 2 wells, even though no statistically significant trends were calculated for the last 5 years' data.

Table 29. 2,4,6-TNT Data from GWOU Performance Monitoring Wells

Location	2,4,6-TNT Concentration (µg/L)				
	2011	2012	2013	2014	2015
MW-2012	0.94	1.4	0.58	0.50	1.6
MW-2046	0.65	0.56	0.65	0.52	0.43
MW-2053	1.0	1.6	0.61	1.1	0.91

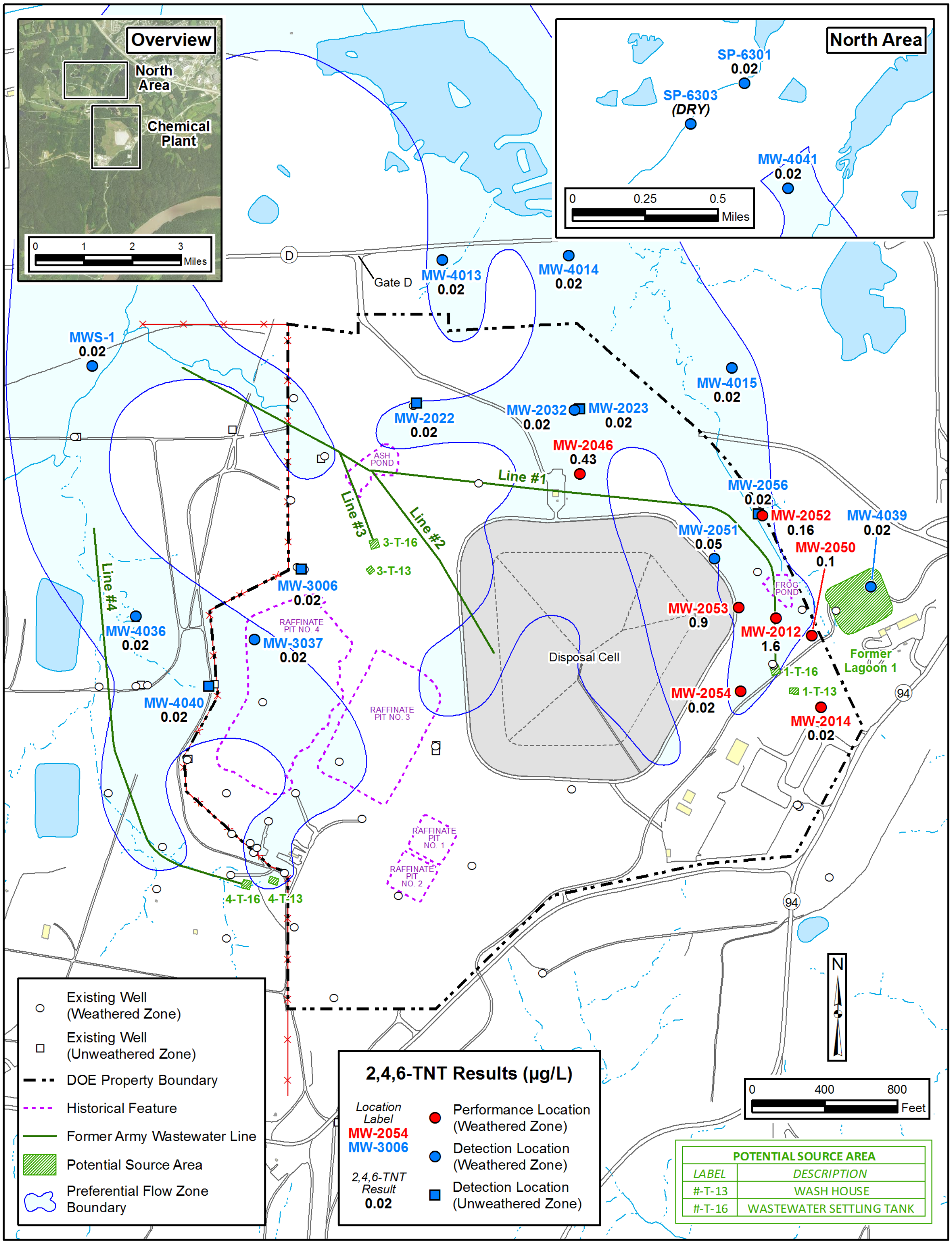


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Figure 44. 2,4,6-TNT Monitoring Locations with 2015 Average Concentrations (Items in green are potential source locations from former Army nitroaromatic production facilities)

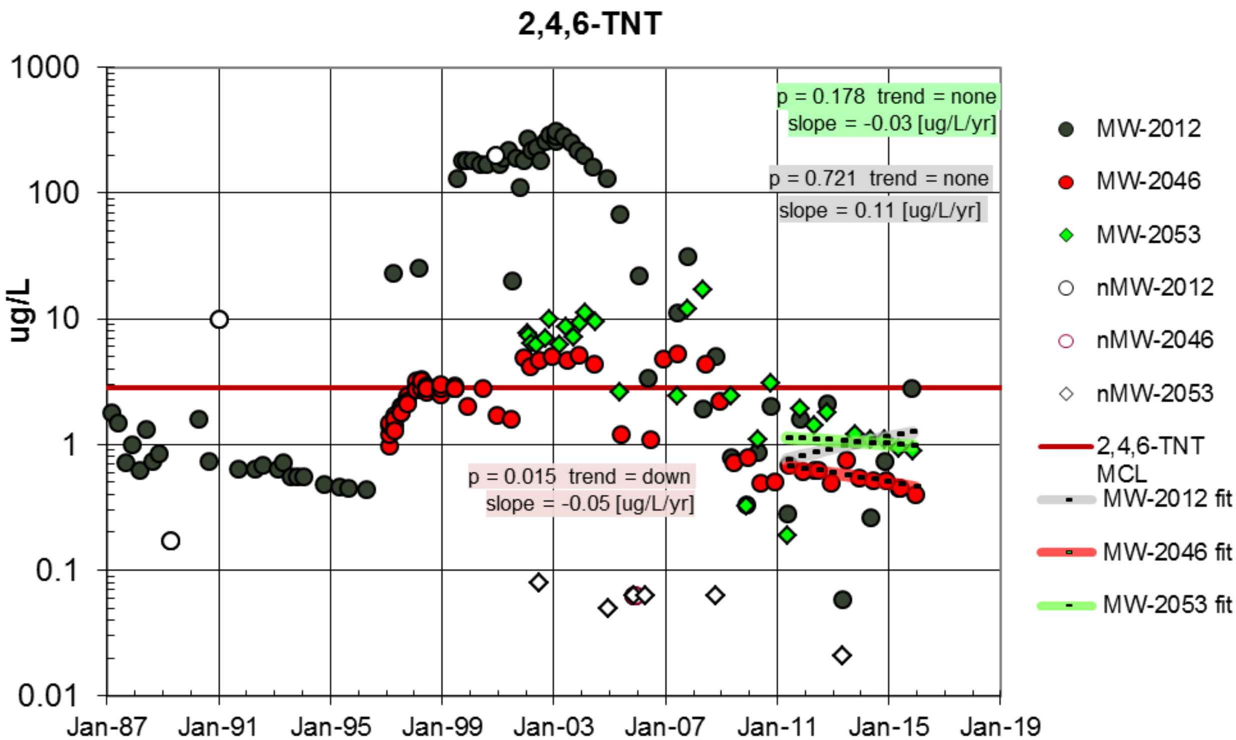

Figure 45. 2,4,6-TNT Concentrations in Performance Monitoring Wells

2,4,6-TNT Detection Monitoring Results

The 2,4,6-TNT concentrations reported in weathered unit detection monitoring wells (Table 30) indicate that no downgradient migration of impacted water has occurred beyond the area of known impact. All weathered unit wells except MW-2051 have 2,4,6-TNT concentrations at or below the detection limit (Figure 46); these concentrations are consistent with historical data. No detectable concentrations of 2,4,6-TNT were reported in the wells in the unweathered unit (Figure 47).

The concentrations reported in Burgermeister Spring and SP-6303 are negligible and are consistent with historical data. A low-level estimated detection was reported at SP-6303 in 2013, which has been dry since that sample was collected (Figure 47). None of the concentrations reported exceeded the trigger levels set for the Objective 3 or 4 wells or the Objective 5 springs.

Table 30. 2,4,6-TNT GWOU Detection Monitoring Locations

Locations	2,4,6-TNT Detection Monitoring Areas
Weathered Unit	
MW-2032	Fringe
MW-2051	Fringe
MW-4014	Downgradient
MW-4039	Fringe
MW-4041	Downgradient—Far
Unweathered Unit	
MW-2022	Vertical Extent
MW-2023	Vertical Extent
MW-2056	Vertical Extent
Springs	
SP-6301	Burgermeister Spring
SP-6303	Burgermeister Spring Branch

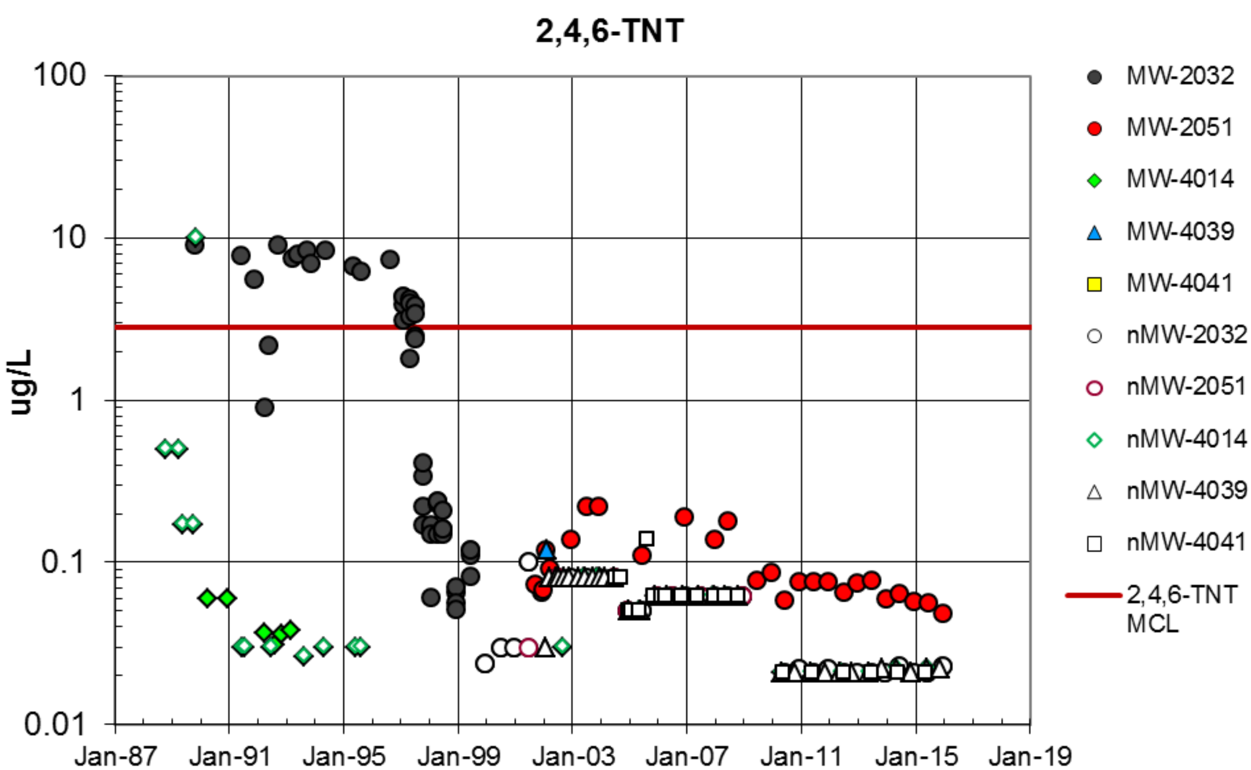

Figure 46. 2,4,6-TNT Concentrations in Weathered Unit Detection Monitoring Wells

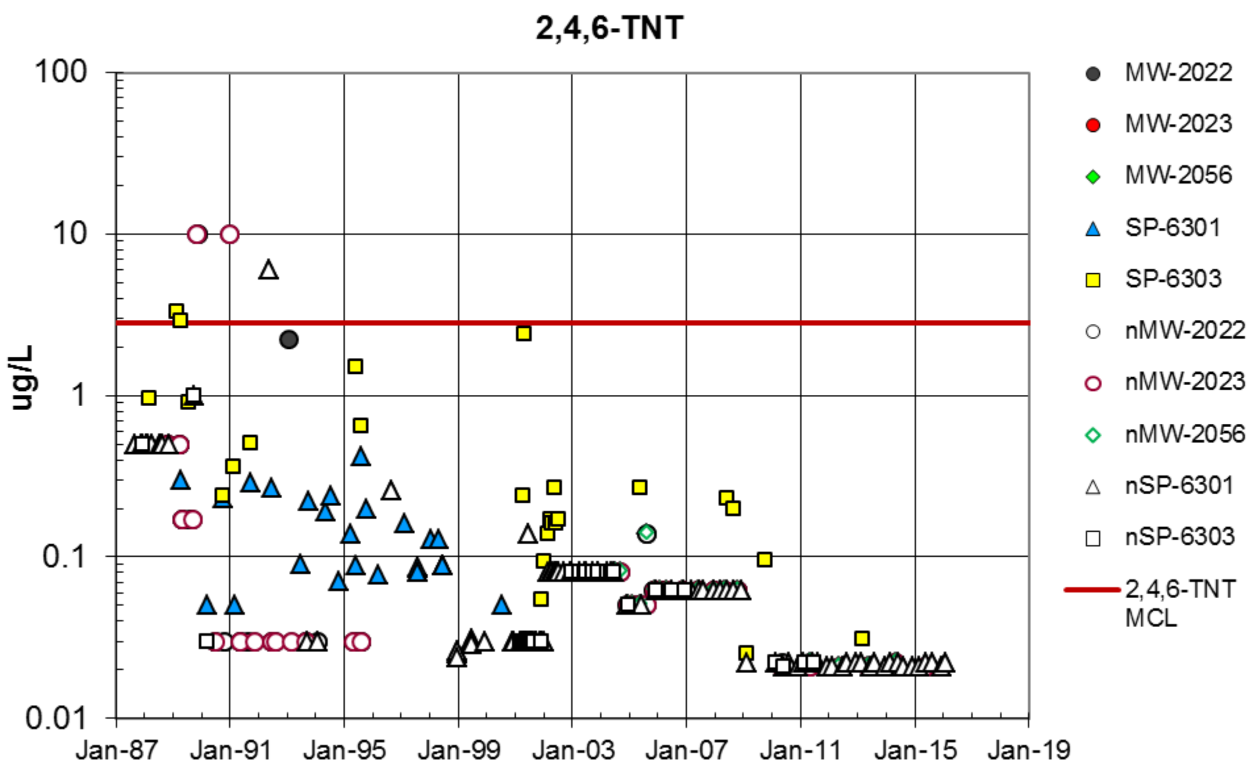

Figure 47. 2,4,6-TNT Concentrations in Unweathered Unit Detection Monitoring Wells and Springs

2,4-DNT and 2,6-DNT Performance Monitoring

The nitroaromatic compounds 2,4-DNT and 2,6-DNT are the most persistent in groundwater at the site. The locations of the performance and detection monitoring wells are shown on Figure 48. Data from the last few years indicate that concentrations of DNT have varied in most of the Objective 2 wells (Table 31 and Table 32). The variability can be attributed to the introduction of surface water into the groundwater system. Concentrations of these compounds are typically higher during periods of low groundwater elevations and decrease as groundwater elevations rise. The introduction of surface water infiltration temporarily dilutes the concentrations in groundwater.

Table 31. 2,4-DNT Data from GWOU Performance Monitoring Wells in the Frog Pond Area

Location	2,4-DNT Concentration (µg/L)				
	2011	2012	2013	2014	2015
MW-2012	3.3	38.7	2.99	0.12	20
MW-2050	20.5	12.5	5.4	2.5	5.4
MW-2053	5.5	0.14 (U)	0.39	0.41	0.019 (U)
MW-2014	0.12	0.12	0.14	0.12	0.12
MW-2052	0.06	0.07	0.06	0.05	0.06
MW-2054	0.08	0.08	0.09	0.10	0.09

Abbreviation:
(U) = analyte not detected above reporting limit for any samples during the year (2 samples per year)

Table 32. 2,6-DNT Data from GWOU Performance Monitoring Wells in the Frog Pond Area

Location	2,6-DNT Concentration (µg/L)				
	2011	2012	2013	2014	2015
MW-2012	18.5	51.9	17.6	4.4	37
MW-2050	29.5	28.5	29	22.5	20
MW-2053	52	20.5	3.5	4.7	6.5
MW-2014	0.35	0.37	0.36	0.35	0.48
MW-2052	0.15	0.21	0.14	0.09	0.13
MW-2054	0.20	0.21	0.21	0.26	0.24

Wells with higher 2,4-DNT and 2,6-DNT concentrations in the former Frog Pond area downgradient of the former TNT-production buildings and former Army Lagoon 1 are generally the most variable (Figure 49 and Figure 50), with lower concentration wells being more stable (Figure 51 and Figure 52). During previous years, the highest concentrations of these two compounds were reported in MW-2012; however, concentrations of DNT, as well as the other nitroaromatic compounds, have decreased substantially at this location. Well MW-2050 is the most stable higher-concentration well and may be the last to decrease to the cleanup standards.

Concentrations of 2,4-DNT in lower-concentration wells MW-2014, MW-2052, and MW-2054 were less than or near the cleanup standard of 0.11 µg/L. Only MW-2014 was slightly above the cleanup standard. Concentrations of 2,6-DNT in the lower-concentration wells were below the cleanup standard of 1.3 µg/L for all samples collected from 2011 through 2015.

The calculated trends of MW-2012 and MW-2053 are meaningless because the concentrations are highly variable, though concentrations in both wells are showing lower highs and lower lows through time. Although results need to be more stable to estimate time until reaching cleanup standards, the high variability appears to favor significantly lower concentrations. The last 5 years of data from the most stable higher-concentration well, MW-2050, do indicate a statistically significant down trend for both 2,4-DNT and 2,6-DNT. The lower-concentration wells are relatively stable with long-term decreasing concentrations of 2,4-DNT and 2,6-DNT.

2,4-DNT and 2,6-DNT Detection Monitoring

Results from detection monitoring locations (Table 33) for the area of 2,4-DNT impact in the Frog Pond area indicate that some migration from this area continues (Figure 53). Results from 2011, 2012, and 2013 from MW-4015 are above the 0.11 µg/L cleanup standard for 2,4-DNT, but only the 2011 result was not qualified as estimated. None of the concentrations reported exceeded the 0.55 µg/L trigger level set for downgradient Objective 3 wells. The data from the unweathered unit wells (Figure 54) indicate that the impacted groundwater in the overlying weathered unit has not moved downward. The concentrations reported in Burgermeister Spring and SP-6303 are negligible and are consistent with historical data. The 2013 detection in SP-6303 was lab qualified as estimated. None of the concentrations reported exceeded the trigger levels set for the Objective 5 springs. Concentrations in these downgradient wells have decreased slightly during the review period.

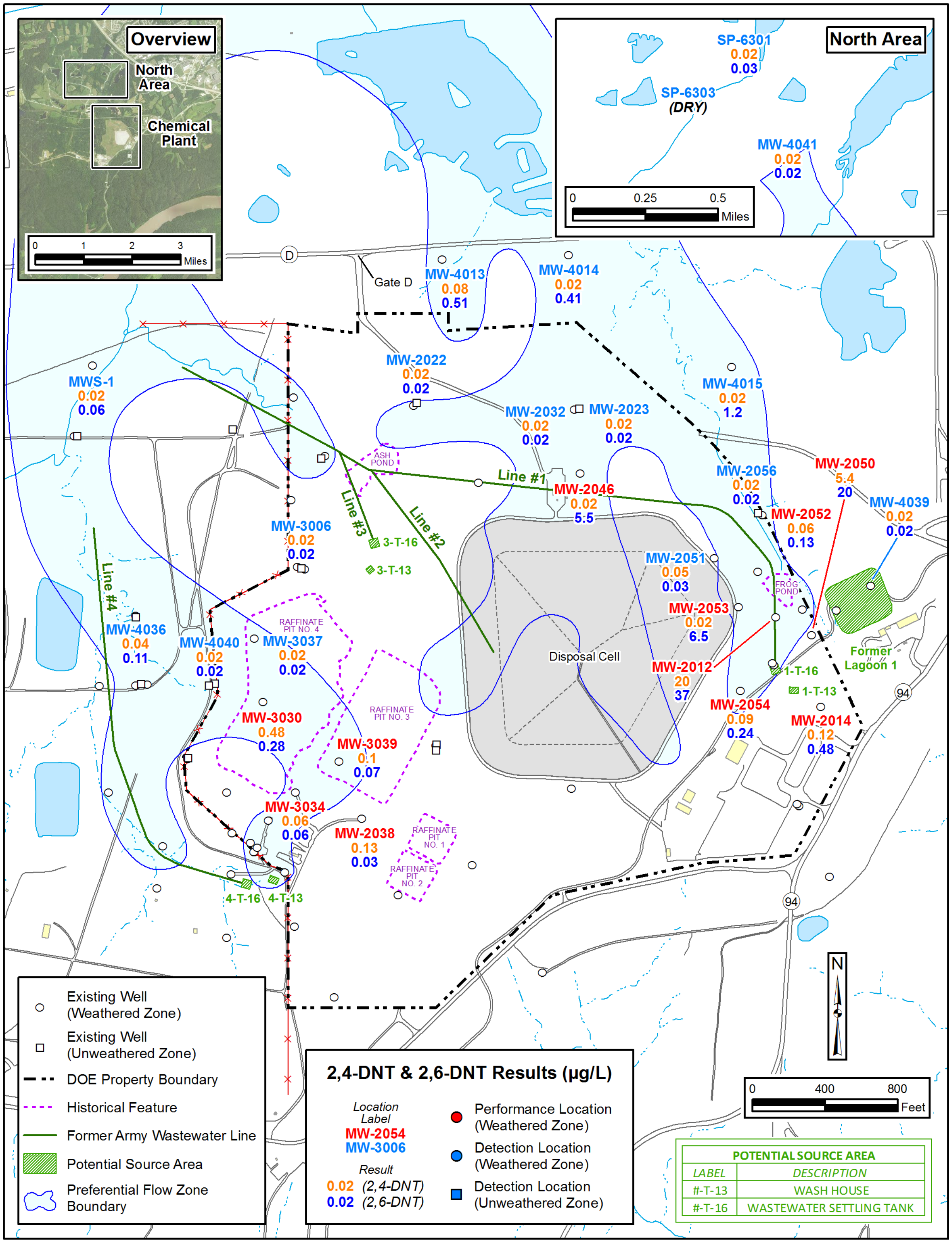

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Figure 48. 2,4-DNT and 2,6-DNT Monitoring Locations with 2015 Average Concentrations (Items in green are potential source locations from former Army nitroaromatic production facilities)

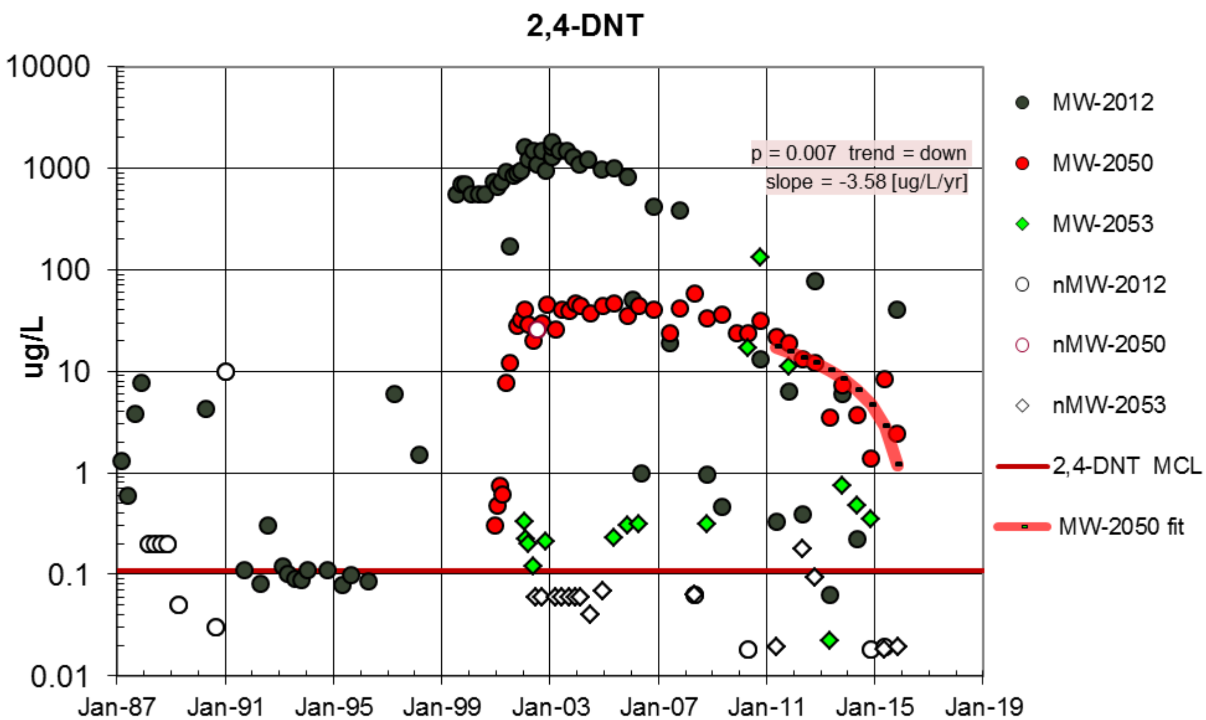

Figure 49. 2,4-DNT in Higher-Concentration Performance Monitoring Wells

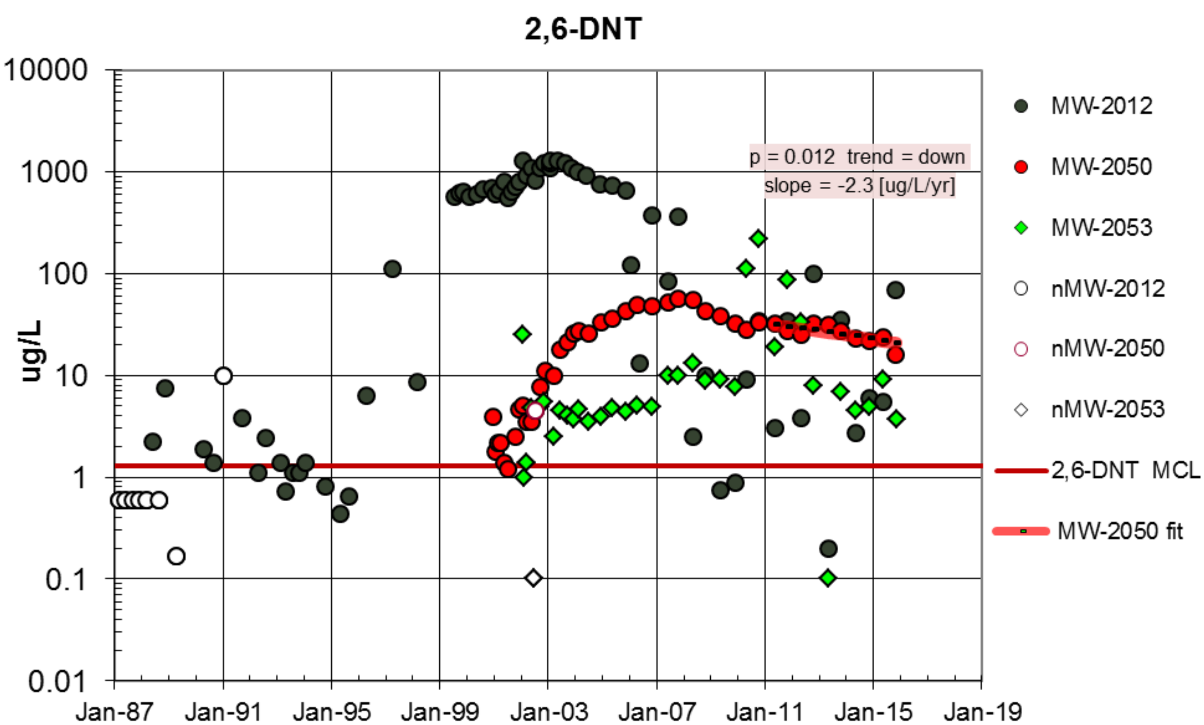

Figure 50. 2,6-DNT in Higher-Concentration Performance Monitoring Wells

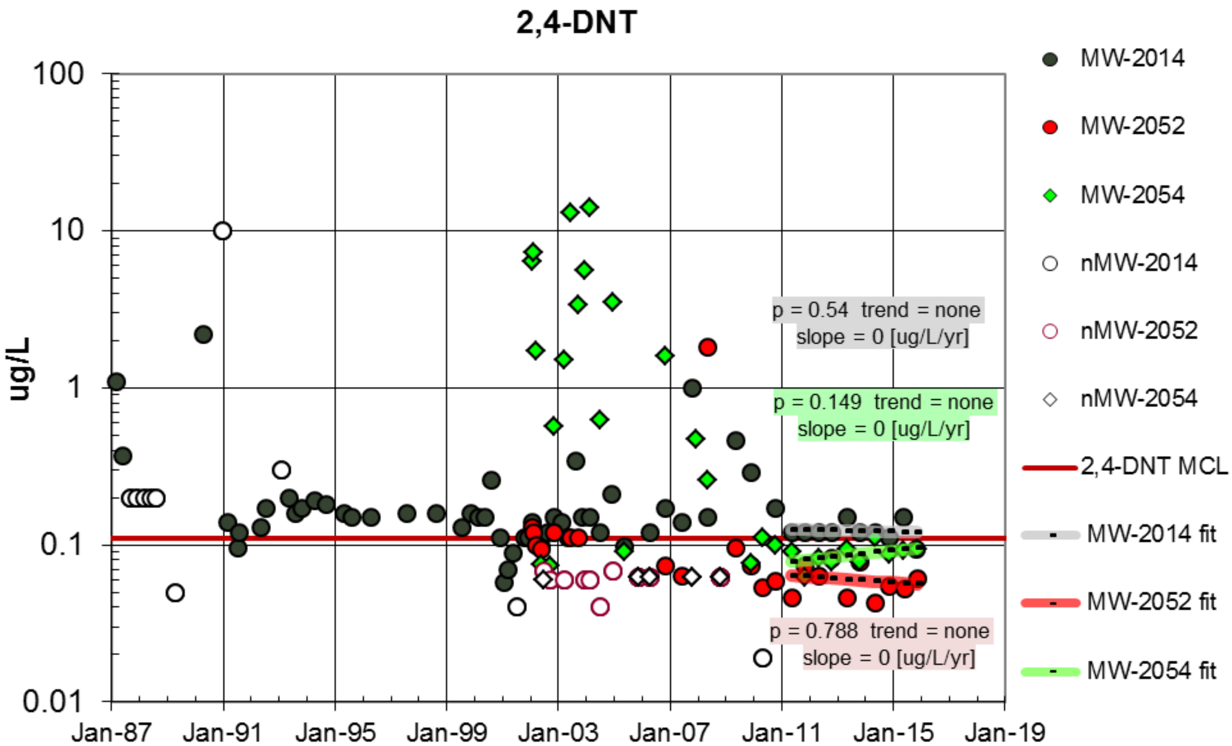

Figure 51. 2,4-DNT in Lower-Concentration Performance Monitoring Wells

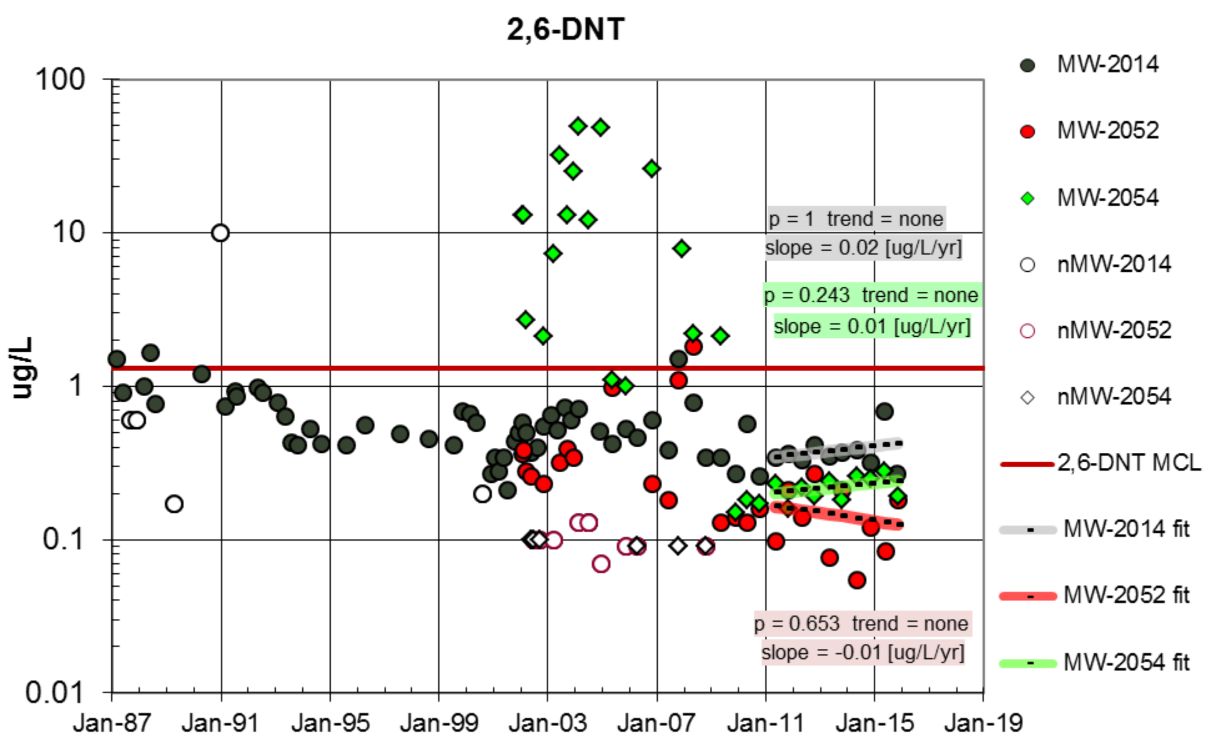

Figure 52. 2,6-DNT in Lower-Concentration Performance Monitoring Wells

Table 33. 2,4-DNT and 2,6-DNT GWOU Detection Monitoring Locations—Frog Pond Area

Location	Detection Monitoring Area
Weathered Unit	
MW-2032	Fringe
MW-2051	Fringe
MW-4013	Downgradient
MW-4014	Downgradient
MW-4015	Downgradient
MW-4039	Fringe
MW-4041	Downgradient—Far
Unweathered Unit	
MW-2023	Vertical Extent
MW-2056	Vertical Extent
Springs	
SP-6301	Burgermeister Spring
SP-6303	Burgermeister Spring Branch

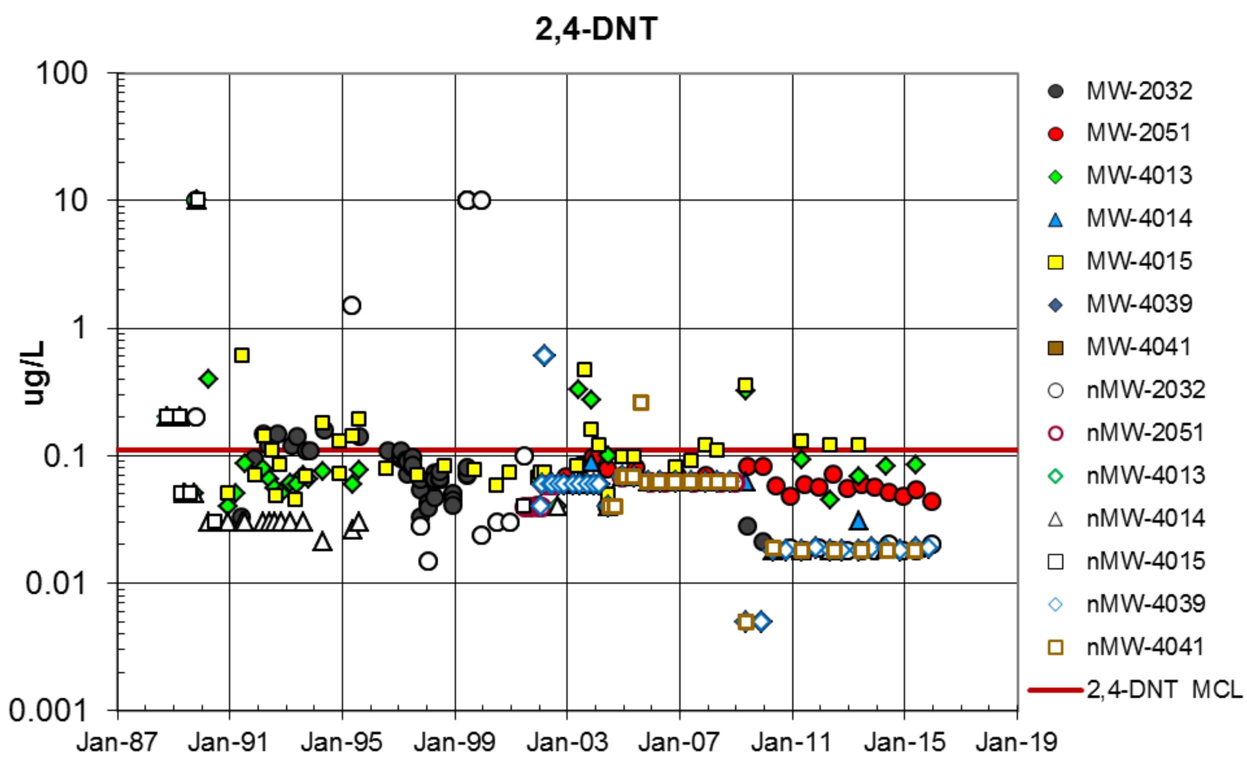

Figure 53. 2,4-DNT in Weathered Unit Detection Monitoring Wells

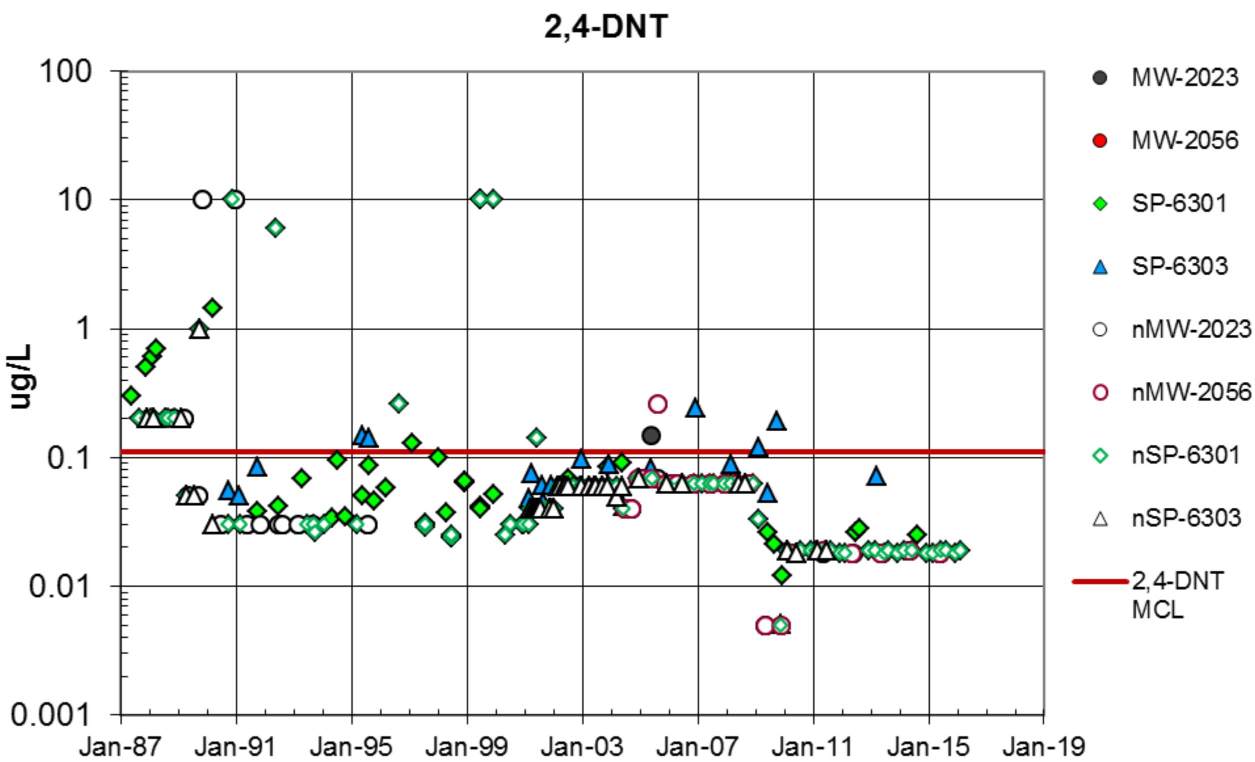

Figure 54. 2,4-DNT in Unweathered Unit Detection Monitoring Wells and Springs

Concentrations of 2,6-DNT show persistent detections in weathered unit wells MW-4013, MW-4014, and MW-4015 (Figure 55). 2,6-DNT levels in these wells are stable, though they may be trending up in MW-4014, the lowest concentrations of the three wells. Results remain below the 1.3 µg/L cleanup standard for the three wells. Concentrations of 2,6-DNT in the other weathered unit wells are at the detection limit. No detectable concentrations of 2,6-DNT were reported in the wells in the unweathered unit (Figure 56).

There were 14 low-level detections of 2,6-DNT reported at Burgermeister Spring (SP-6301) in the previous 5 years, though only 3 were not qualified as estimated. Within the perspective of historical data, concentrations are decreasing at Burgermeister Spring. A 0.31 µg/L detection (below the 1.3 µg/L cleanup standard) was reported at SP-6303 in 2013. This spring has been dry since mid-2013.

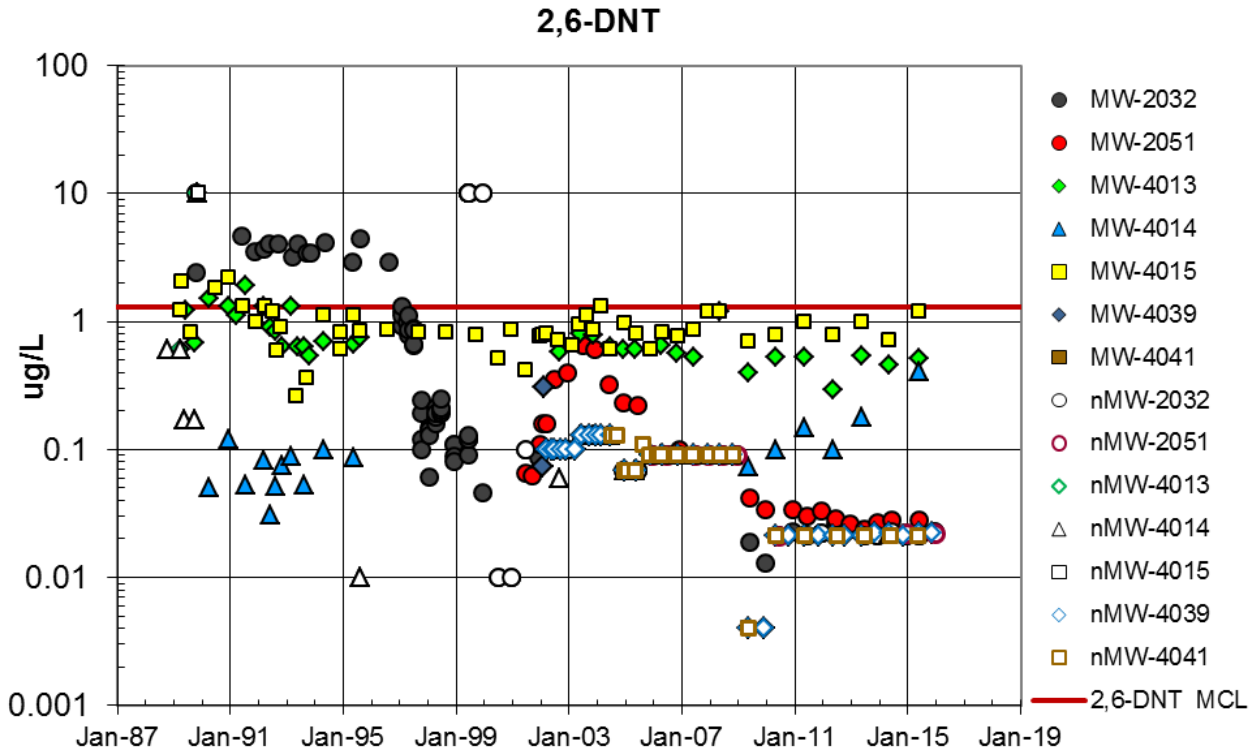

Figure 55. 2,6-DNT in Weathered Unit Detection Monitoring Wells

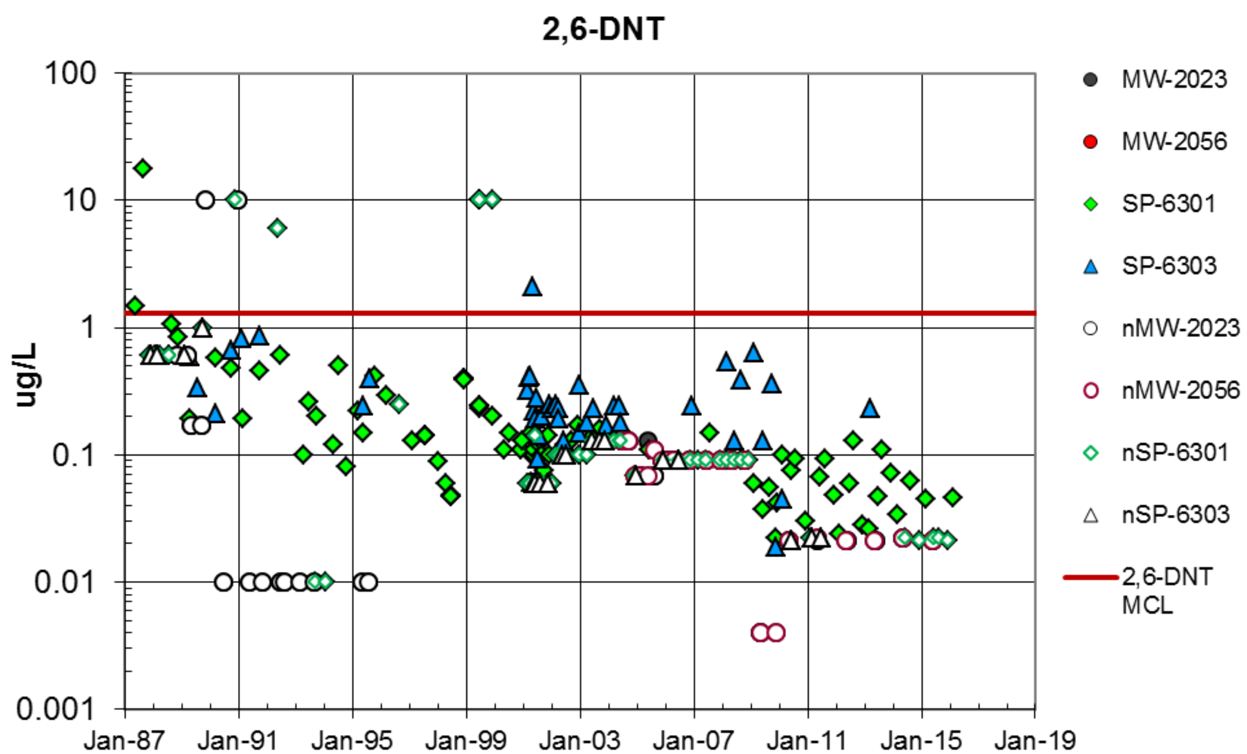

Figure 56. 2,6-DNT in Unweathered Unit Detection Monitoring Wells and Springs

Overall, nitroaromatic compound impact in the former Frog Pond area is confined to the weathered unit of the Burlington-Keokuk Limestone. The concentrations of 2,4-DNT and 2,6-DNT are variable with generally decreasing concentrations. Most locations exhibit long-term decreasing trends. Concentrations of 1,3-DNB, NB, and 2,4,6-TNT are currently below the cleanup standard for all monitoring locations.

Nitroaromatic Compounds—Former Raffinate Pits Area

The other area of nitroaromatic compound impact at the Chemical Plant site is in the former Raffinate Pits area where portions of former Army TNT-production lines 3 and 4 were located. Groundwater in this area is impacted by 2,4-DNT in concentrations that exceed the cleanup standard of 0.11 µg/L. Nitroaromatic compound impact is limited to the weathered unit of the Burlington-Keokuk Limestone. Table 34 presents a summary of the 2,4-DNT data from the former Raffinate Pits area for the period of 2011 through 2015.

Table 34. 2,4-DNT Data from GWOU Performance Monitoring Wells in the Raffinate Pits Area

Location	2,4-DNT Concentration (µg/L)				
	2011	2012	2013	2014	2015
MW-2038	0.13	0.15	0.12	0.13	0.13
MW-3030	0.63	0.57	0.60	0.64	0.48
MW-3034	0.07	0.06	0.06	0.06	0.06
MW-3039	0.19	0.16	0.15	0.15	0.10

The highest 2,4-DNT concentrations in the former Raffinate Pits area continue to be observed in well MW-3030 (Figure 57). Concentrations in wells MW-2038, MW-3030, MW-3034, and MW-3039 are consistently decreasing except for a temporary rebound in MW-3030 during 2009. The 2,4-DNT concentrations in MW-3034 have been less than or equal to the cleanup standard of 0.11 µg/L since 2009. For the first time since 2,4-DNT monitoring began at well MW-3039, sample results in 2015 were below the cleanup standard.

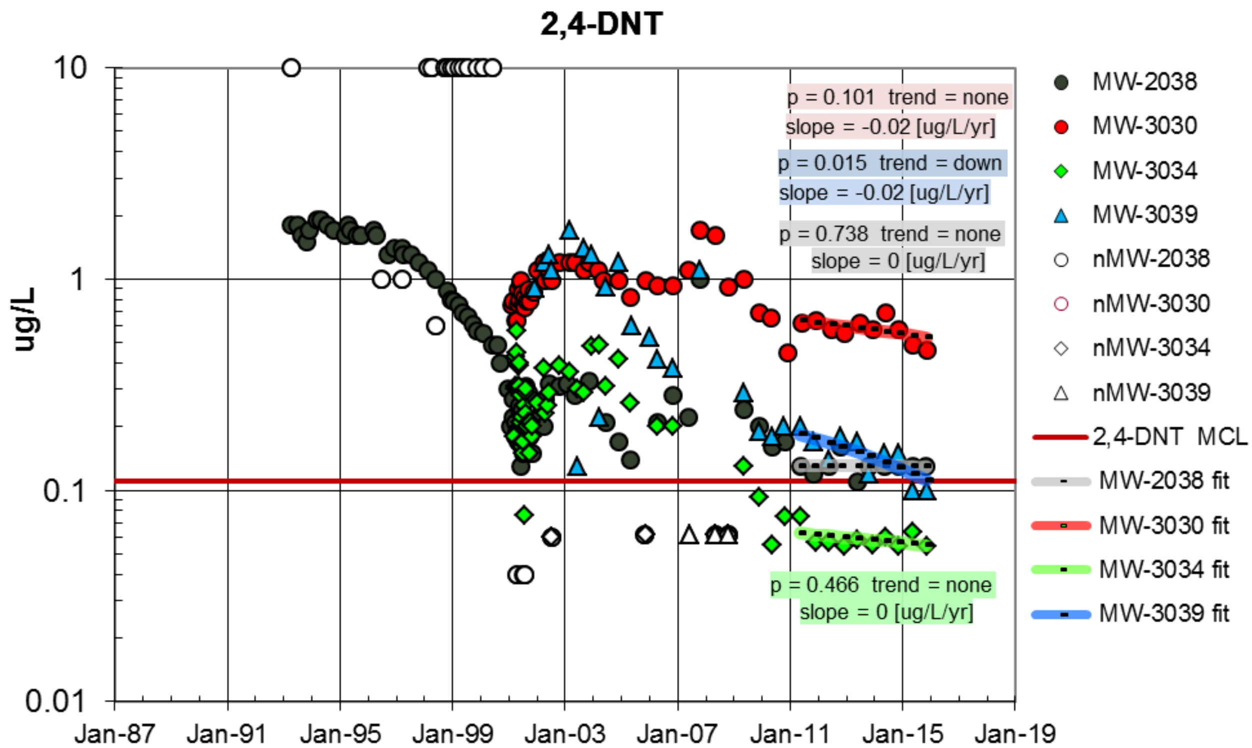

Figure 57. 2,4-DNT Concentrations in Performance Monitoring Wells in the Former Raffinate Pits Area

Trend analysis based on the data from 2011 through 2015 indicates that 2,4-DNT concentrations in the former Raffinate Pits area are decreasing. A statistically downward trend was calculated for well MW-3039, which in 2015 decreased to below the cleanup standard. Concentrations in wells MW-2038 and MW-3030 continued their long-term decline despite no statistically significant trend for the last 5 years. Concentrations in well MW-3034 are stable at low levels below the cleanup standard. If long-term trends continue, concentrations of 2,4-DNT at MW-2038 could drop below the 0.11 µg/L cleanup standard in the next 5 years. Concentrations at well MW-3030, at a higher concentration, will probably take another 20 to 30 years to reach the cleanup standard.

Results from detection monitoring locations (Table 35) for the area of 2,4-DNT impact in the Raffinate Pits area show that minimal migration from this area has occurred. The source of 2,4-DNT detected in wells MW-4036 and MW-3037 may be the Chemical Plant site, the Army property, or both. These results are questionable in that the replicate analysis of the one-time concentration above the 0.11 µg/L cleanup standard in MW-3037 (Figure 58) was not within control limits, and the detections in MW-4036 were qualified as estimated. All sample results from the unweathered unit wells since the early 1990s are below detection limits and verify that the impacted groundwater in the overlying weathered unit has not migrated downward.

Table 35. 2,4-DNT and 2,6-DNT GWOU Detection Monitoring Locations—Raffinate Pits Area

Locations	Detection Monitoring Areas
Weathered Unit	
MW-3037	Fringe
MW-4036	Downgradient
MWS-1	Downgradient
Unweathered Unit	
MW-3006	Vertical Extent
MW-4040	Vertical Extent

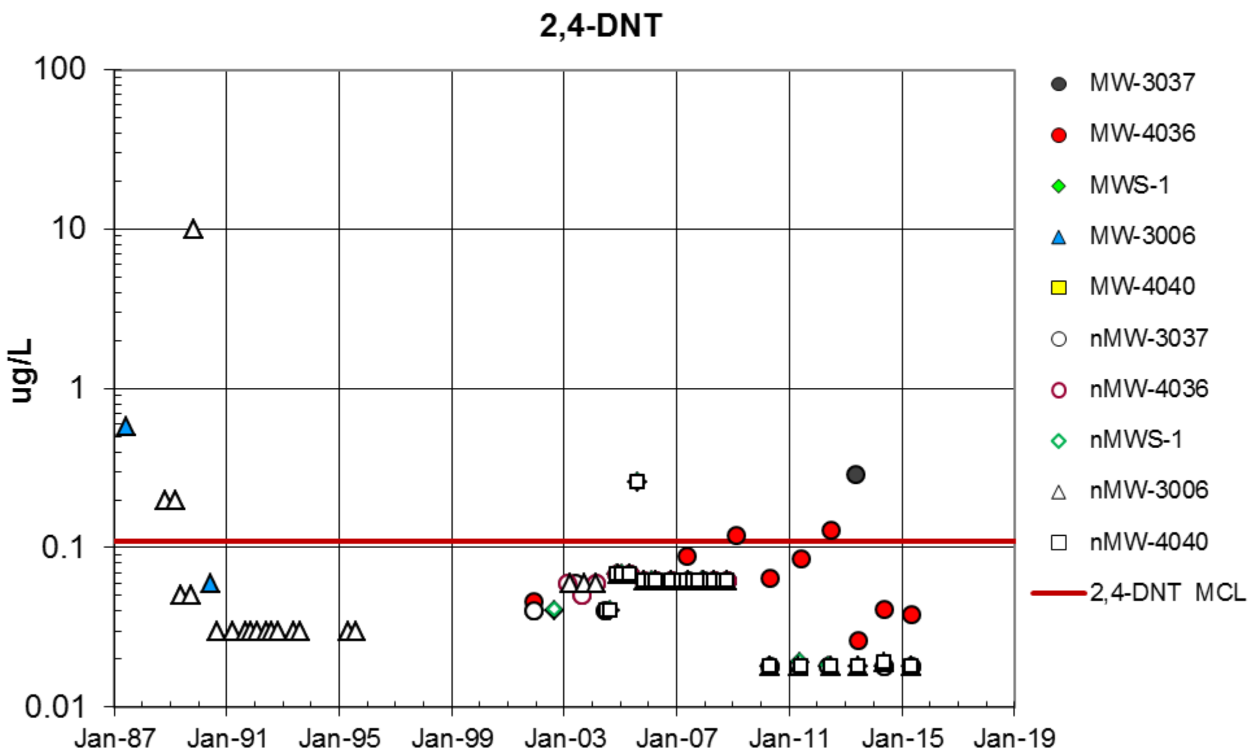

Figure 58. 2,4-DNT in Raffinate Pits Area Detection Monitoring Wells—Weathered Unit

6.4.2 Quarry Residuals Operable Unit (QROU)

EPA signed the QROU ROD (DOE 1998a) on September 30, 1998. The QROU ROD specified long-term groundwater monitoring and ICs to limit groundwater use during the monitoring period. Groundwater north of the Femme Osage Slough will be monitored until a target level of 300 pCi/L for uranium is attained. In addition, groundwater south of the slough will be monitored to ensure protection of human health and the environment.

In 2000, DOE initiated a long-term monitoring program as outlined in the *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit* (DOE 2000b). This network was modified to add wells upgradient of the Quarry (MW-1012), downgradient of the area of impact (MW-1028), and within the area of highest uranium impact (MW-1051 and MW-1052).

6.4.2.1 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 the bedrock consists of up to 30 ft of unsaturated silty-clay soil and loess deposits (DOE 1989). Three Ordovician formations constitute the bedrock: the Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium associated with the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium thickness increases with distance from the edge of the river floodplain toward the river, where the maximum thickness is approximately 100 ft.

Alluvium at the Quarry is truncated by an erosional contact with the Ordovician bedrock bluff consisting of Kimmswick, Decorah, and Plattin Formations. These formations also form the rim wall of the Quarry. The bedrock unit underlying alluvial materials north of Femme Osage Slough is the Decorah Group. Primary sediments between the bluff and the slough are intermixed and interlayered clays, silts, and sands. Organic material is intermixed throughout the sediments. The area between the bedrock bluff and Femme Osage Slough contains a naturally occurring oxidation-reduction front, which acts as a barrier to the migration of dissolved uranium in groundwater by inducing its precipitation. This reduction zone is the primary mechanism controlling uranium distribution south of the Quarry.

The uppermost groundwater flow systems at the Quarry are composed of alluvial and bedrock aquifers. Water levels in the alluvial aquifer are primarily controlled by surface water levels in the Missouri River and the infiltration of precipitation and overland runoff that recharges the bedrock aquifer.

Eight monitoring wells in the Darst Bottom area were used to study the water quality of the Missouri River alluvium upgradient of the Quarry and provide a reference for background values of uranium. Several other bedrock wells were installed north of the Quarry to provide background values for uranium in the bedrock units. A summary of the uranium background values is provided in Table 36 (DOE 1998a).

Table 36. Background Uranium Levels for Units at the Quarry

Unit	Uranium (pCi/L)	
	Background Value (UCL_{95})	**Background Range**
Alluvium[a]	2.77	0.1−16
Kimmswick-Decorah[b]	3.41	0.5−8.5
Plattin[c]	3.78[d]	1.2−5.1

Notes:
[a] Based on data from Darst Bottom wells (U.S. Geological Survey and DOE).
[b] Based on data from MW-1034 and MW-1043 (DOE).
[c] Based on data from MW-1042 (DOE).
[d] This background value is lower than previously published as a result of recent data evaluation (DOE 1998b).

Abbreviation:
UCL_{95} = 95th percentile upper confidence limit of the mean concentration

6.4.2.2 Quarry Hydrogeologic Data Analysis

Groundwater flow at the Quarry is monitored using all the wells in the long-term monitoring network. The static groundwater levels of the monitoring network are measured at least quarterly to establish that groundwater flow has not changed significantly and resulted in shifts in potential contaminant migration. Groundwater flow is generally to the south from the bedrock bluff of the Quarry toward the Femme Osage Slough. The flow directions of the shallow groundwater have remained relatively unchanged from previous years. Spring and fall water elevations are given on Figure 59 and Figure 60.

Groundwater elevations in the Quarry area fluctuate significantly (Figure 61), primarily in response to the level of the Missouri River. The bedrock wells along the Quarry rim (Line 1) are less influenced by river levels and have a smaller range of water level variability than wells near the slough and those screened in the Missouri River alluvium (Lines 2, 3, and 4). Water levels of wells in the Quarry area were lower on average in 2014 through the spring of 2015 in response to lower-than-typical river stages caused by drought conditions in the area and upstream.

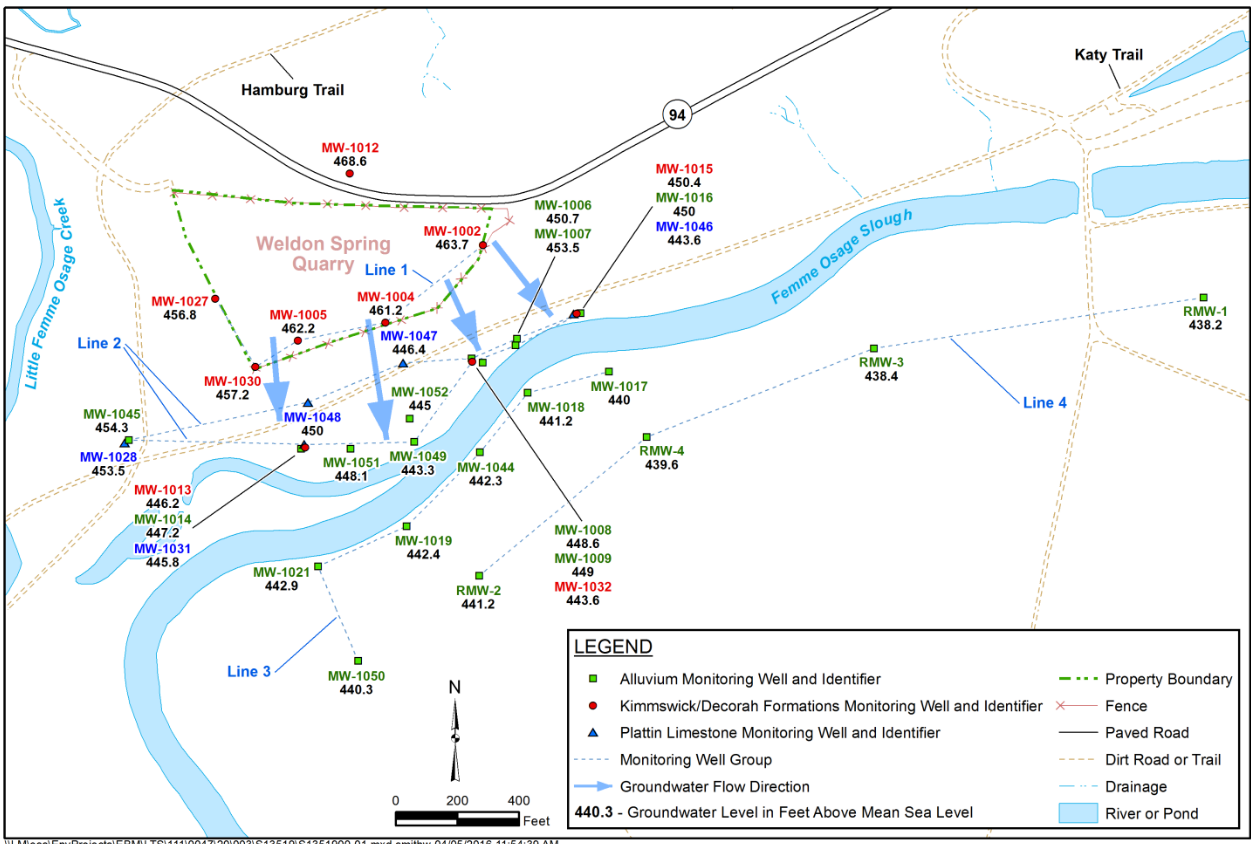

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Figure 59. Groundwater Elevations at the Weldon Spring Quarry (March 23, 2015)

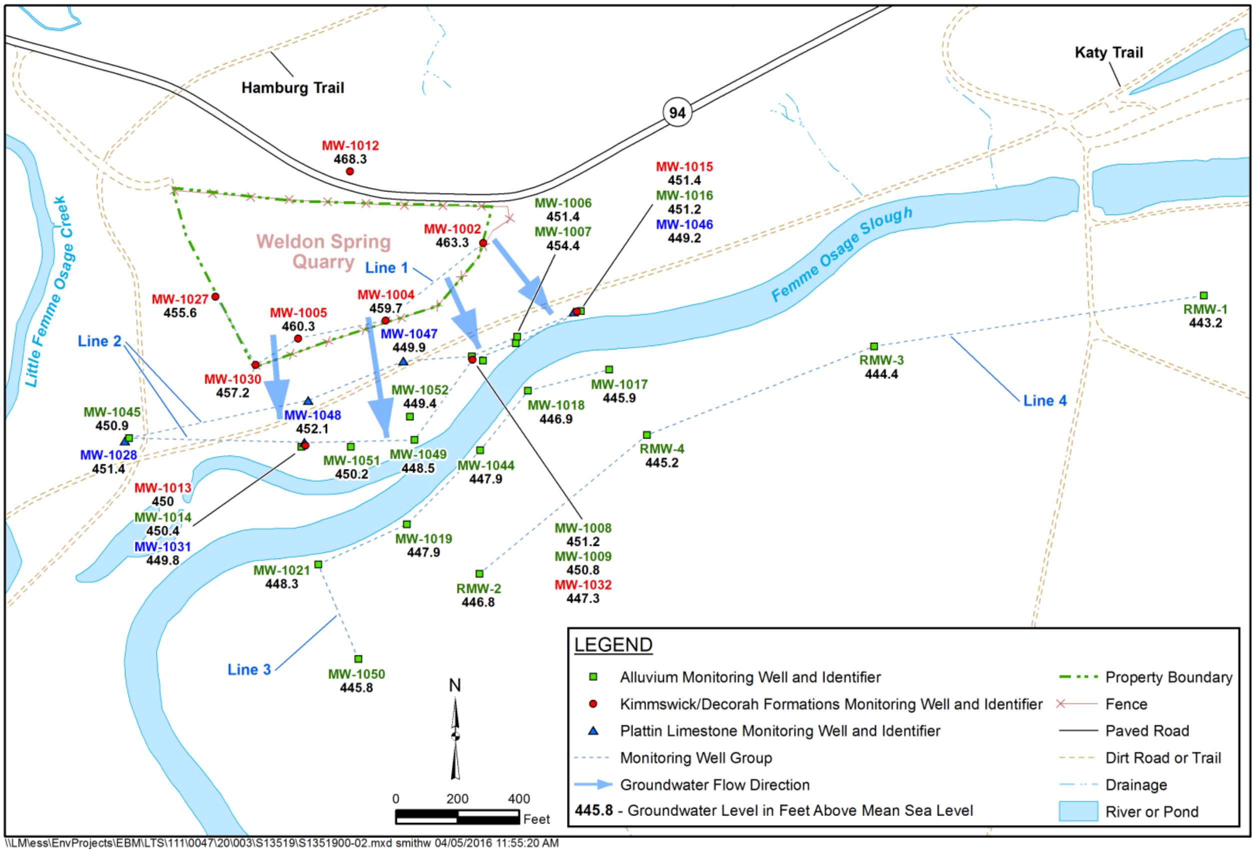

Figure 60. Groundwater Elevations at the Weldon Spring Quarry (September 28 to 30, 2015)

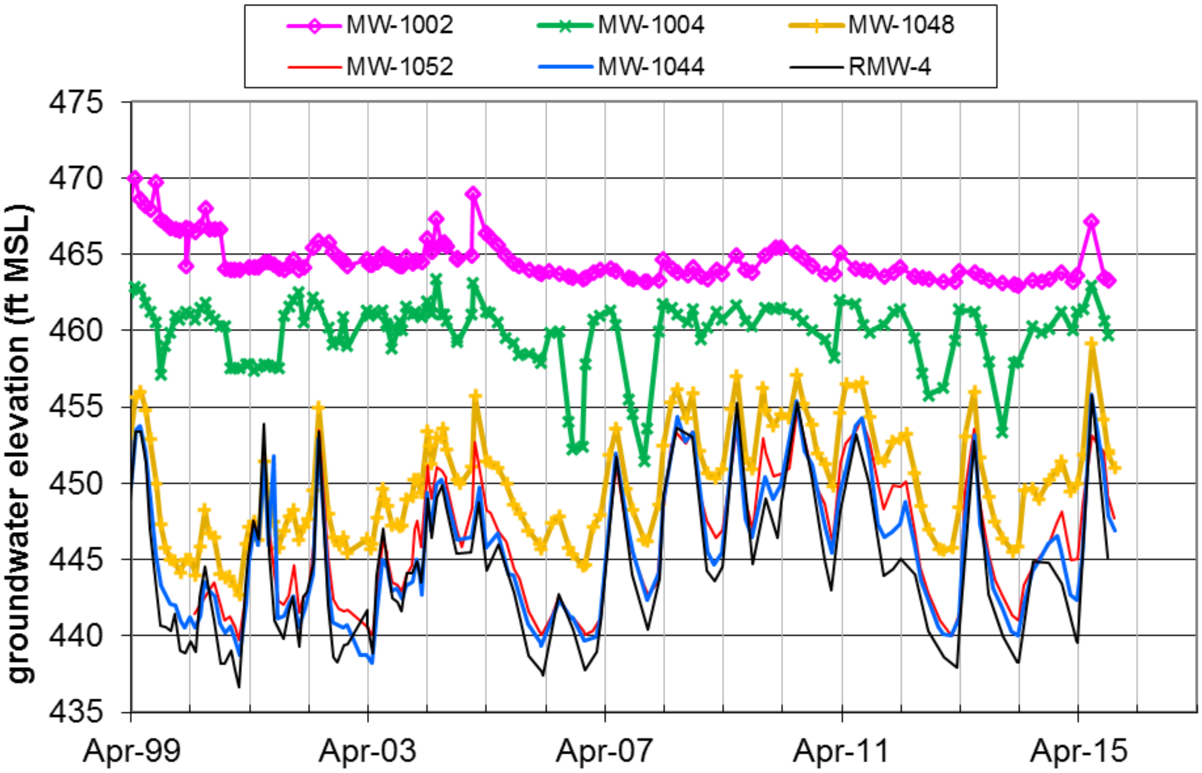

Figure 61. Groundwater Elevations in the Quarry Area (lines with no symbols are alluvial aquifer wells)

6.4.2.3 Contaminants of Interest

Uranium and nitroaromatic compounds that leached from wastes in the Quarry proper contaminated the groundwater beneath and downgradient of the Quarry. Contaminant levels have decreased since the removal of the wastes from the Quarry. The remaining source of groundwater contamination is residual material in the fractures and uranium that has precipitated or sorbed onto the alluvial materials north of the Femme Osage Slough.

Uranium entered the shallow aquifer via migration through bedrock fractures in the Kimmswick Limestone and the Decorah Group that constitute the Quarry. Uranium migration in groundwater north of the slough is limited by naturally reducing conditions. Under reducing conditions, uranium migration is slowed by chemical processes that favor uranium adsorption onto aquifer materials and precipitation of stable uranium minerals.

Nitroaromatic compounds in the groundwater system, primarily 2,4-DNT, result from the disposal of these wastes in the Quarry proper. Nitroaromatic compounds entered the shallow aquifer via migration through bedrock fractures in the Quarry. The mobility of nitroaromatic compounds in the bedrock aquifer is relatively high because these compounds do not tend to sorb to bedrock materials. The potential exists for microorganism activity to transform and degrade TNT and DNT in the alluvial materials north of the slough.

6.4.2.4 QROU Monitoring Program

Long-term monitoring at the Quarry is designed to (1) monitor uranium levels south of the slough to ensure that they remain protective of human health and the environment, and (2) monitor uranium and 2,4-DNT levels within the area of groundwater impact north of the slough until they attain target levels that have been identified as having a negligible impact on the groundwater south of the slough (DOE 2000a). To implement these two monitoring objectives, the wells were categorized into monitoring lines (Table 37 and Figure 62). Each line provides specific information relevant to long-term goals at the Quarry.

Table 37. Monitoring Line Categories for Wells at the Quarry

Background	Line 1	Line 2	Line 3	Line 4
MW-1012	MW-1004	MW-1032	MW-1017 (A)	RMW-1 (A)
	MW-1005	MW-1013	MW-1018 (A)	RMW-2 (A)
	MW-1027	MW-1048	MW-1019 (A)	RMW-3 (A)
	MW-1030	MW-1015	MW-1021 (A)	RMW-4 (A)
	MW-1002	MW-1031	MW-1044 (A)	
		MW-1028	MW-1050 (A)	
		MW-1046		
		MW-1047		
		MW-1008 (A)		
		MW-1051 (A)		
		MW-1014 (A)		
		MW-1006 (A)		
		MW-1052 (A)		
		MW-1007 (A)		
		MW-1016 (A)		
		MW-1009 (A)		
		MW-1045 (A)		
		MW-1049 (A)		

Abbreviation:
A = alluvial wells

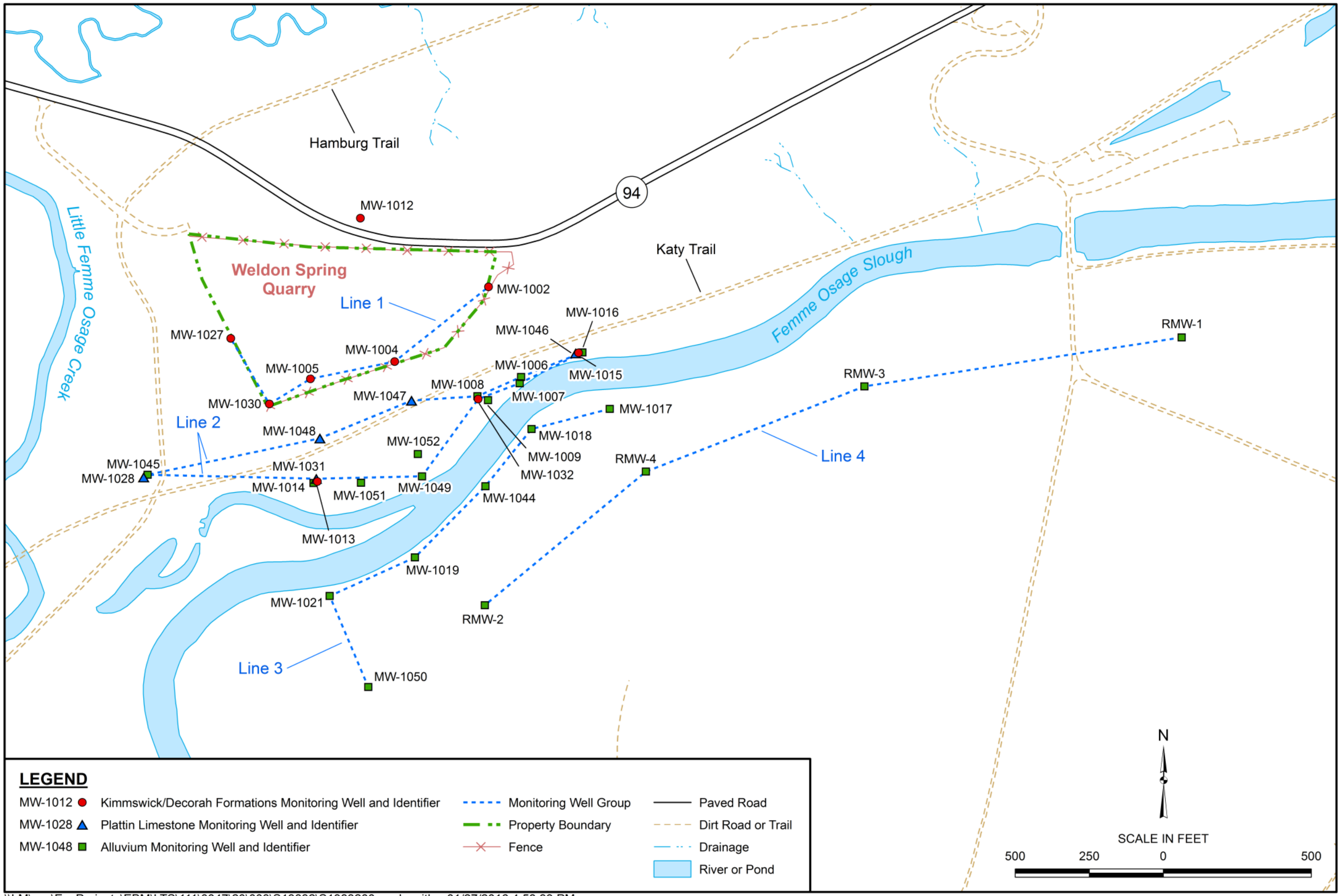

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Figure 62. QROU Monitoring Network

The sampling frequency for each location was selected to provide adequate reaction time on the basis of travel times from the residual sources and areas of impact to potential receptors. Monitoring wells on the Quarry rim (Line 1) were sampled semiannually starting in 2009 due to declining uranium levels. Monitoring wells between the Quarry and the Femme Osage Slough, the area of highest impact, are sampled quarterly. Locations south of the slough are sampled semiannually or annually. All locations in the Quarry Area were sampled for uranium, sulfate, and dissolved iron. A selected group of wells north of the slough was sampled for nitroaromatic compounds.

6.4.2.5 Monitoring Results for Groundwater in the Area of Impact at the Quarry

Contaminant concentrations are monitored using 24 wells screened in either the bedrock or alluvial materials in the area of uranium and 2,4-DNT impact north of the Femme Osage Slough. The data are discussed in the following sections.

Uranium Results Line 1 Wells

Uranium is monitored in both the bedrock and the adjoining alluvial materials north of the Femme Osage Slough. These wells are monitoring the declining concentrations in groundwater north of the slough until there is a negligible potential for impact on the groundwater south of the slough.

Levels of uranium in the Line 1 wells along the Quarry rim continue to be high. The annual averages for total uranium from 2011 through 2015 are summarized in Table 38. Wells with higher uranium values are shown on Figure 63. MW-1004 and MW-1005 had uranium levels that exceeded the target level of 300 pCi/L. Wells with lower uranium values are shown on Figure 64. Uranium levels in the Line 1 wells have shown a general decrease except for MW-1030, which stopped decreasing in 2007 at a level below the 20 pCi/L uranium cleanup standard. Since 2006, the annual average levels of uranium in MW-1002, MW-1027, and MW-1030 have been less than the target level of 300 pCi/L established for groundwater north of the Femme Osage Slough. Uranium levels in MW-1002 and MW-1030 have consistently been less than the MCL of 20 pCi/L since 2001.

Table 38. Average Total Uranium in the QROU Line 1 Wells

Location	Line	Geologic Unit	Average Uranium (pCi/L)				
			2011	2012	2013	2014	2015
MW-1004	1	Kimmswick-Decorah	**544**	**513**	**513**	**479**	**508**
MW-1005	1	Kimmswick-Decorah	**442**	**697**	**391**	**405**	**366**
MW-1027	1	Kimmswick-Decorah	112	88	104	82	67
MW-1030	1	Kimmswick-Decorah	6.9	2.7	7.0	7.4	6.1
MW-1002	1	Kimmswick-Decorah	2.8	2.8	2.5	2.4	2.3
MW-1012	1[a]	Kimmswick-Decorah	2.1	2.3	2.4	2.1	1.9

Notes:
[a] Upgradient location.
Concentrations in **bold** exceed the target level of 300 pCi/L.

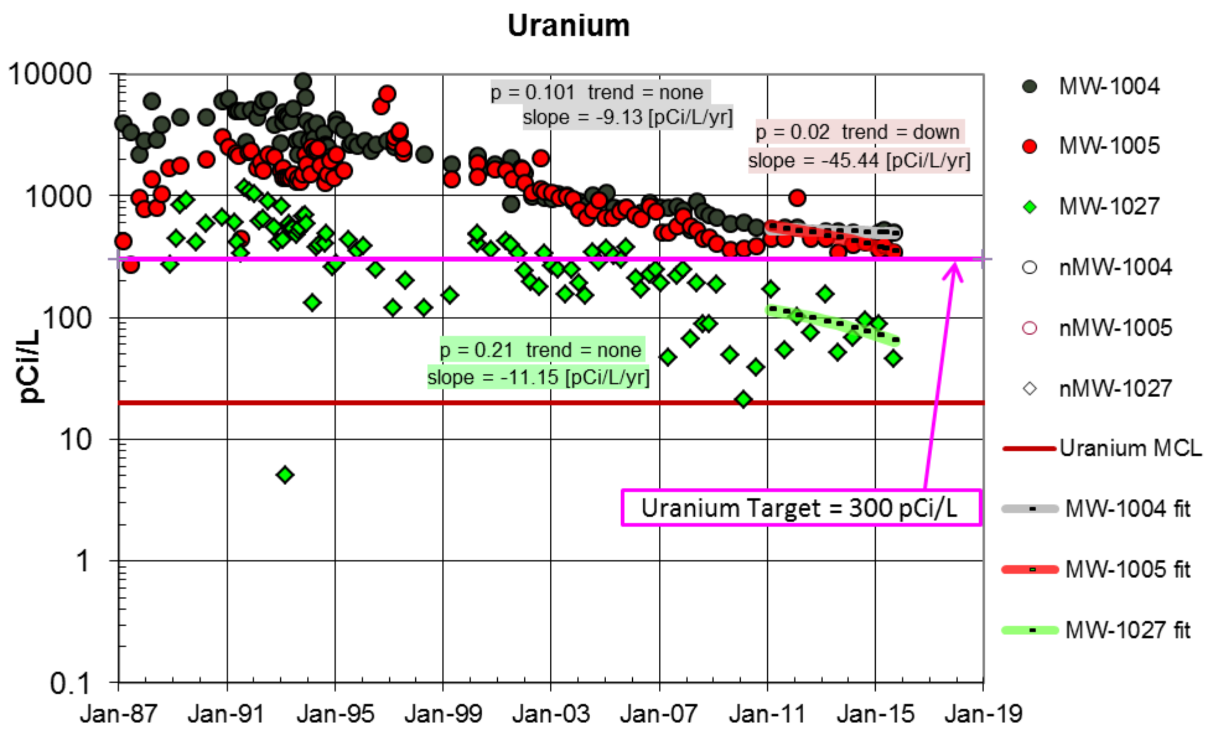

Figure 63. Uranium in Line 1 Monitoring Wells—Higher Concentrations

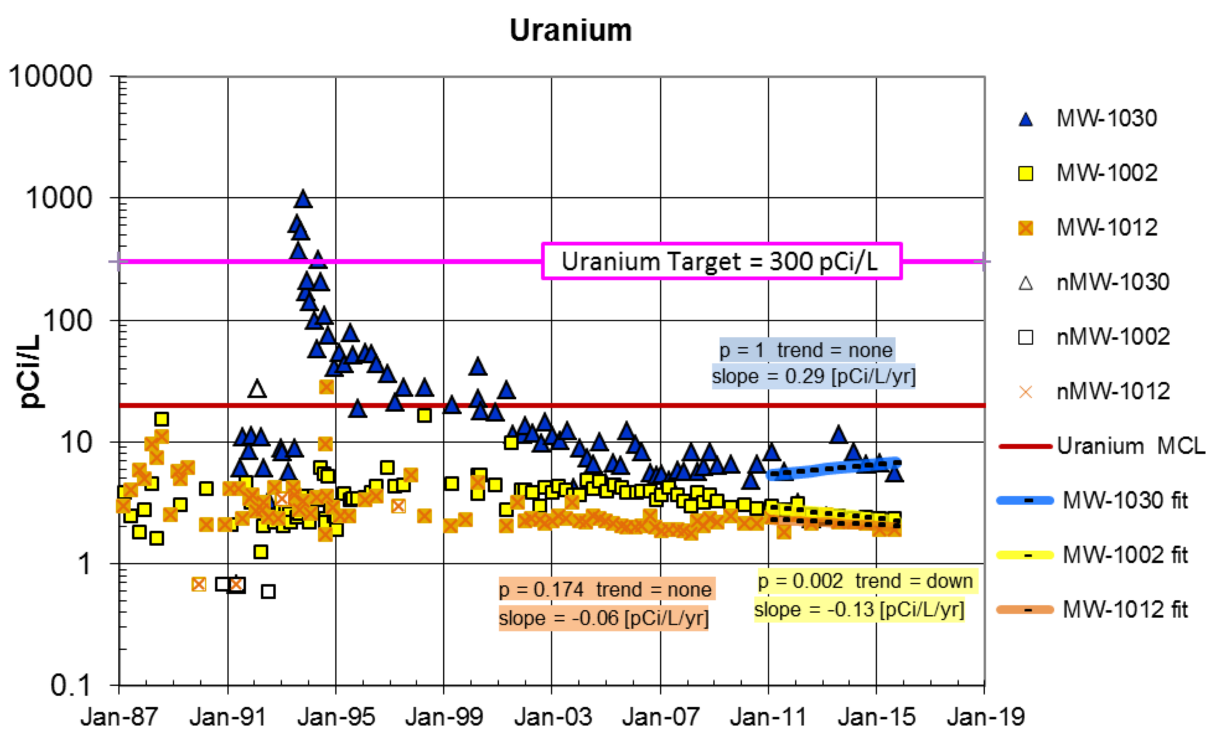

Figure 64. Uranium in Line 1 Monitoring Wells—Lower Concentrations

The results of trend analysis for the Line 1 wells (on Figure 63 and Figure 64) indicate that uranium concentrations in recent years have been decreasing in most of the wells, as indicated by negative slopes. Statistically downward trends have been calculated for MW-1002 and MW-1005. If the current decreases in uranium continue in these wells, it is estimated that the target level of 300 pCi/L could be reached in 5 to 10 years, though the decline in MW-1004 uranium levels has slowed over the last 5 years.

Uranium Results Line 2 Bedrock Wells

Bedrock wells located between the Quarry rim and Femme Osage Slough continue to have elevated uranium levels. The annual averages for uranium from 2011 through 2015 are summarized in Table 39. In the 2011 through 2015 time period, only MW-1032 exceeded the target level of 300 pCi/L. Wells with higher concentrations (Figure 65) have generally been decreasing since 2000. If MW-1032 continues to decline at its historical rate, it will be below the 300 pCi/L target level by the next Five-Year Review. The higher-uranium-concentration wells are all screened in the shallower Kimmswick-Decorah (well depths 25 to 35 ft) except for MW-1048, which is screened in the deeper Plattin Formation. It is directly south and downgradient of the Quarry.

All of the lower-uranium-concentration wells are screened in the Plattin Formation (well depths 47 to 55 ft), and all are below the 20 pCi/L uranium MCL (Figure 66). Uranium concentrations in MW-1047 began acting erratically in 2013, rising suddenly then dropping off two different times, with one result above the 20 pCi/L MCL. It is south and directly downgradient of the Quarry (as is higher-concentration well MW-1048), so it would not be unexpected for it to occasionally have higher concentrations. The down trend for MW-1046 is beginning to stabilize as it has reached background levels. MW-1028 has an uptrend for the last 5 years of data but is still at low levels that are below historical averages.

Uranium levels in the Line 2 bedrock wells have generally decreased since 2000 (Figure 65). The highest levels of uranium are in MW-1032, which is beneath the area of highest uranium impact in the overlying alluvium. It is expected that the average uranium concentrations in all Line 2 bedrock wells will be less than the target level of 300 pCi/L in the next 5 years.

Table 39. Average Total Uranium in QROU Line 2 Bedrock Wells

Location	Line	Geologic Unit	Average Uranium (pCi/L)				
			2011	2012	2013	2014	2015
MW-1032	2	Kimmswick-Decorah	**546**	**462**	**388**	**364**	**345**
MW-1013	2	Kimmswick-Decorah	204	265	222	191	272
MW-1048	2	Plattin	162	182	177	134	149
MW-1015	2	Kimmswick-Decorah	125	109	94	102	82
MW-1031	2	Plattin	10	10	11	9.6	9.0
MW-1028	2	Plattin	1.7	2.2	2.0	2.3	2.6
MW-1046	2	Plattin	1.2	1.0	0.8	0.6	0.6
MW-1047	2	Plattin	0.7	0.7	1.5	14	4.7

Note:
Concentrations in **bold** exceed the target level of 300 pCi/L

Abbreviation:
pCi/L = picocuries per liter

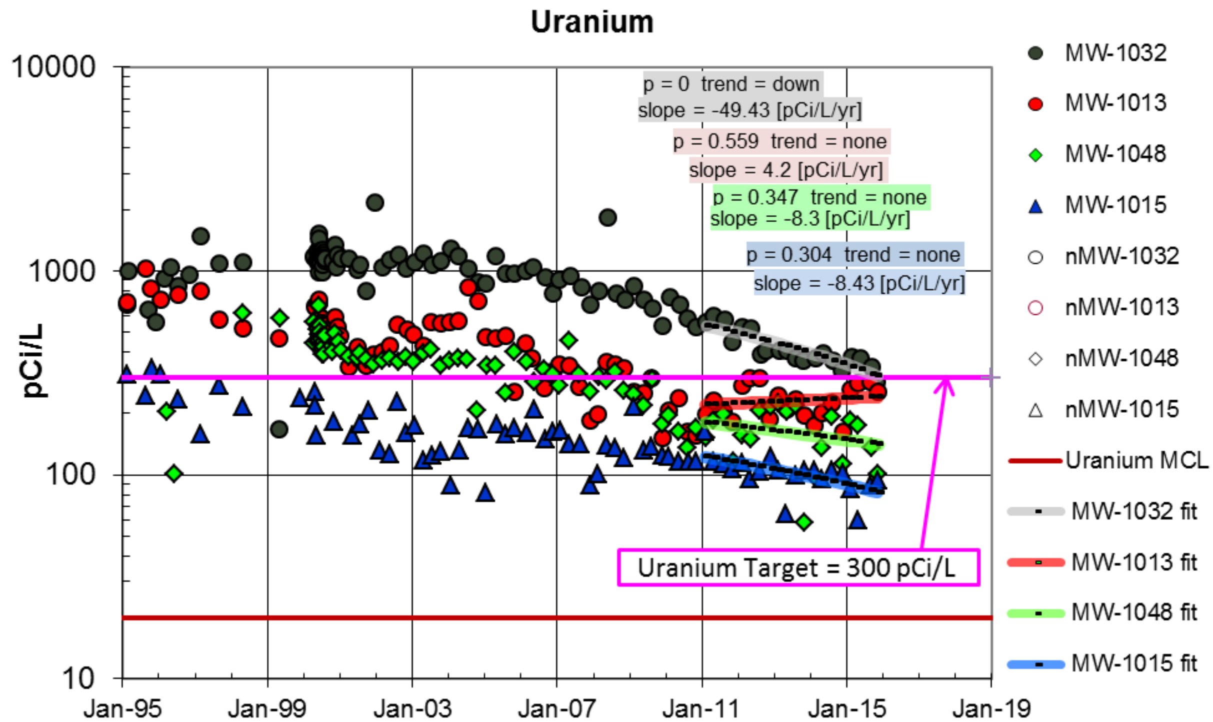

Figure 65. Uranium in Line 2 Bedrock Wells—Higher Concentrations

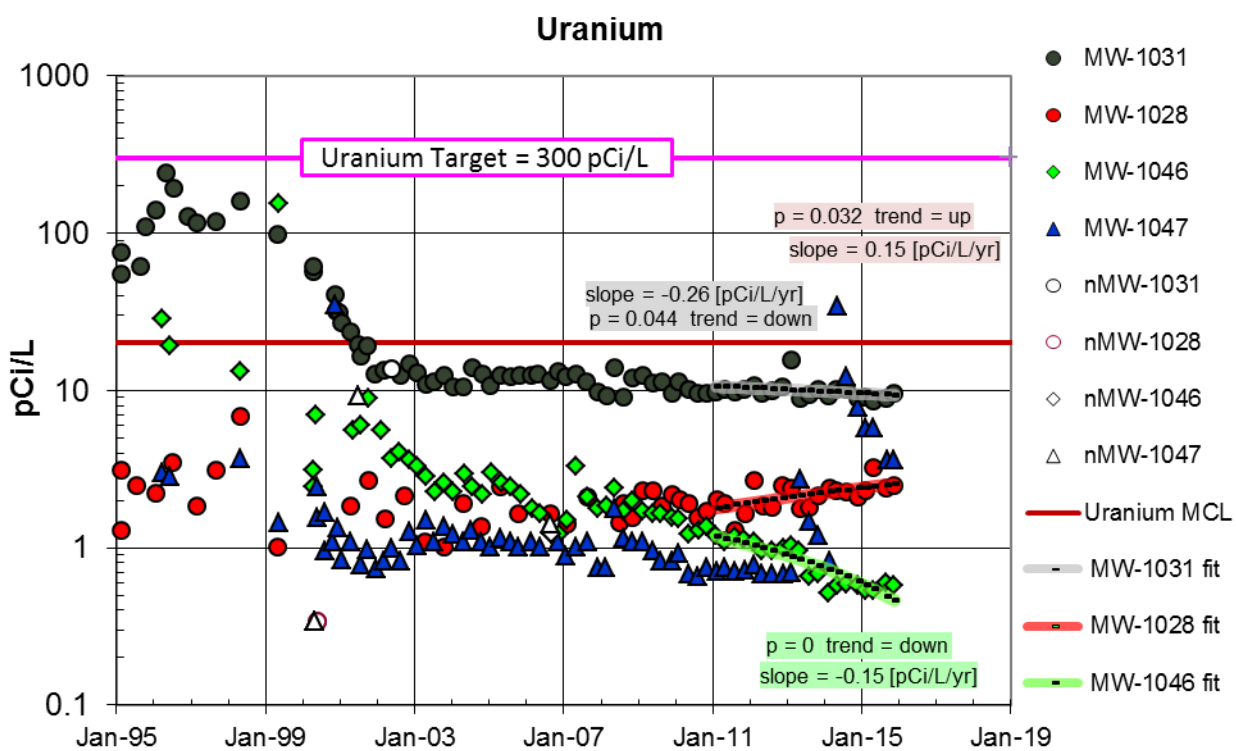

Figure 66. Uranium in Line 2 Bedrock Wells—Lower Concentrations

Uranium Results Line 2 Alluvial Wells

The highest levels of uranium in groundwater are in the alluvial aquifer between the Quarry rim and Femme Osage Slough. The annual averages for uranium in the alluvial wells from 2011 through 2015 are summarized in Table 40. Uranium concentrations in the wells above the 300 pCi/L target level (Figure 67) have been relatively stable for over 25 years with no long-term increasing or decreasing trends, though concentrations do vary by an order of magnitude. The highly variable uranium concentrations in wells MW-1051 and MW-1052 typically (though not always) are lower when water levels are low (Figure 68). The extreme variability in 2000 was related to multiple samples being collected during testing after their April 2000 installation.

Uranium concentrations in wells below the 300 pCi/L target level (Figure 69) have also been relatively stable over the past 25 years, in that a concentration from today would fit within the historical range of the past 25 years, though most vary over an order of magnitude. Concentrations in well MW-1007 vary over 3 orders of magnitude and occasionally exceed the target level. Concentrations in MW-1007 do not appear to be correlated with water levels, though it is only 10 ft deep and adjacent to the slough. Uranium results in well MW-1049 have mostly been below the uranium detection limit for more than the past 10 years. It is 15 ft deeper (total depth is 37 ft) than any of the other alluvial wells.

Table 40. Average Total Uranium in QROU Line 2 Alluvial Wells

Location	Line	Geologic Unit	Average Uranium (pCi/L)				
			2011	2012	2013	2014	2015
MW-1008	2	Alluvium	**2139**	**1360**	**1950**	**2457**	**3485**
MW-1051	2	Alluvium	**857**	**736**	**1049**	**962**	**1501**
MW-1014	2	Alluvium	**1095**	**1037**	**957**	**634**	**1170**
MW-1006	2	Alluvium	**876**	**935**	**1071**	**1179**	**1023**
MW-1052	2	Alluvium	**759**	**989**	**1306**	177	**1646**
MW-1007	2	Alluvium	26	6.7	50	**473**	**368**
MW-1016	2	Alluvium	131	109	103	86	94
MW-1009	2	Alluvium	1.1	0.9	5.4	5.0	55
MW-1045	2	Alluvium	1.4	3.8	2.2	3.6	2.9
MW-1049	2	Alluvium	NA	NA	NA	NA	NA

Note:
Concentrations in **bold** exceed the target level of 300 pCi/L.

Abbreviation:
NA = most or all results were below detection or qualified as estimated

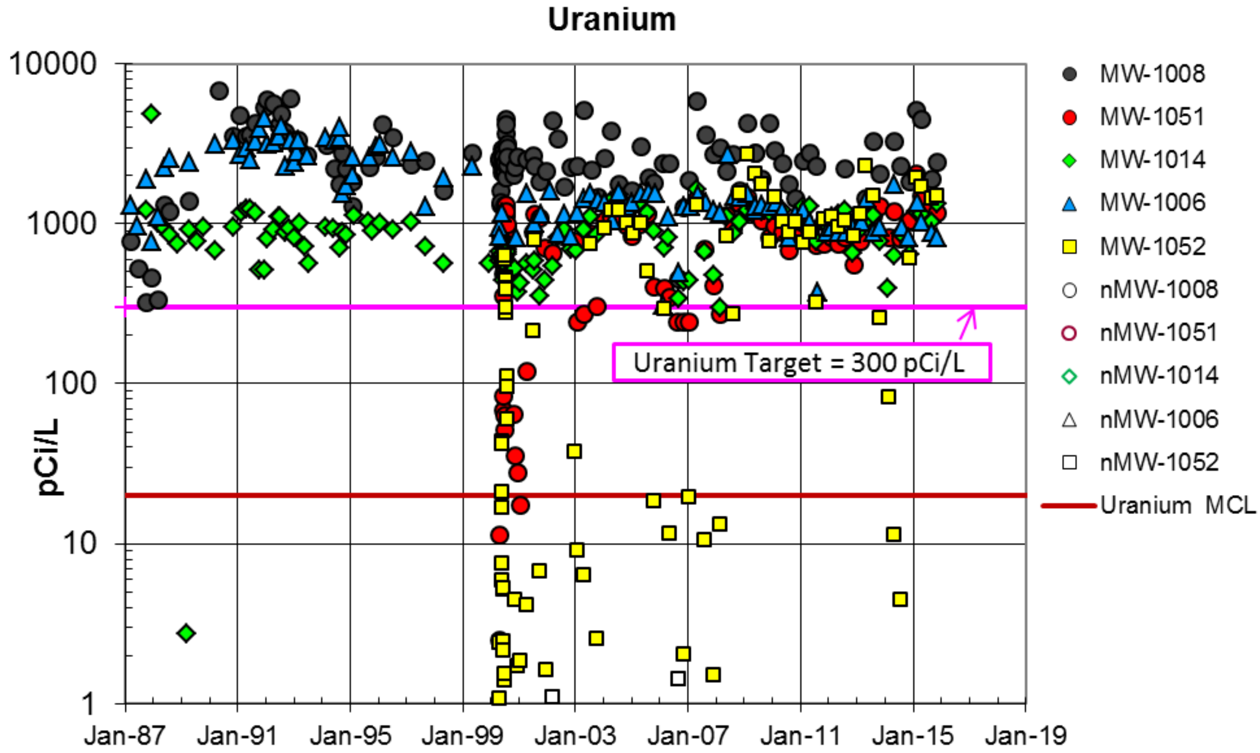

Figure 67. Uranium in Line 2 Alluvial Wells—Higher Concentrations

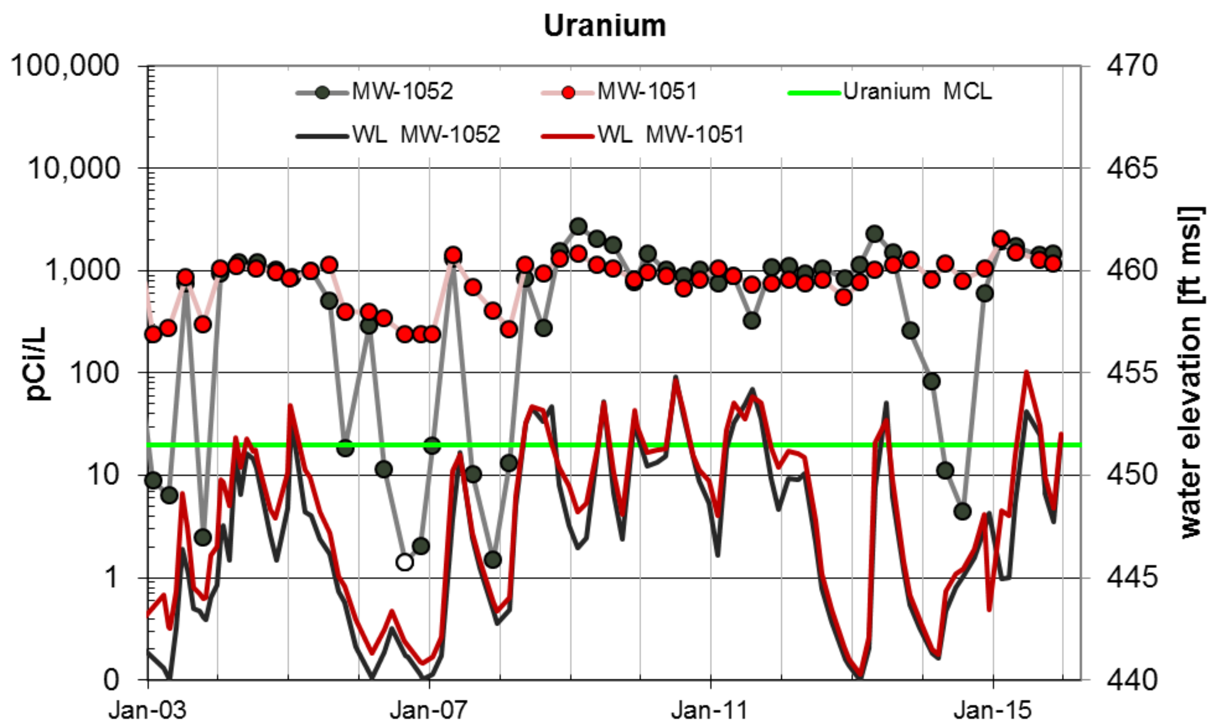

Figure 68. Variable Uranium Concentrations in MW-1052 and MW-1051

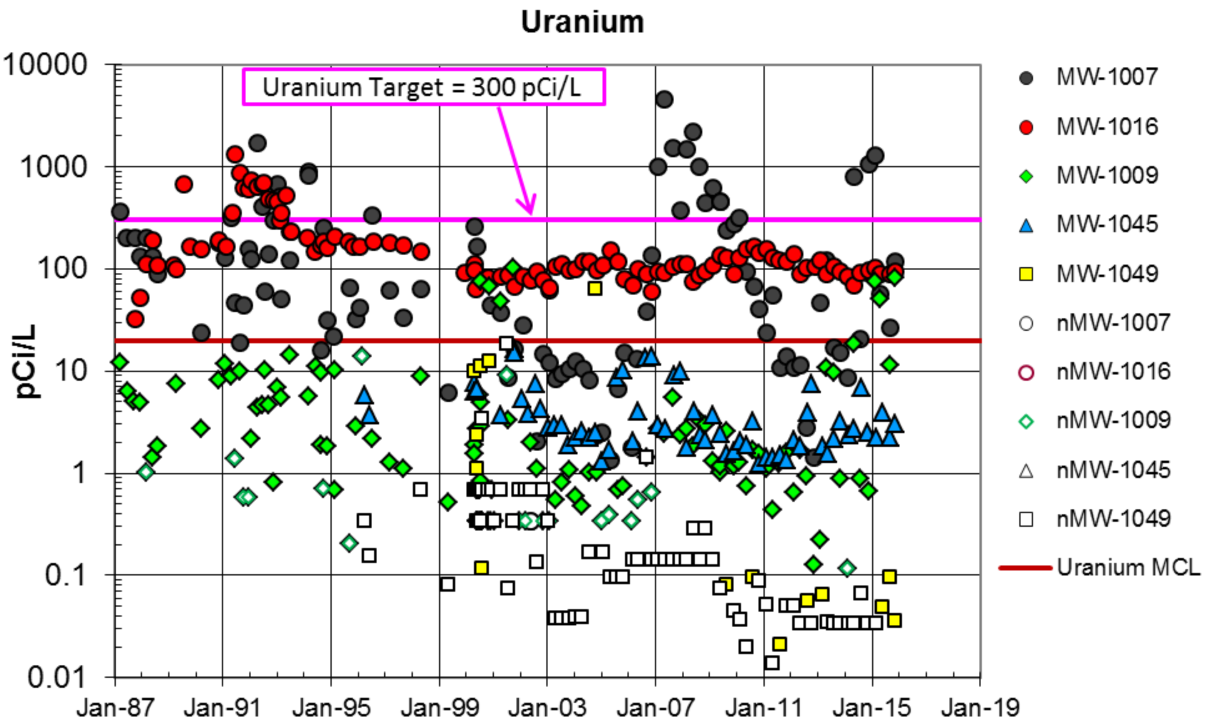

Figure 69. Uranium in Line 2 Alluvial Wells—Lower Concentrations

The alluvial wells are screened primarily in the oxidized portion of the groundwater system, where changes in groundwater elevations have typically affected the uranium levels measured in the wells. Geochemical data from these wells support the presence of dissolved uranium in the groundwater. The geochemistry of the groundwater in this area exhibits high oxidation-reduction potential (ORP) values and sulfate concentrations and low dissolved iron concentrations, indicators of an oxidizing environment.

Uranium Attainment Objectives

The attainment objective for the long-term monitoring of uranium in 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 (DOE 2000b). The average uranium levels in eight wells north of the slough exceeded the target level in 2015 (one bedrock well and seven alluvial wells). The 90th percentile associated with the data from the Line 1 and 2 wells was 1,470 pCi/L. This value is higher than those determined for 2010 through 2014, which had been decreasing since 2009 (Figure 70). Looking at the 90th percentile for Lines 1 and 2 separately indicates that the increased metric was the result of changes in uranium levels in the Line 2 wells, primarily the uranium levels measured in the Line 2 alluvial wells. Concentration levels in these wells have historically varied about an order of magnitude or more (Figure 67 and Figure 69). The changes in the Line 2 bedrock wells, whose 90th percentile dropped below the 300 pCi/L target in 2015, are similar to those seen in the Line 1 wells. In general, the levels in Line 1 and the Line 2 bedrock wells have decreased, whereas the levels in the Line 2 alluvium are within the historical range.

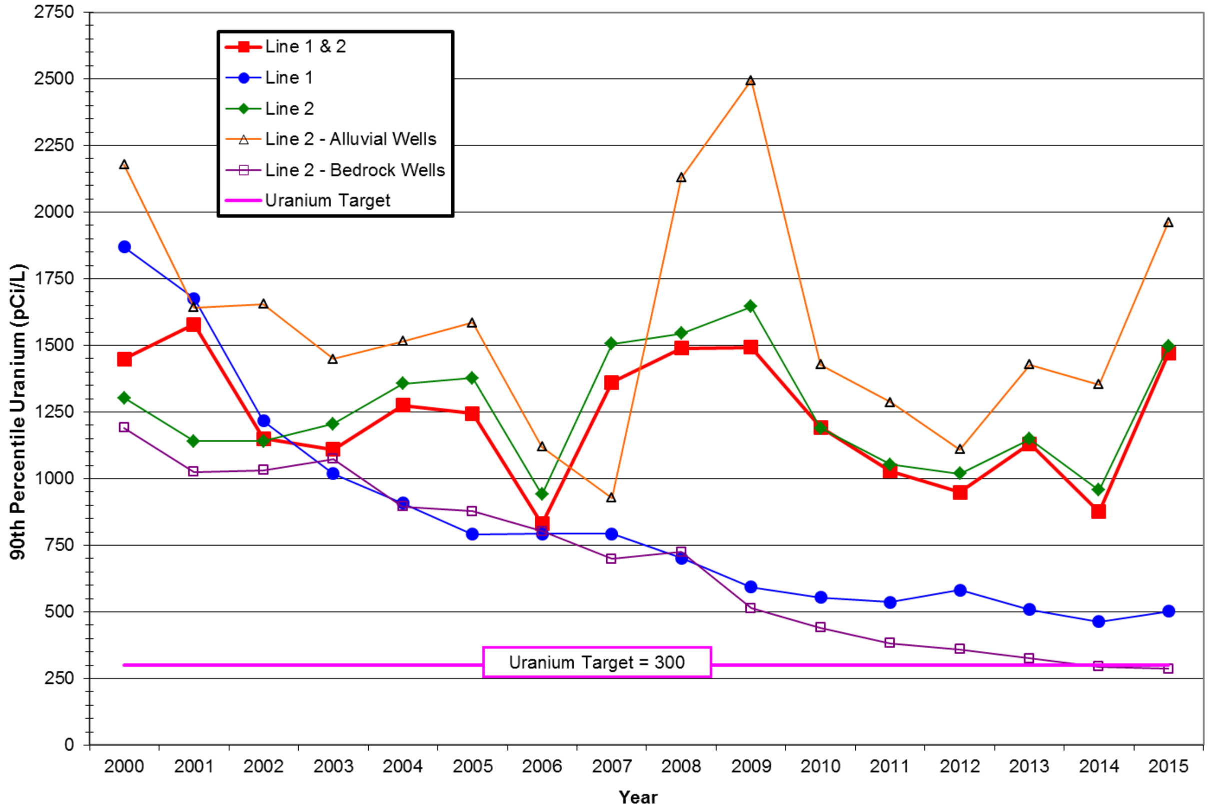

Figure 70. 90th Percentile of Uranium in Line 1 and 2 Wells (2000–2015)

Overall, the decreasing uranium levels in the Quarry rim and area north of the Femme Osage Slough are the result of bulk waste removal and restoration activities in the Quarry proper. Remedial activities in the Quarry have reduced and possibly prevented infiltration of precipitation and storm water into the residually contaminated fracture system in the Quarry proper. Uranium does not bind as readily to the bedrock as it does to the alluvial materials; therefore, decreases should occur more readily in the bedrock as groundwater flushes through the system. The distribution of uranium in groundwater is still predominantly controlled by the precipitation of uranium along the oxidizing-reducing front north of the Femme Osage Slough. Although uranium levels have increased in some of the alluvial wells north of the slough, levels are within historical ranges. Sample results from monitoring in wells screened in the reducing portion of the area north of the slough indicate that uranium levels continue to remain low.

Nitroaromatic Compounds

Samples from eight monitoring wells were analyzed for the nitroaromatic compound 2,4-DNT. Two of these monitoring wells, MW-1027 and MW-1006, have historically had 2,4-DNT concentrations above the 0.11 µg/L cleanup standard, though the levels are generally declining and were below 0.11 µg/L during 2015 (Figure 71). Levels in these wells are variable, and occasional results above the cleanup standard over the next 5 to 10 years would not be unexpected. The only other detections during the previous 5 years were at MW-1004 and were qualified as estimated. The remaining wells monitor upgradient and downgradient water quality along the Quarry rim or between the Quarry and Femme Osage Slough. Historical results of

2,4-DNT (Figure 72) and 2,6-DNT (Figure 73) document the success of the bulk waste removal from the Quarry.

The attainment objective for the long-term monitoring of 2,4-DNT in 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 (DOE 2000b). The eight monitoring wells selected for continued long-term monitoring were used to calculate this metric. The 90th percentile associated with the data from the eight wells was below the objective in 3 of the 5 most recent years. These values continue to be at the low end of the historical range (Figure 74). Present concentrations in groundwater pose little potential impact to groundwater in the Missouri River alluvium.

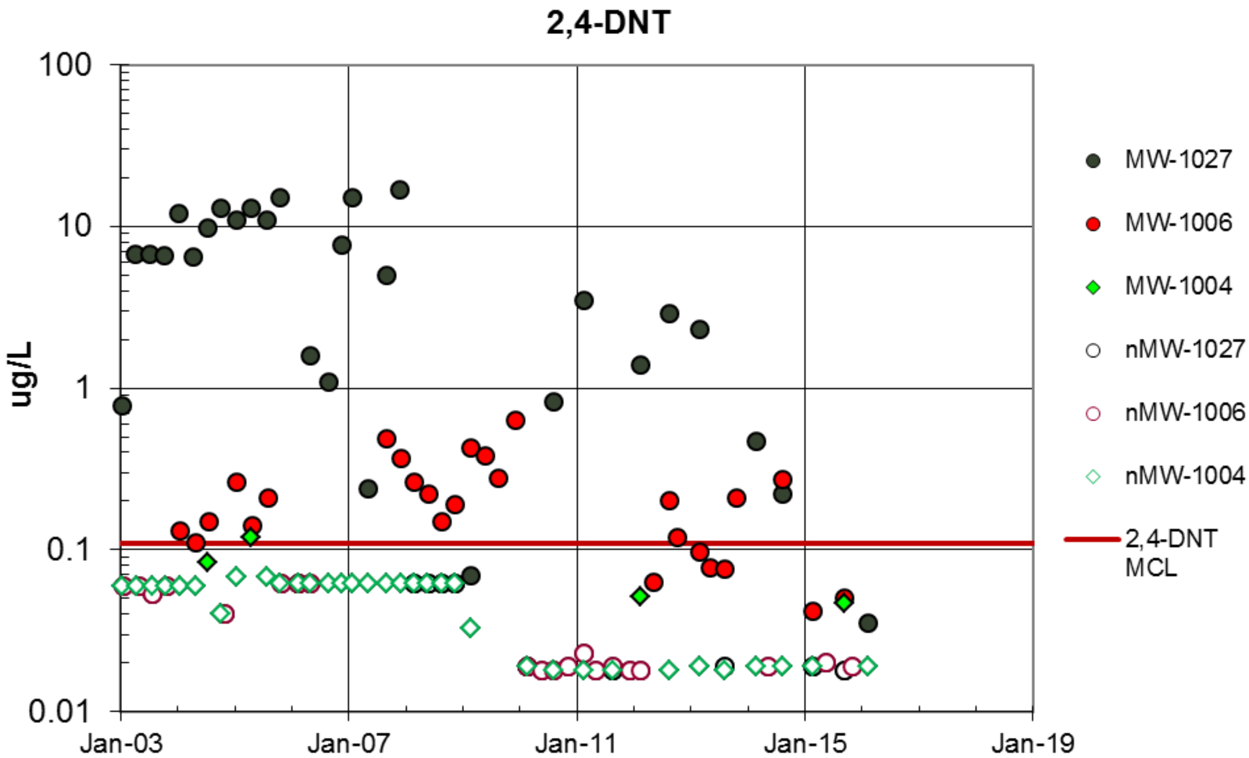

Figure 71. 2,4-DNT in MW-1027, MW-1006, and MW-1004

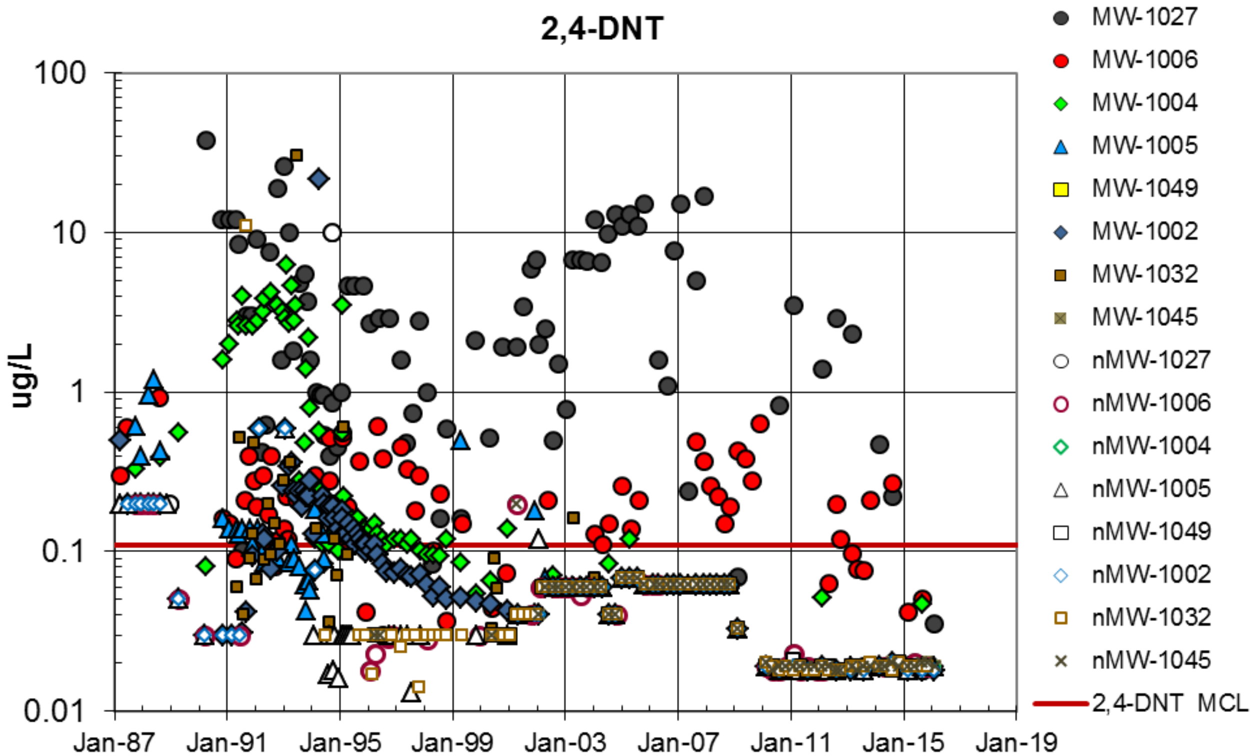

Figure 72. Historical 2,4-DNT Results for the Eight Selected Monitoring Wells

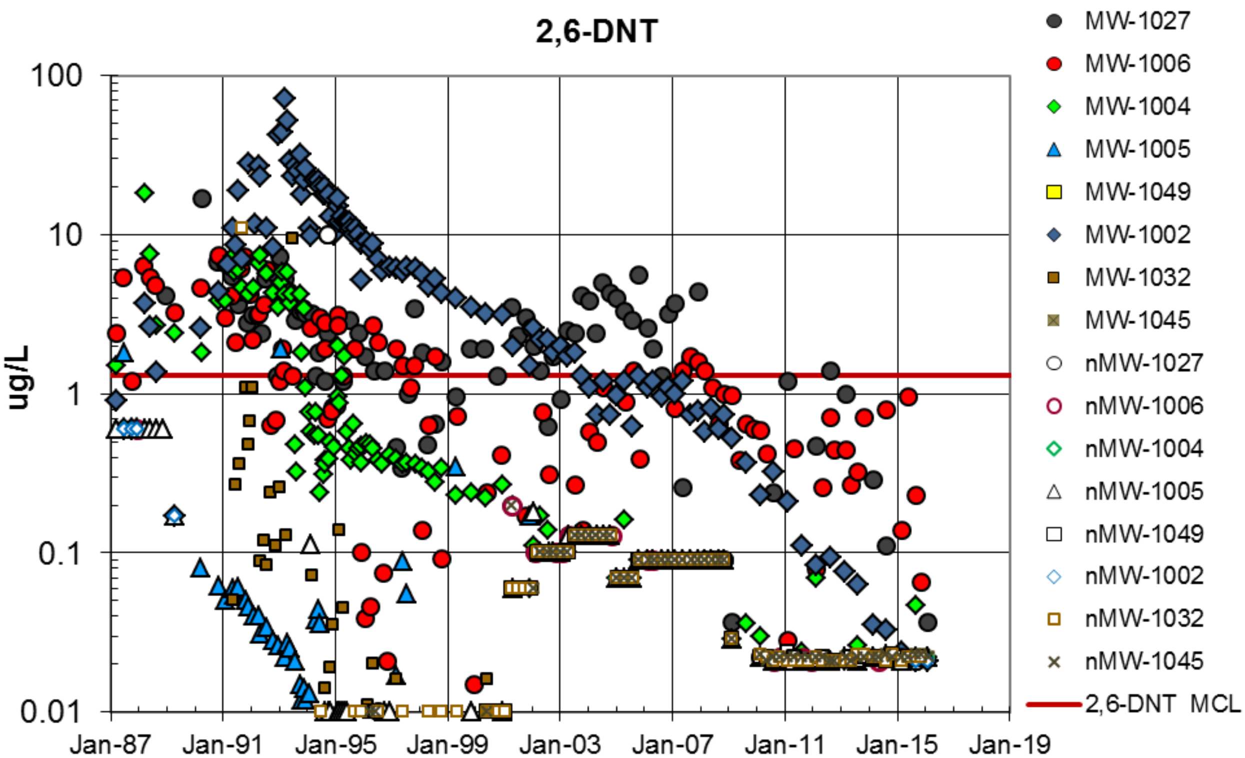

Figure 73. Historical 2,6-DNT Results for the Eight Selected Monitoring Wells

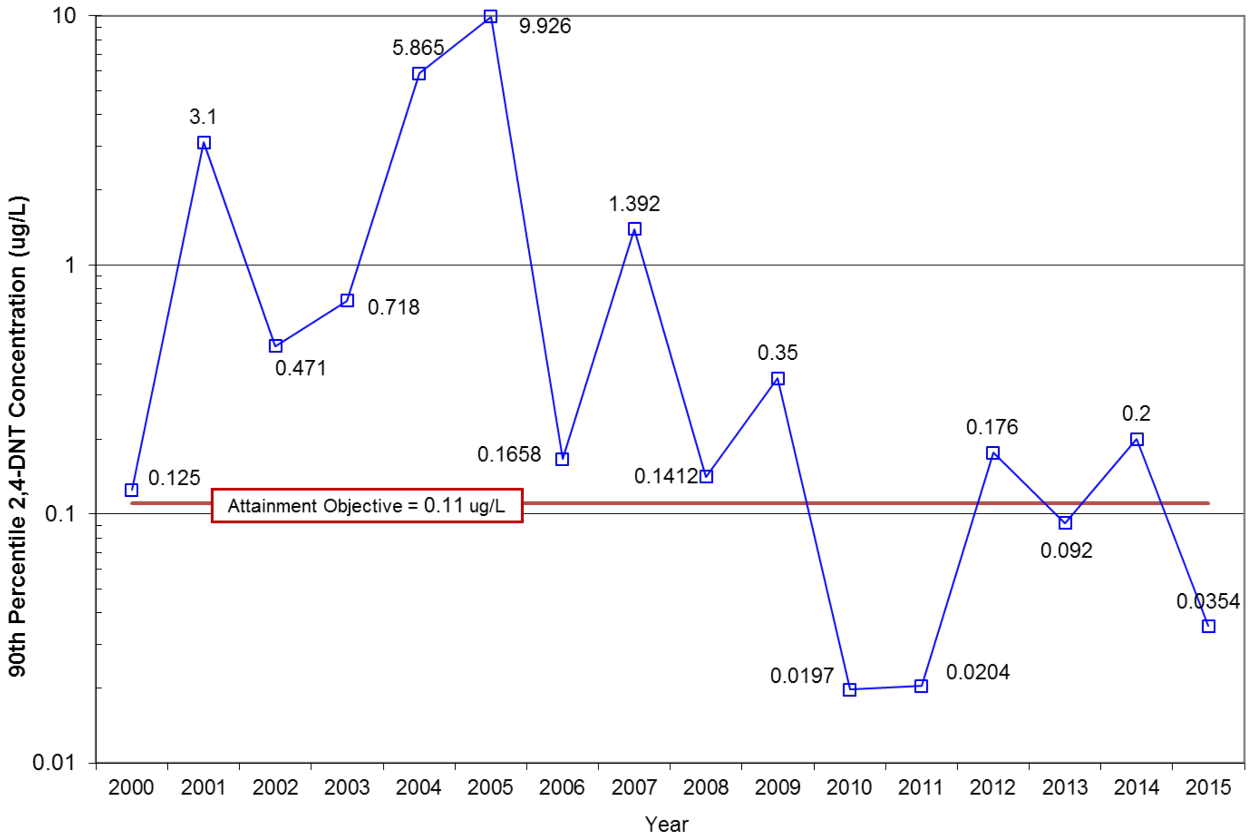

Figure 74. 90th Percentile of 2,4-DNT in Long-Term Monitoring Wells

Geochemical Parameters

The geochemistry of the shallow aquifer is monitored to verify the presence of the reduction zone and to confirm that the reduction zone is capable of the ongoing attenuation of uranium in groundwater. Groundwater is analyzed for sulfate, dissolved iron, ferrous iron, and Eh (a measure of the oxidation-reduction state of groundwater constituents). Sulfate is monitored as an indicator of oxidation-reduction conditions in the groundwater in the vicinity of the Quarry. Higher sulfate concentrations are generally observed in an oxidizing environment. Sulfate concentrations generally track uranium concentrations in wells with variable uranium concentrations (high sulfate, high uranium and low sulfate, low uranium). Iron (total dissolved and ferrous) is also monitored as an indicator of oxidation-reduction conditions in the groundwater. Iron concentrations typically increase in a reducing environment. These results generally correlate with observed uranium concentrations upgradient and downgradient of the reduction zone, as uranium is typically more mobile in an oxidizing environment and precipitates in a reducing environment. Geochemical parameter summaries for each Line 1 and Line 2 monitoring location are presented in: Table 41 and Figure 75 through Figure 79 for sulfate, Table 42 and Figure 81 through Figure 84 for iron, and Table 43 for ORP. Figure 80 shows the association of uranium and sulfate in well MW-1007.

Table 41. Average Values for Sulfate at the Weldon Spring Quarry

Location	Line	Geologic Unit	Sulfate (mg/L)				
			2011	2012	2013	2014	2015
MW-1004	1	Kimmswick-Decorah	103	95	86	97	93
MW-1005	1	Kimmswick-Decorah	92	125	100	125	81
MW-1027	1	Kimmswick-Decorah	63	63	61	67	55
MW-1030	1	Kimmswick-Decorah	119	51	52	69	42
MW-1002	1	Kimmswick-Decorah	93	91	79	94	75
MW-1012 [a]	1	Kimmswick-Decorah	40	38	34	40	35
MW-1032	2	Kimmswick-Decorah	98	99	90	101	101
MW-1013	2	Kimmswick-Decorah	61	65	60	60	62
MW-1048	2	Plattin	58	51	43	44	49
MW-1015	2	Kimmswick-Decorah	68	66	88	78	81
MW-1031	2	Kimmswick-Decorah	30	29	30	23	28
MW-1028	2	Plattin	29	36	31	38	24
MW-1046	2	Plattin	59	58	47	35	36
MW-1047	2	Plattin	73	72	76	80	80
MW-1008	2	Alluvium	71	59	70	97	94
MW-1051	2	Alluvium	85	89	112	130	151
MW-1014	2	Alluvium	97	99	112	103	125
MW-1006	2	Alluvium	47	72	75	123	96
MW-1052	2	Alluvium	43	35	47	35	53
MW-1007	2	Alluvium	14	16	18	179	40
MW-1016	2	Alluvium	78	79	78	64	66
MW-1009	2	Alluvium	15	9	20	30	27
MW-1045	2	Alluvium	23	27	22	34	23
MW-1049	2	Alluvium	0.8	5	4	7	ND

Note:
[a] MW-1012 is upgradient.

Abbreviation:
ND = not detected

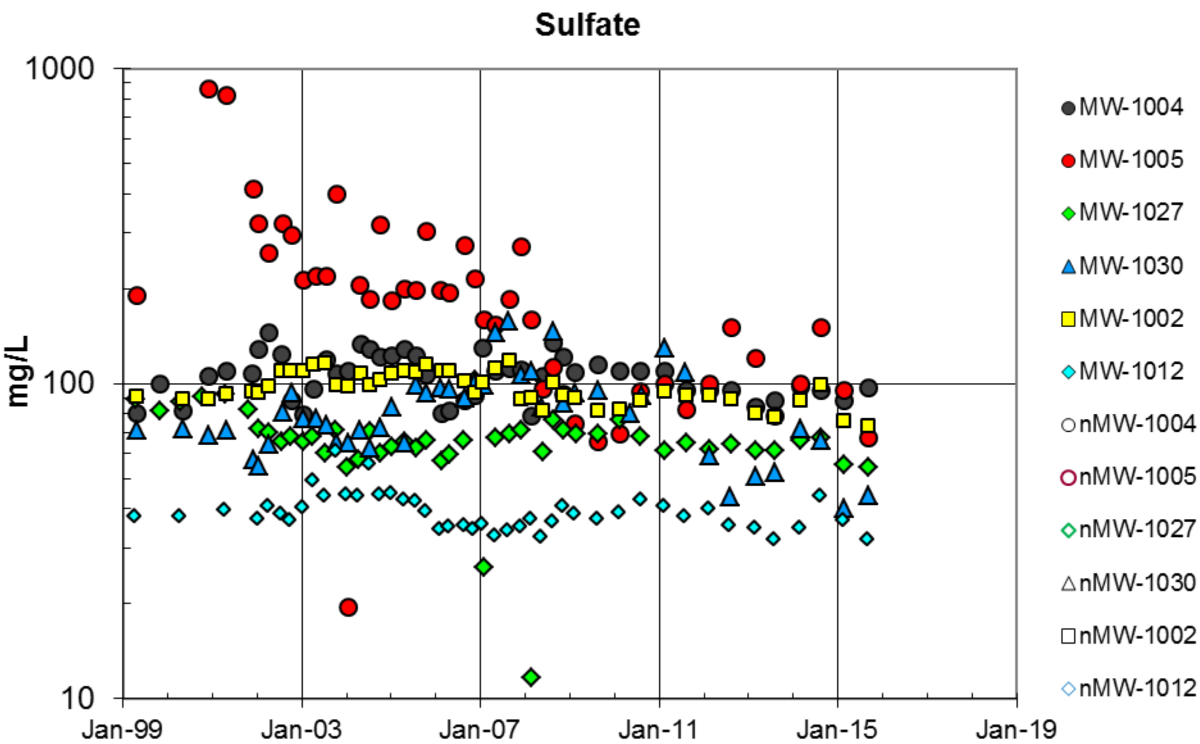

Figure 75. Sulfate in Line 1 Wells (Bedrock), MW-1012 is Upgradient

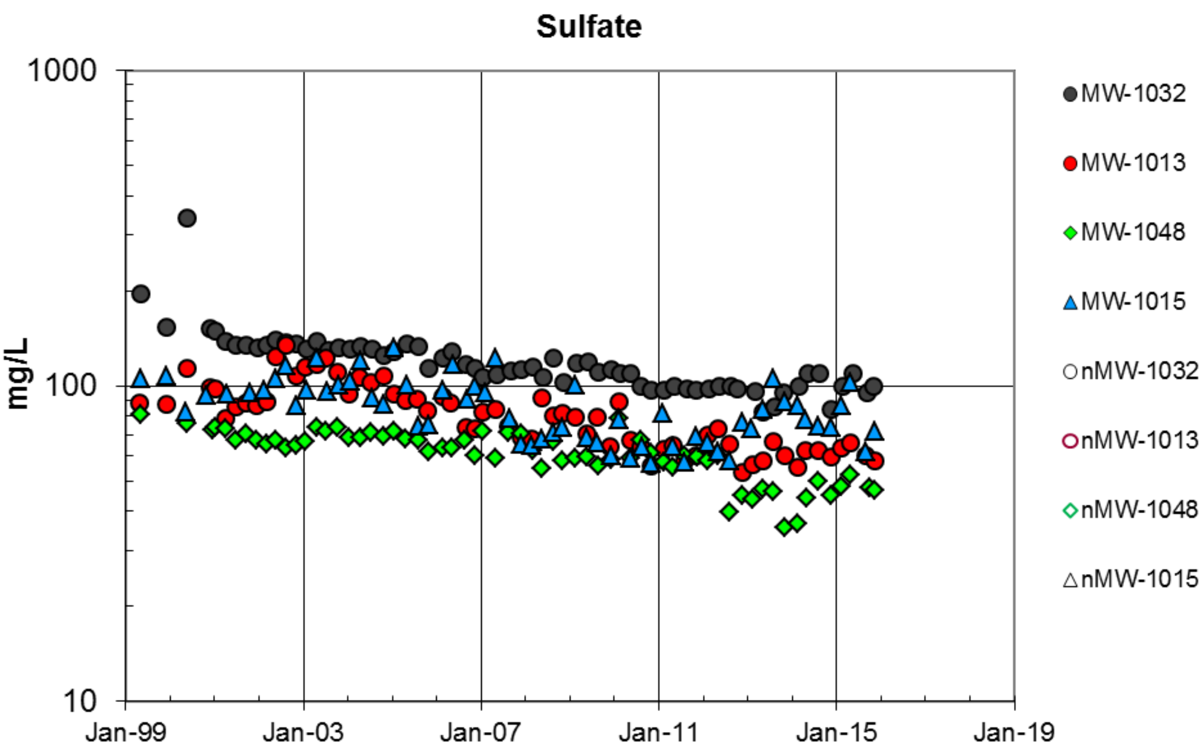

Figure 76. Sulfate in Line 2 Bedrock Wells—Higher-Uranium Concentration Wells

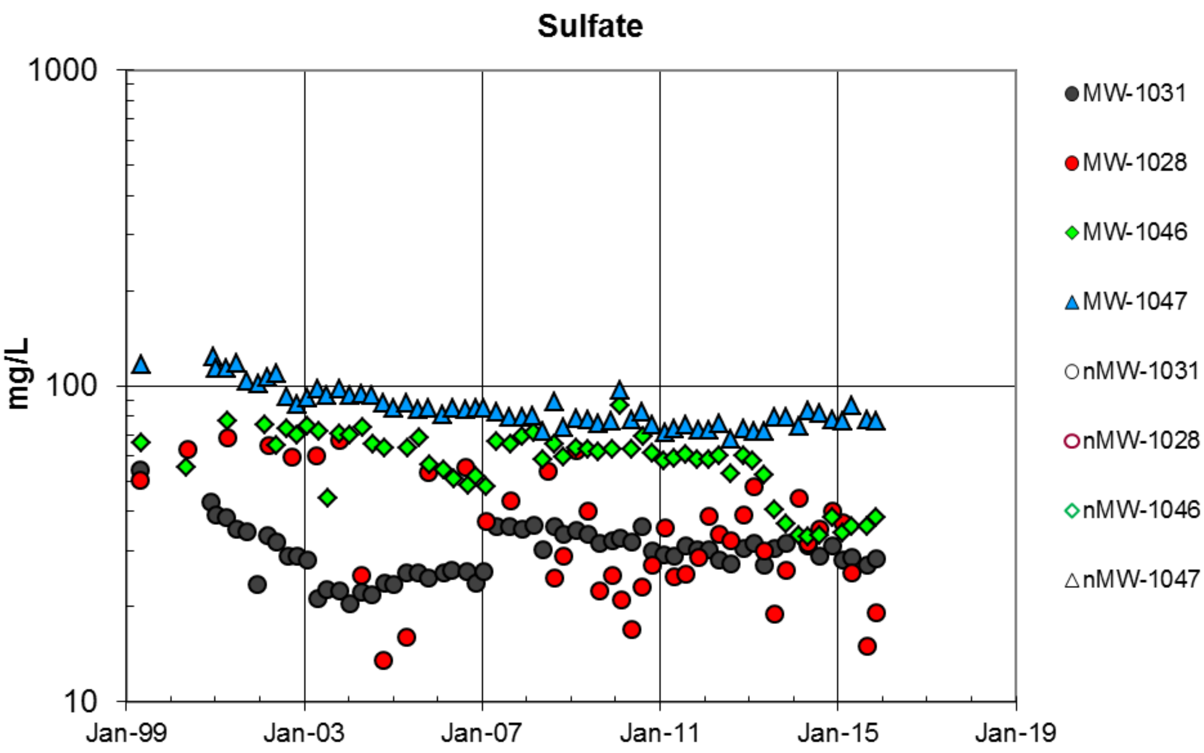

Figure 77. Sulfate in Line 2 Bedrock Wells—Lower-Uranium Concentration Wells

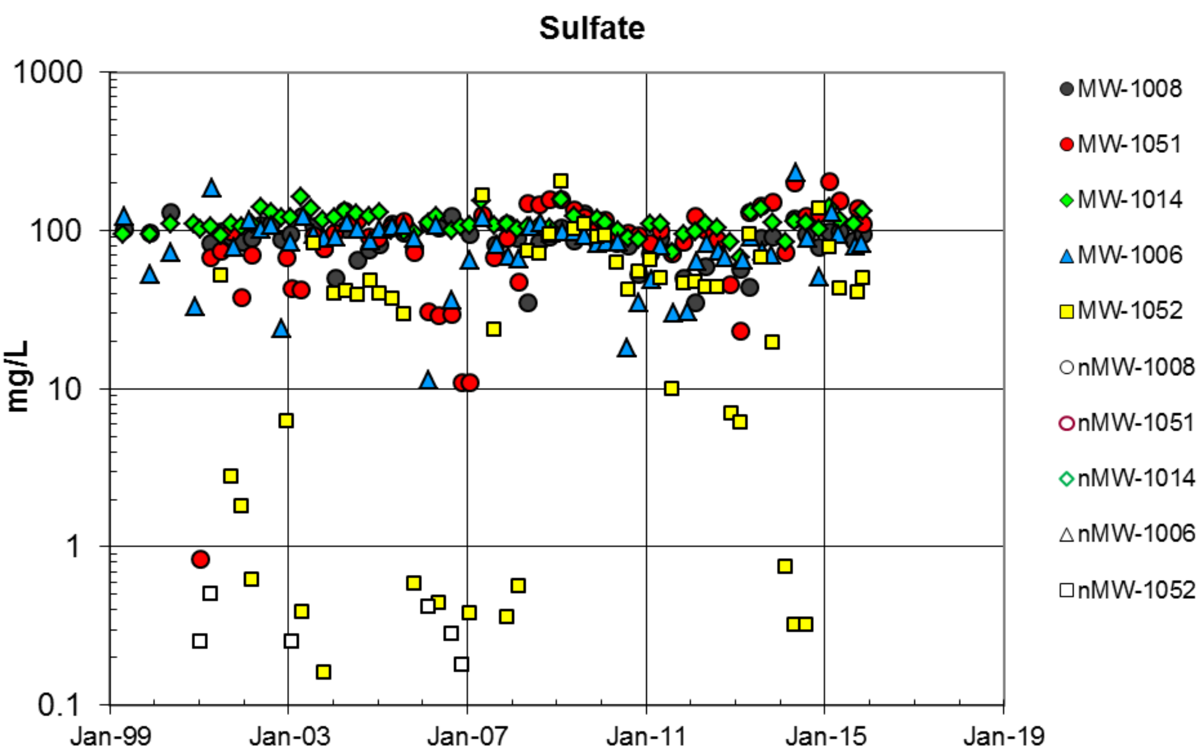

Figure 78. Sulfate in Line 2 Alluvial Wells—Higher-Uranium Concentration Wells

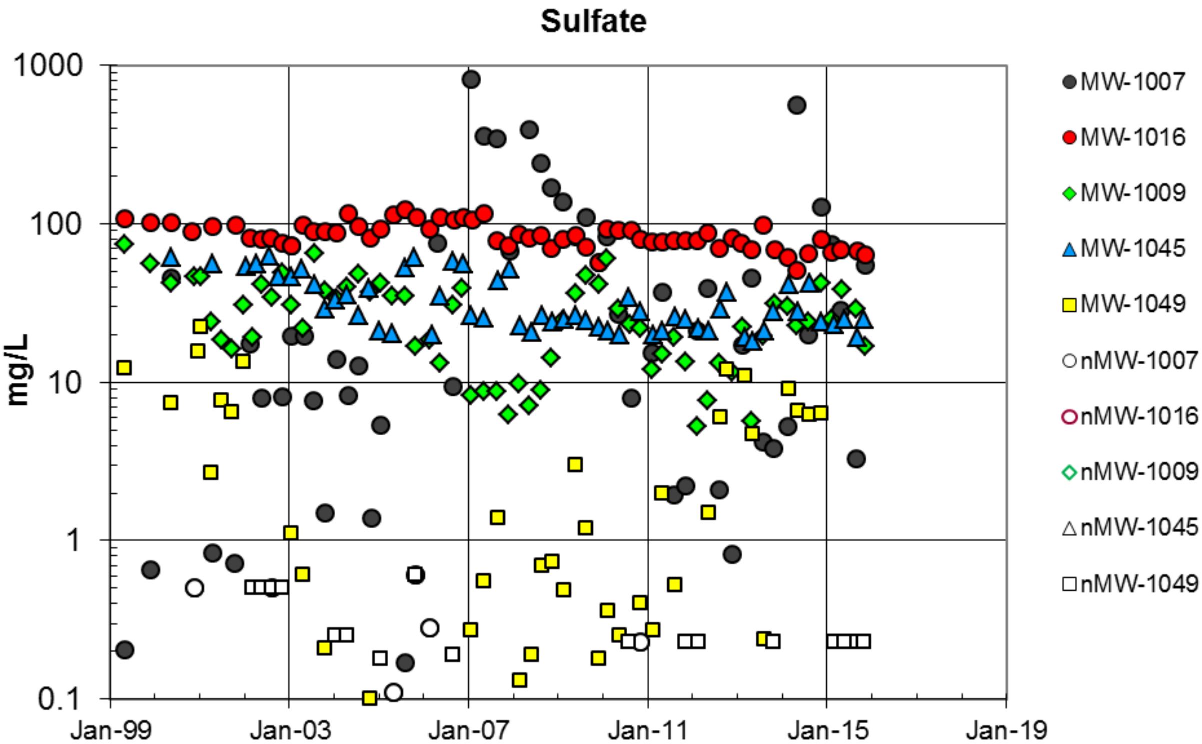

Figure 79. Sulfate in Line 2 Alluvial Wells—Lower-Uranium Concentration Wells

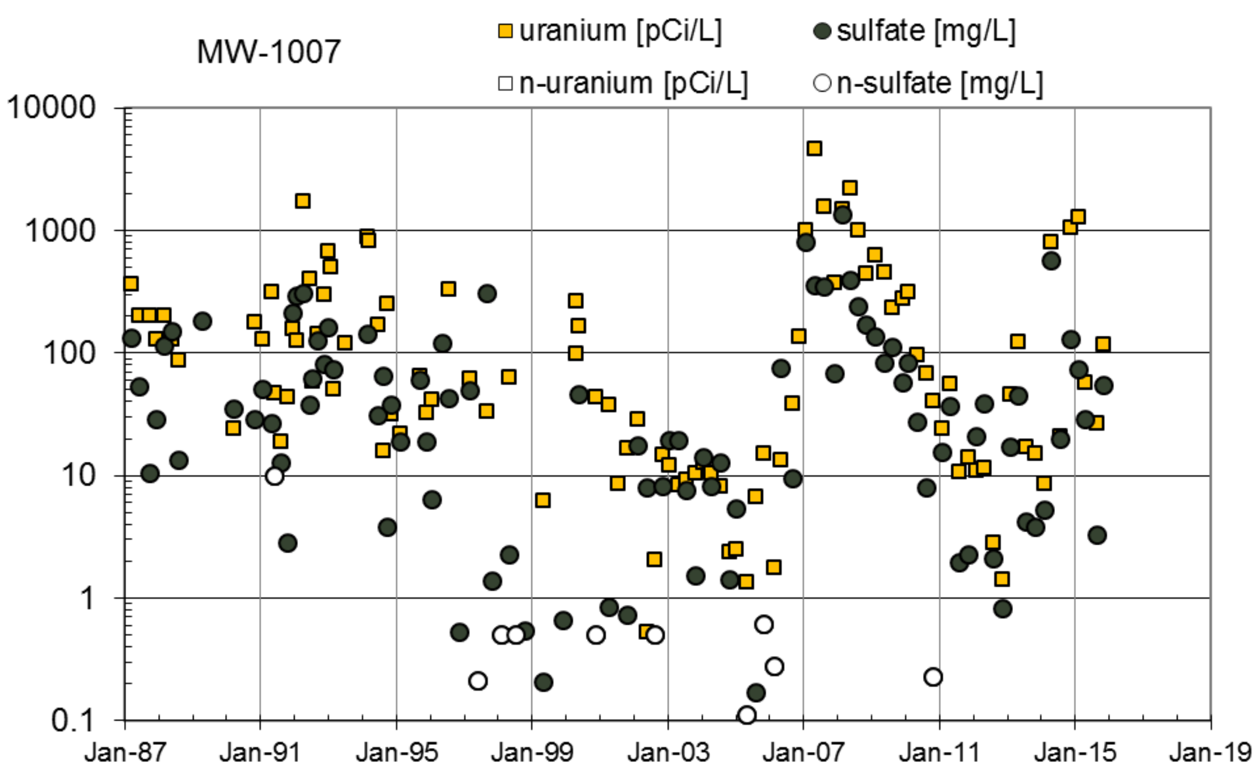

Figure 80. Sulfate and Uranium Variability in MW-1007

Table 42. Average Values for Dissolved Iron at the Weldon Spring Quarry

Location	Line	Geologic Unit	Dissolved Iron (µg/L)				
			2011	2012	2013	2014	2015
MW-1004	1	Kimmswick-Decorah	385	275	185	114	134
MW-1005	1	Kimmswick-Decorah	376	1,400	1,050	905	950
MW-1027	1	Kimmswick-Decorah	ND	ND	346	48	35
MW-1030	1	Kimmswick-Decorah	11,160	10,350	5,270	5,670	1,050
MW-1002	1	Kimmswick-Decorah	ND	ND	38	30	ND
MW-1012*	1	Kimmswick-Decorah	ND	ND	ND	ND	ND
MW-1032	2	Kimmswick-Decorah	167	106	ND	ND	92
MW-1013	2	Kimmswick-Decorah	3,628	3,820	3,945	3,410	3,805
MW-1048	2	Plattin	884	1,140	1,653	1,573	1,548
MW-1015	2	Kimmswick-Decorah	48	77	68	188	35
MW-1031	2	Kimmswick-Decorah	35	ND	ND	319	28
MW-1028	2	Plattin	41	ND	ND	41	32
MW-1046	2	Plattin	37	ND	ND	237	288
MW-1047	2	Plattin	36	ND	ND	30	28
MW-1008	2	Alluvium	ND	94	ND	ND	ND
MW-1051	2	Alluvium	104	418	1,910	ND	213
MW-1014	2	Alluvium	602	282	161	78	38
MW-1006	2	Alluvium	1,980	1,310	236	114	1,123
MW-1052	2	Alluvium	8,193	10,578	14,194	35,450	3,758
MW-1007	2	Alluvium	51,975	48,050	42,900	34,125	48,275
MW-1016	2	Alluvium	ND	ND	ND	ND	ND
MW-1009	2	Alluvium	26,225	37,725	17,050	17,975	27,800
MW-1045	2	Alluvium	54	ND	ND	ND	47
MW-1049	2	Alluvium	46,750	45,750	44,750	45,000	47,750

Abbreviation:
ND = not detected

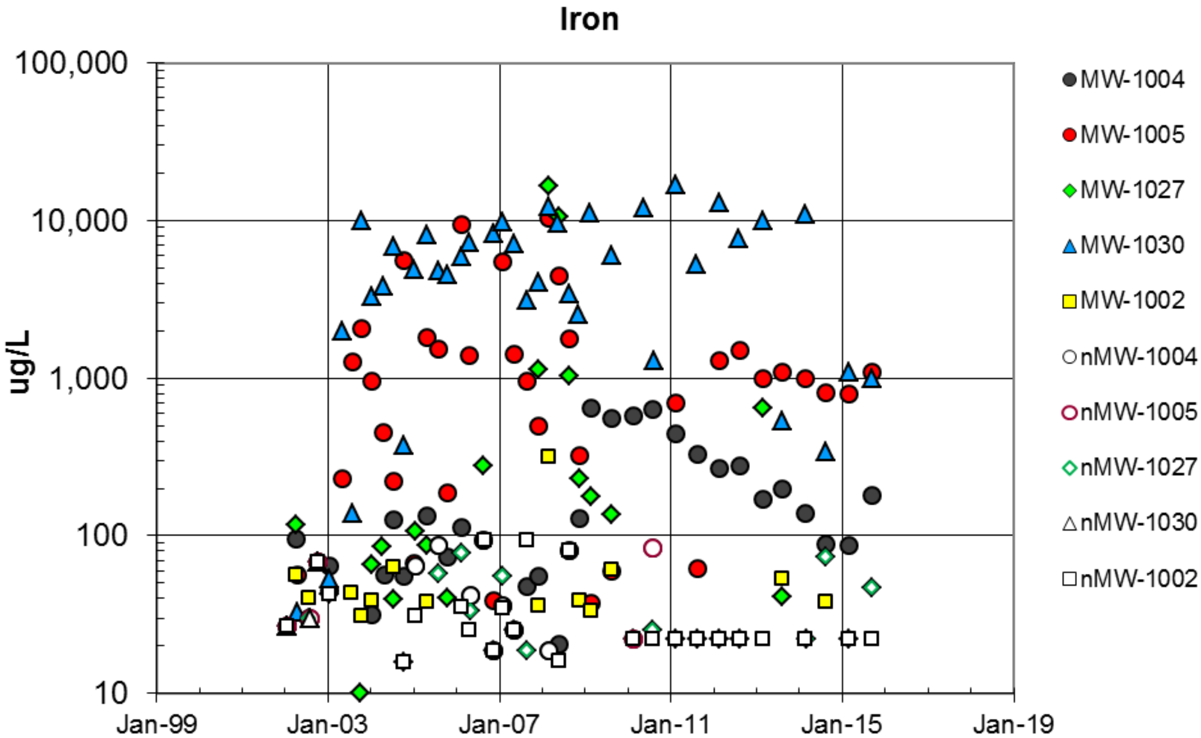

Figure 81. Dissolved Iron in Line 1 Bedrock Wells

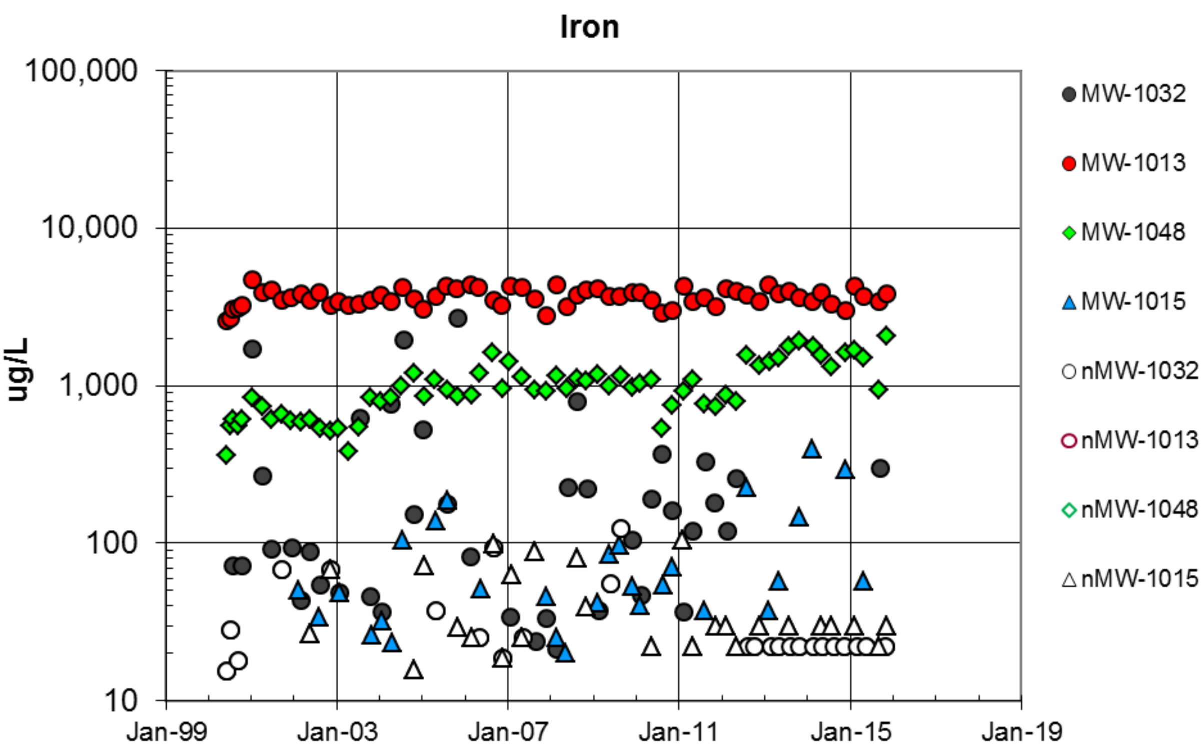

Figure 82. Dissolved Iron in Line 2 Bedrock Wells—Higher-Uranium Concentration Wells

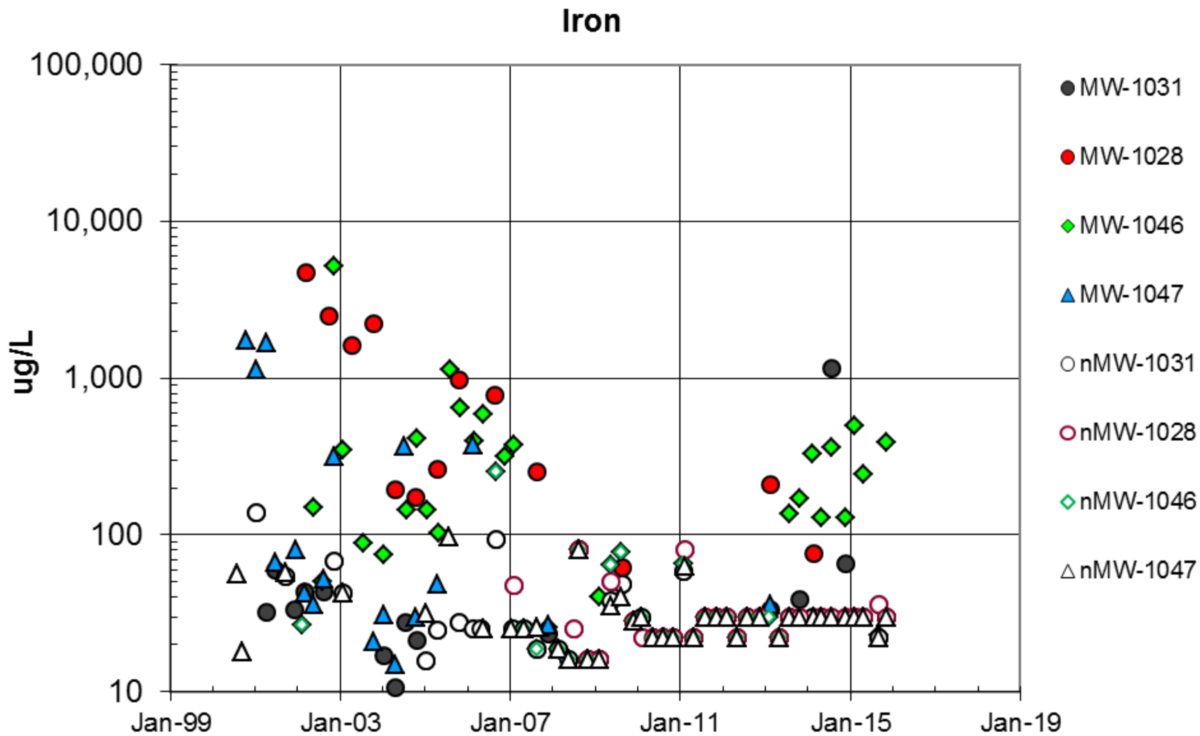

Figure 83. Dissolved Iron in Line 2 Bedrock Wells—Lower-Uranium Concentration Wells

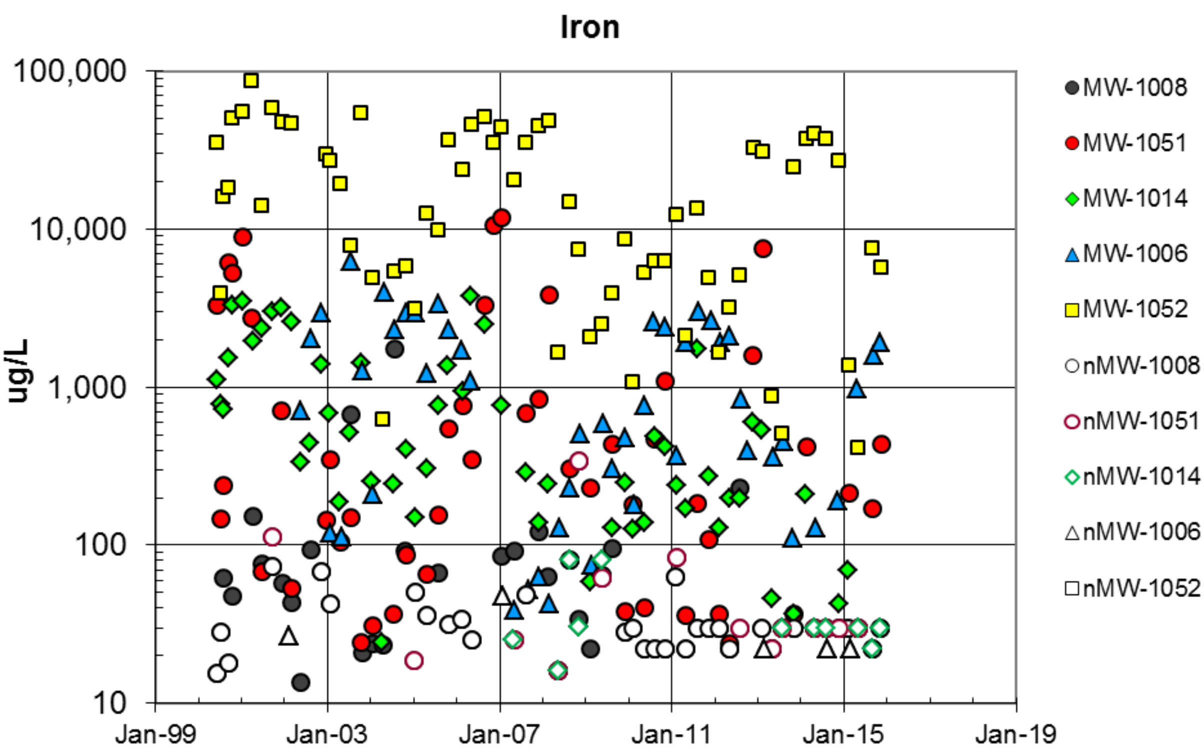

Figure 84. Dissolved Iron in Line 2 Alluvial Wells—Higher-Uranium Concentration Wells

Table 43. Average Values for Oxidation-Reduction Potential in the Missouri River Alluvial Aquifer

Location	Line	Geologic Unit	Oxidation-Reduction Potential (mV)				
			2011	**2012**	**2013**	**2014**	**2015**
MW-1004	1	Kimmswick-Decorah	80	48	66	148	49
MW-1005	1	Kimmswick-Decorah	91	36	15	143	48
MW-1027	1	Kimmswick-Decorah	178	121	44	71	43
MW-1030	1	Kimmswick-Decorah	−21	−111	−11	168	25
MW-1002	1	Kimmswick-Decorah	223	100	48	189	49
MW-1012*	1	Kimmswick-Decorah	153	86	127	247	73
MW-1032	2	Kimmswick-Decorah	51	50	96	83	70
MW-1013	2	Kimmswick-Decorah	−41	−53	−33	−4	−32
MW-1048	2	Plattin	9	−113	−52	−20	−63
MW-1015	2	Kimmswick-Decorah	76	51	31	81	26
MW-1031	2	Kimmswick-Decorah	100	102	167	112	60
MW-1028	2	Plattin	82	101	155	144	88
MW-1046	2	Plattin	143	134	54	50	−13
MW-1047	2	Plattin	84	74	97	126	25
MW-1008	2	Alluvium	69	81	85	102	45
MW-1051	2	Alluvium	45	66	84	119	41
MW-1014	2	Alluvium	33	30	139	157	64
MW-1006	2	Alluvium	−19	10	113	114	48
MW-1052	2	Alluvium	−64	−57	−34	−84	−34
MW-1007	2	Alluvium	−142	−128	−104	−59	−120
MW-1016	2	Alluvium	129	101	70	156	46
MW-1009	2	Alluvium	−116	−133	−100	−75	−100
MW-1045	2	Alluvium	90	78	94	137	56
MW-1049	2	Alluvium	−169	−155	−137	−128	−136

Notes:
[a] Convert oxidation-reduction potential to Eh by adding 200 mV to the ORP value.
[b] MW-1012 is upgradient

Abbreviation:
mV = millivolts

A review of the geochemical data indicates that although the area of highest impact has an oxidizing environment, reducing conditions are prevalent along the northern edge of the slough, as shown by data in wells MW-1007, MW-1009, and MW-1049. This is consistent with the uranium data where low levels are detected, especially in MW-1049 where very low sulfate and high dissolved iron concentrations are also observed. The location of this reduction area was consistent during the review period, and the attenuation of uranium in this area continues.

6.4.2.6 Monitoring Results for the Missouri River Alluvium

Groundwater quality in the Missouri River alluvium is monitored using 10 wells screened in the alluvial materials. These wells are sampled for uranium and geochemical parameters to verify that water quality remains protective of human health.

Uranium

The six monitoring wells immediately south of the slough (Line 3) and the four RMW series wells (Line 4) were sampled for uranium during the review period (Table 44) to verify that levels remain within the range of its natural variation in Missouri River alluvium. The results indicate that the average uranium levels were less than the statistical background value in the alluvium (Table 36). All of the locations south of the slough have uranium levels that are well below the drinking water standard of 20 pCi/L. Most Line 3 wells have uranium concentrations consistently below detection levels (Figure 85), and Line 4 wells continued their long-term down-trend over the past 5 years (Figure 86).

Table 44. Values for Total Uranium in the Missouri River Alluvial Aquifer

Location	Line	Uranium (pCi/L)				
		2011	2012	2013	2014	2015
MW-1017	3	0.06	0.11	0.09	ND	0.08
MW-1018	3	ND	ND	ND	ND	ND
MW-1019	3	ND	ND	ND	ND	ND
MW-1021	3	ND	ND	ND	ND	ND
MW-1044	3	0.06	ND	0.08	ND	0.12
MW-1050	3	ND	ND	ND	ND	ND
RMW-1	4	1.4	1.0	0.76	0.74	0.51
RMW-2	4	2.6	2.6	2.0	1.6	1.4
RMW-3	4	0.71	0.64	0.43	0.23	0.22
RMW-4	4	0.63	0.29	0.68	0.71	0.44

Abbreviation:
ND = analyte not detected above the method detection limit

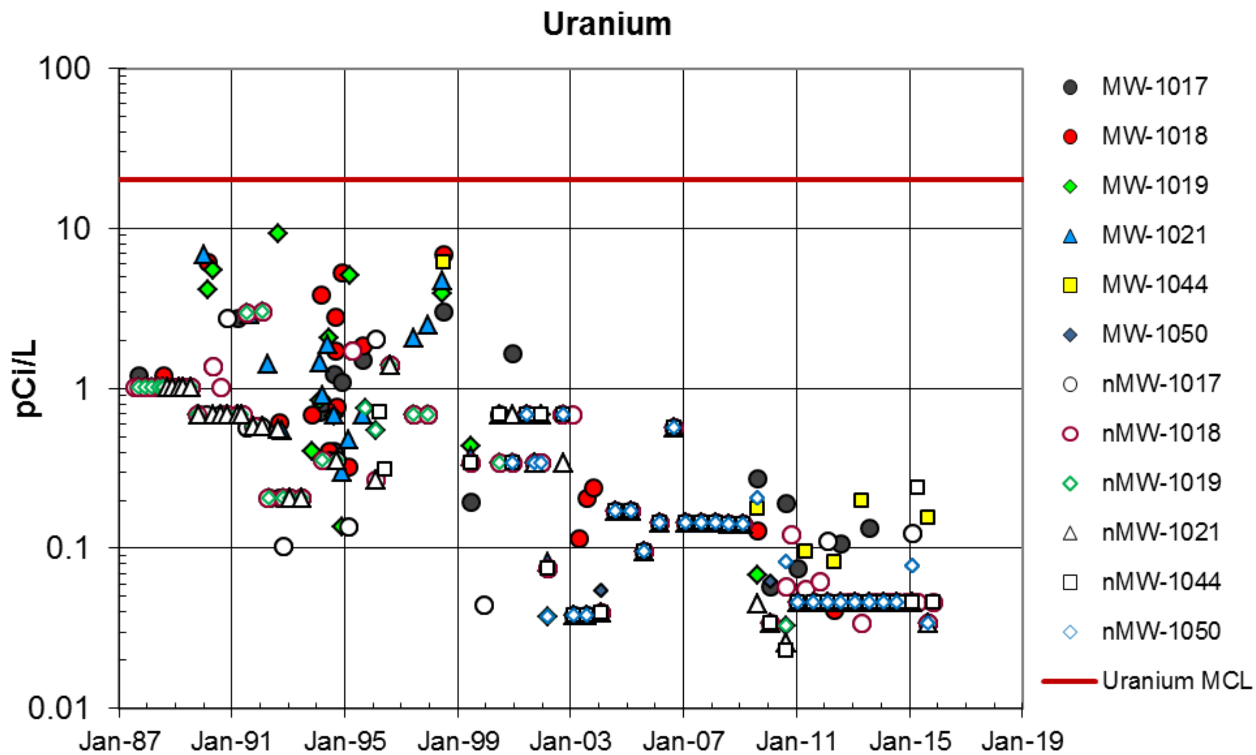

Figure 85. Uranium in Line 3 Monitoring Wells

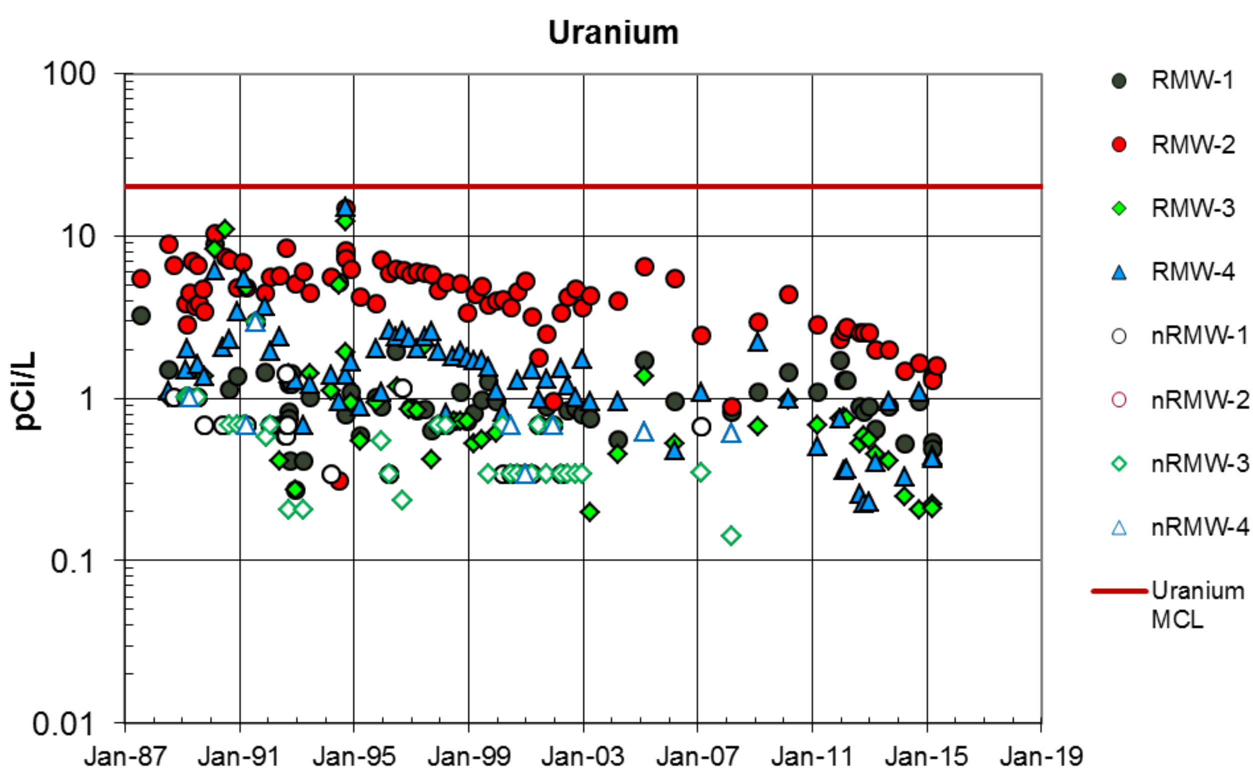

Figure 86. Uranium in Line 4 Monitoring Wells

Geochemical Parameters

The monitoring wells south of the slough were sampled for sulfate, dissolved iron, and ORP to assess oxidation-reduction conditions in the Missouri River alluvium downgradient of the area of uranium impact. Sulfate results are given in Table 45 and are shown on Figure 87 (Line 3 wells) and Figure 88 (Line 4 wells). Dissolved iron results are given in Table 46 and are shown on Figure 89 (Line 3 wells) and Figure 90 (Line 4 wells). ORP values for Line 3 and Line 4 wells are given in Table 47.

The data continue to indicate that a strongly reducing environment is prevalent in the groundwater immediately south of the slough, as shown by high dissolved iron concentrations, low sulfate concentrations, and low ORP values. This environment is not favorable for uranium migration, if it were to pass beyond the reduction zone north of the slough. Data from the review period were consistent for all locations except MW-1044. Increased sulfate concentrations were reported in MW-1044 beginning in late 2008 and have continued through 2015. High iron concentrations and low Eh values indicate that a reducing environment is still prevalent in this area. Uranium levels remain low at this location and at the remainder of the locations along the southern edge of the Femme Osage Slough.

Table 45. Average Values for Sulfate in the Missouri River Alluvial Aquifer

Location	Line	Sulfate (mg/L)				
		2011	2012	2013	2014	2015
MW-1017	3	1.0	1.2	0.94	1.1	0.90
MW-1018	3	18	5.8	2.2	1.9	14
MW-1019	3	0.76	0.68	0.29	0.16	0.46
MW-1021	3	0.72	0.53	8.6	0.41	0.64
MW-1044	3	213	84	37	120	133
MW-1050	3	8.4	1.4	4.1	1.7	0.61
RMW-1	4	27	21	15	9.5	9.5
RMW-2	4	14	16	5.0	6.9	6.9
RMW-3	4	11	32	12	12	12
RMW-4	4	4.5	7.0	17	110	110

Table 46. Average Values for Dissolved Iron in the Missouri River Alluvial Aquifer

Location	Line	Dissolved Iron (µg/L)				
		2011	2012	2013	2014	2015
MW-1017	3	20,200	20,500	22,200	22,250	24,800
MW-1018	3	37,000	37,650	41,500	40,000	40,600
MW-1019	3	13,750	13,950	14,450	13,800	13,850
MW-1021	3	14,900	17,750	20,150	17,450	17,500
MW-1044	3	37,000	34,100	29,650	21,600	21,850
MW-1050	3	14,900	17,200	16,550	15,200	17,450
RMW-1	4	5,500	3,800	7,700	7,310	8,320
RMW-2	4	7,700	7,170	8,300	12,400	13,200
RMW-3	4	14,000	17,900	15,000	15,000	15,400
RMW-4	4	18,000	17,000	18,000	20,800	16,900

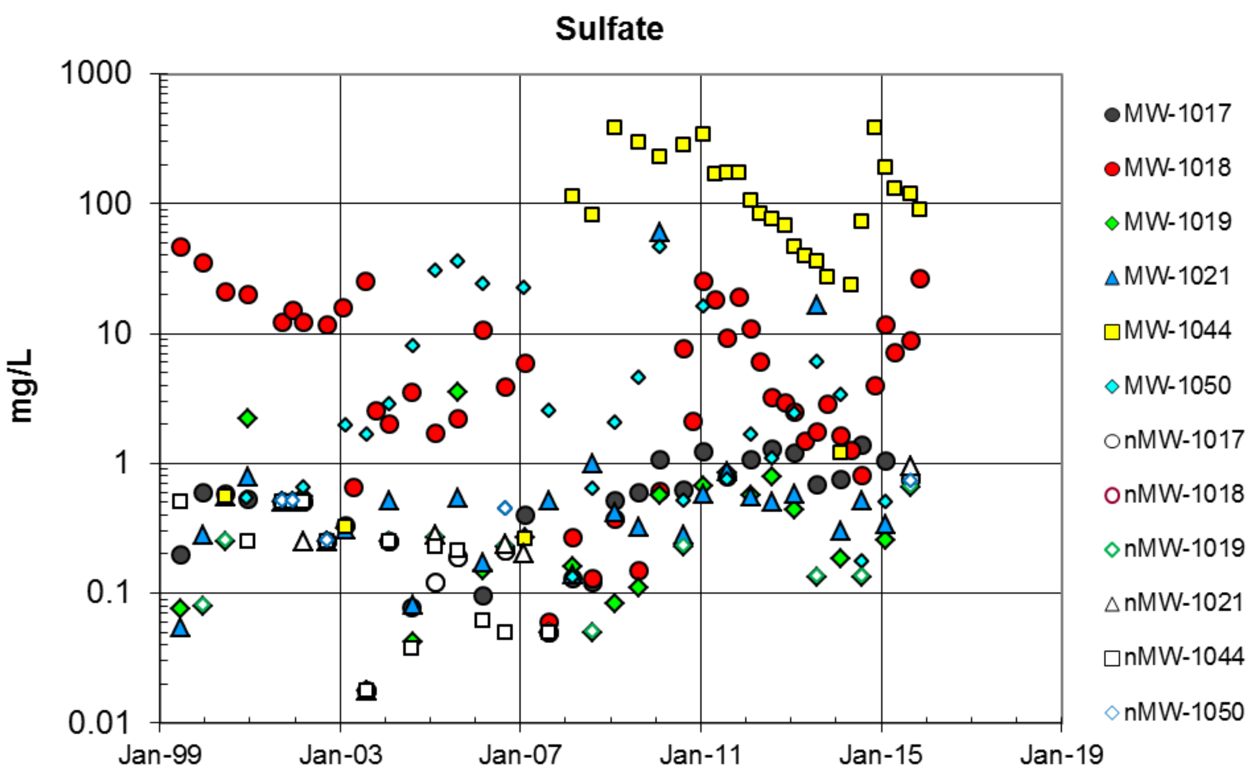

Figure 87. Sulfate in Line 3 Wells

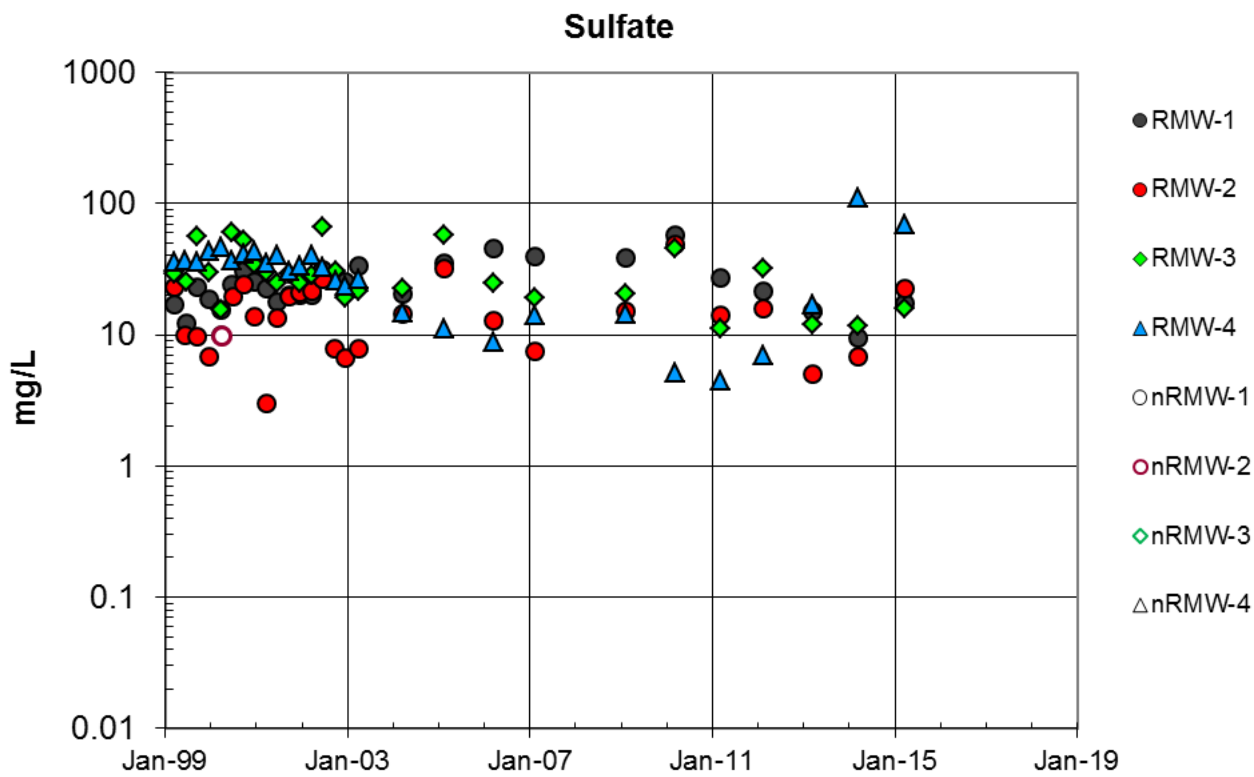

Figure 88. Sulfate in Line 4 Wells

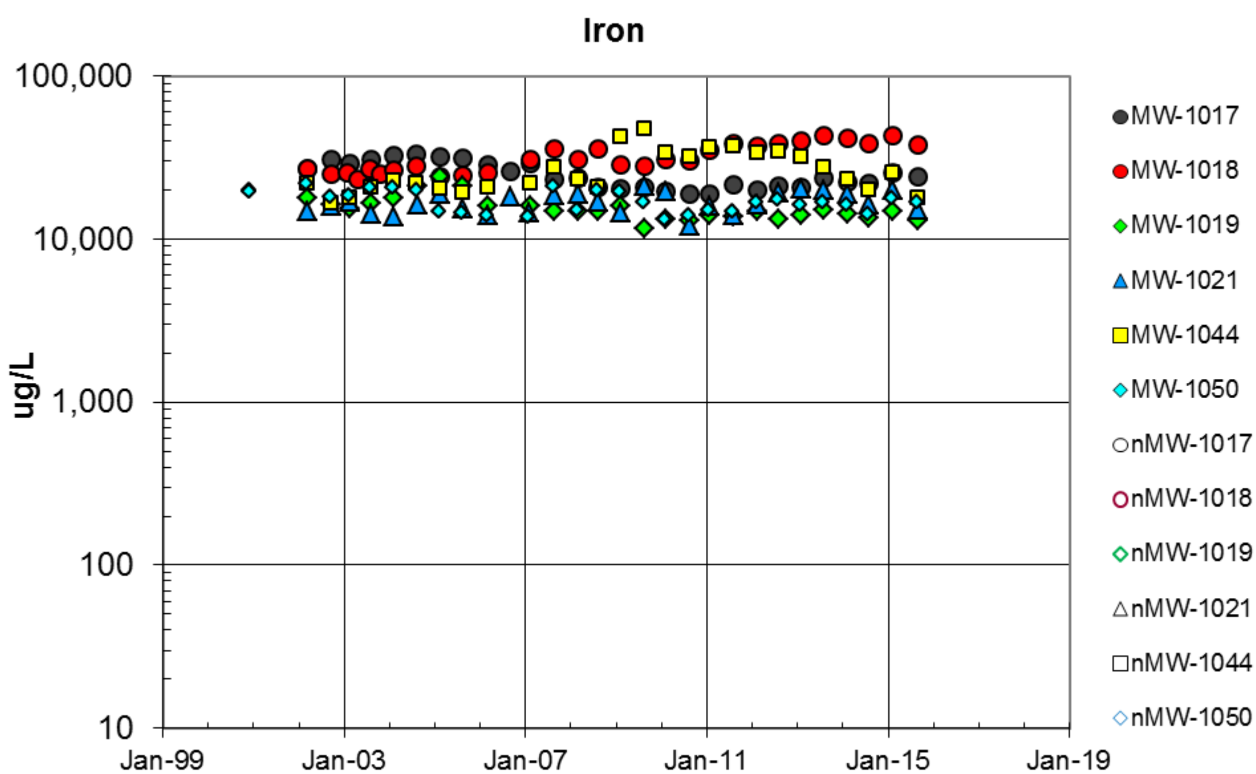

Figure 89. Dissolved Iron in Line 3 Wells

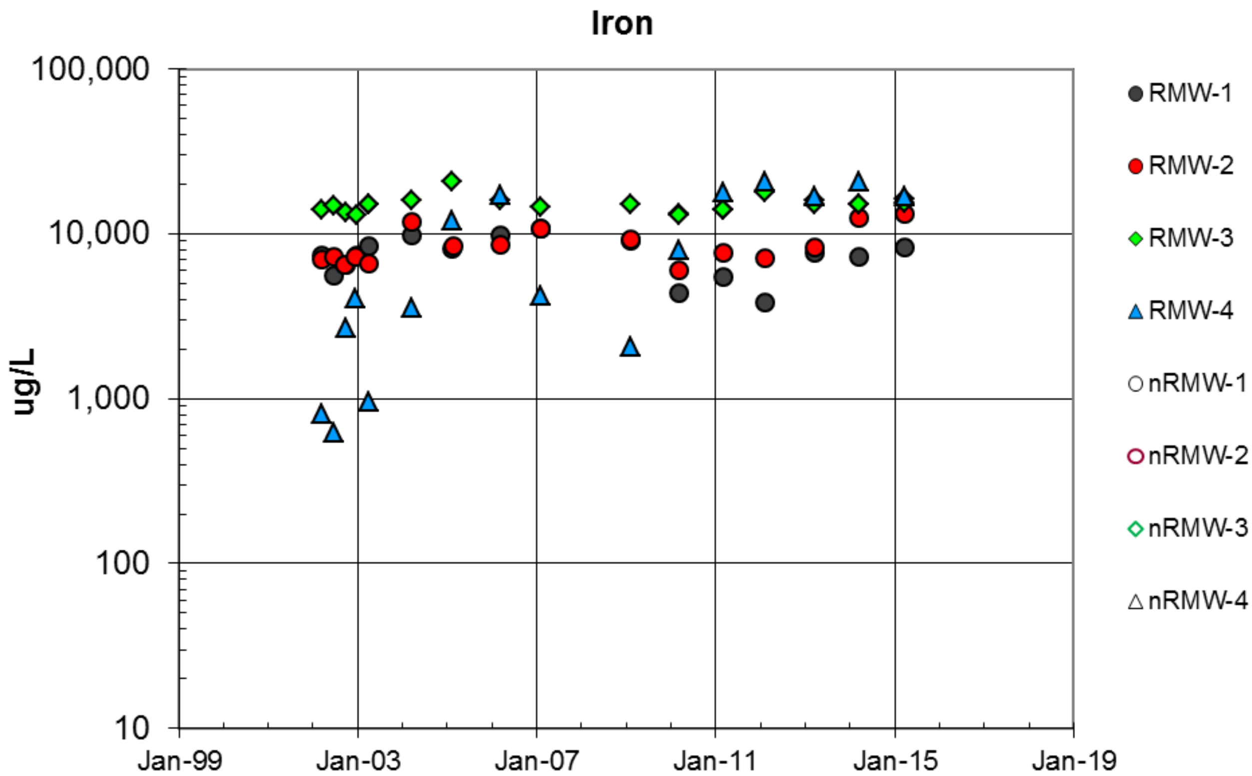

Figure 90. Dissolved Iron in Line 4 Wells

Table 47. Average Values for Oxidation-Reduction Potential in the Missouri River Alluvial Aquifer

Location	Line	Oxidation-Reduction Potential (mV)				
		2011	2012	2013	2014	2015
MW-1017	3	−169	−155	−147	−128	−147
MW-1018	3	−173	−160	−77	−139	−150
MW-1019	3	−135	−135	−142	−122	−131
MW-1021	3	−141	−142	−137	−117	−132
MW-1044	3	−187	−182	−169	−157	−163
MW-1050	3	−148	−149	−164	−115	−138
RMW-1	4	−19	−39	−54	−45	−79
RMW-2	4	−113	−125	−63	−91	−119
RMW-3	4	−124	−125	−126	−112	−134
RMW-4	4	−130	−151	NAL	−116	−130

Note:
[a] Convert oxidation-reduction potential to Eh by adding 200 mV to the oxidation-reduction value.

Abbreviations:
mV = millivolts
NAL = not analyzed

6.4.3 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 disposal cell leachate. Semiannual detection monitoring began in mid-1998, after cell construction and waste placement activities had begun.

Under the monitoring program for the disposal cell, the monitoring wells, spring, and leachate are sampled semiannually (in June and December). Samples from the wells and spring are analyzed for the analytes listed in Table 48. Leachate was analyzed for the analytes listed in Table 49. Sampling was performed as specified in Appendix K of the LTS&M Plan (DOE 2008c).

The performance of the disposal cell is gauged on the concentrations of signature parameters in the groundwater. Signature parameters are those constituents present in the leachate at concentrations that are at least 1 order of magnitude greater than in the underlying groundwater. Initially, barium, iron, manganese, and uranium were identified as signature parameters for the leachate. In 2008, the list was reduced to include only barium and uranium. Under the monitoring program, signature parameter data from each monitoring event are compared to the 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 at the 95 percent confidence limits using the data set from 1997 through 2002.

Table 48. Disposal Cell Detection Monitoring—Groundwater and Spring Analyte List

Radiological	Metals	Nitroaromatic Compounds	Other	General Indicator Parameters
Radium-226 Radium-228 Thorium-228 Thorium-230 Thorium-232	Arsenic Barium Chromium Lead Manganese Nickel Selenium Thallium Uranium	1,3,5-TNB 1,3-DNB 2,4,6-TNT 2,4-DNT 2,6-DNT NB	PCBs PAHs	pH Temperature Specific conductance

Abbreviations:
DNB = dinitrobenzene
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
TNB = trinitrobenzene
TNT = trinitrotoluene

Table 49. Disposal Cell Detection Monitoring—Leachate Analyte List

Radiological	Inorganic Ions	Metals	Nitroaromatic Compounds	Other	General Indicator Parameters
Radium-226 Radium-228 Thorium-228 Thorium-230 Thorium-232	Chloride Fluoride Nitrate Sulfate	Arsenic Barium Chromium Cobalt Iron Lead Manganese Nickel Selenium Thallium Uranium	1,3,5-TNB 1,3-DNB 2,4,6-TNT 2,4-DNT 2,6-DNT NB	PCBs PAHs	pH Temperature Specific conductance COD TDS TOC Turbidity

Abbreviations:
COD = chemical oxygen demand
DNB = dinitrobenzene
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
TDS = total dissolved solids
TNB = trinitrobenzene
TNT = trinitrotoluene
TOC = total organic carbon

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 there are changes in the groundwater system. Data are compared to the 3 most recent years of data to determine if statistically significant changes in concentrations are present. A measured concentration is considered statistically significant if it is greater than the arithmetic mean plus 3 times the standard deviation for a given location.

Wells with data showing a statistically significant increase are resampled to confirm the exceedance. If the resampling results 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, the analytical data are assessed, and sitewide monitoring data are reviewed. If the exceeding parameter is a COC for the GWOU, this information is evaluated under the monitoring program for that OU.

6.4.3.1 Groundwater Flow

Groundwater flow rate and direction are evaluated annually as specified in Appendix K of the LTS&M Plan (DOE 2008c). The potentiometric surface map of the weathered unit shallow aquifer at the Chemical Plant indicates a generally northward groundwater flow direction (Figure 11). The configuration of the potentiometric surface has remained relatively unchanged since the construction of the disposal cell. 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:

$$v = \left(\frac{K}{n}\right)\left(\frac{\mathrm{dh}}{\mathrm{dl}}\right)$$

$$v = \left(\frac{20\ \mathrm{ft/day}}{0.10}\right)\left(\frac{606\ \mathrm{ft} - 583\ \mathrm{ft}}{2100\ \mathrm{ft}}\right) = 2.2\ \mathrm{ft/day}$$

Where: v = velocity
K = average hydraulic conductivity
n = effective porosity
dh/dl = hydraulic gradient

The average hydraulic conductivity (K) of the weathered zone, using data from the cell monitoring wells, is 7×10^{-3} centimeters per second (20 ft/day) and ranges from 10^{-2} to 10^{-7} centimeters per second (DOE 2005a). An effective porosity (n) of 0.10 was selected to estimate the maximum groundwater flow rate in this area. The hydraulic gradient (dh/dl) in the disposal cell area is 0.011 ft/ft and is based on water elevation data from MW-2055 (average of 606.1 ft above mean sea level for the previous 5 years) and MW-2032 (average of 582.9 ft above mean sea level for the previous 5 years), which are located about 2,100 ft apart. This approach is consistent with the calculations presented in Appendix K of the LTS&M Plan (DOE 2008c). The average flow rate for 2015 was 2.2 ft/day, which is the same as the average flow rate calculated since 2005.

6.4.3.2 Disposal Cell Monitoring Results—Signature Parameters

The monitoring results for the signature parameters collected from 2011 through 2015 are presented in Table 50 and are shown on Figure 91 and Figure 92 along with applicable BTLs. The results were less than the applicable BTLs, which indicates that there is no statistical evidence of leakage into the groundwater beneath the disposal cell. The general groundwater quality in the detection monitoring wells and Burgermeister spring during this period was consistent with historical data. Leachate concentrations are shown on charts for comparison.

The monitoring results for the disposal cell leachate are presented in Table 11. The LCRS is sampled semiannually, and the data are used for comparison with corresponding concentrations in wells if elevated levels of constituents are identified in the groundwater. In general, the composition of the leachate has remained stable over the past 5 years, with the exception of iron, manganese, and uranium. These three constituents have shown a general decline.

Table 50. Signature Parameter Results and Associated BTLs at Disposal Cell Monitoring Locations

Parameter	Location	BTL	Results									
			June 2011	Dec 2011	June 2012	Dec 2012	June 2013	Dec 2013	June 2014	Dec 2014	June 2015	Dec 2015
Barium (µg/L)	MW-2032	337	148	182	194	190	152	167	125	165	125	148
	MW-2046	277	215	198	200	148	158	198	161	171	151	156
	MW-2047	471	397	338	350	365	376	339	366	368	351	367
	MW-2051	285	250	238	262	268	279	260	262	292	259	279
	MW-2055	98	19	17	18	19	20	20	20	19	18	18
	SP-6301	180	131	115	123	114	116	135	111	101	86	113
Uranium (pCi/L)	MW-2032	6.4	2.4	2.3	2.0	2.0	2.2	2.0	3.9	3.6	4.8	3.0
	MW-2046	1.8	1.1	1.2	1.2	1.1	1.2	1.3	1.2	1.1	1.3	1.2
	MW-2047	2.7	1.1	1.2	1.2	1.2	1.2	1.3	1.2	1.0	1.3	1.1
	MW-2051	4.5	1.2	1.3	1.2	1.1	1.5	1.3	1.3	1.1	1.3	1.1
	MW-2055	7.5	1.9	1.9	1.8	1.7	1.7	1.8	2.0	1.5	1.9	1.9
	SP-6301	159	36	44	35	43	24	58	17	15	17	24

Abbreviation:
BTL = baseline tolerance limit

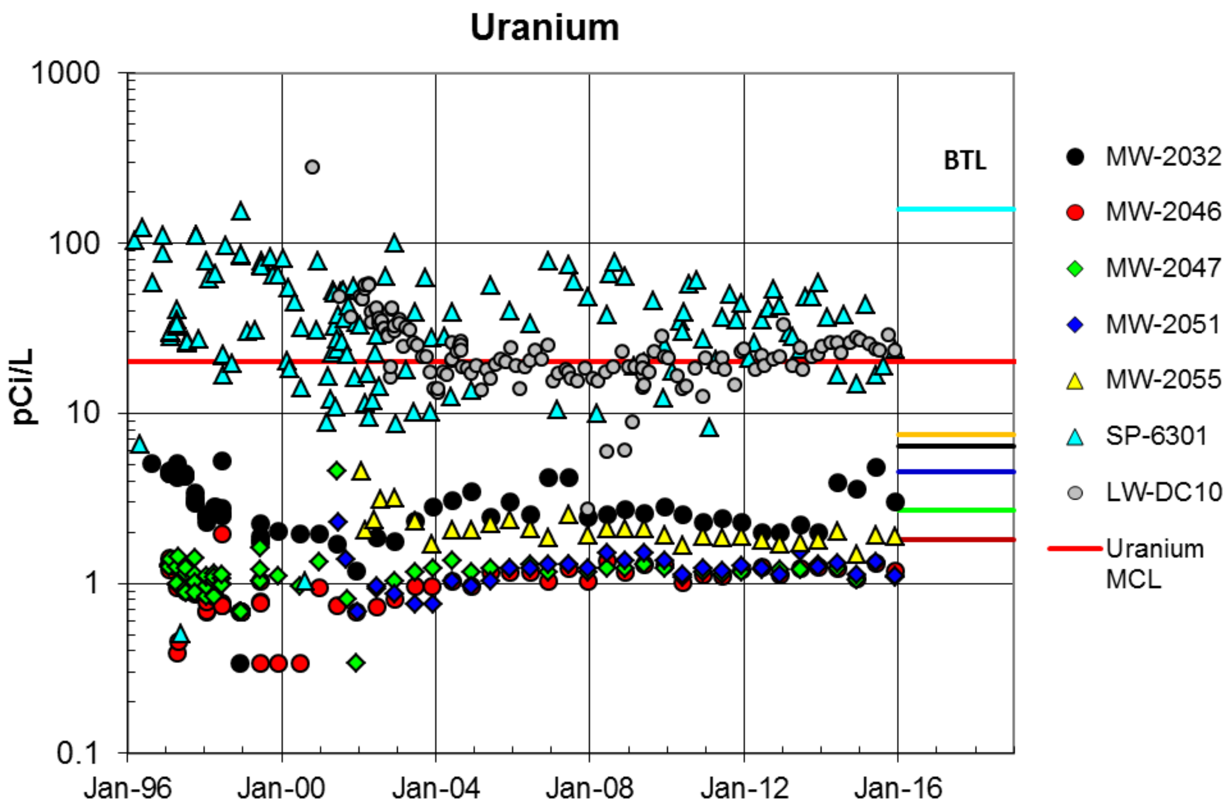

Figure 91. Uranium Concentrations—Disposal Cell Monitoring Wells with BTLs

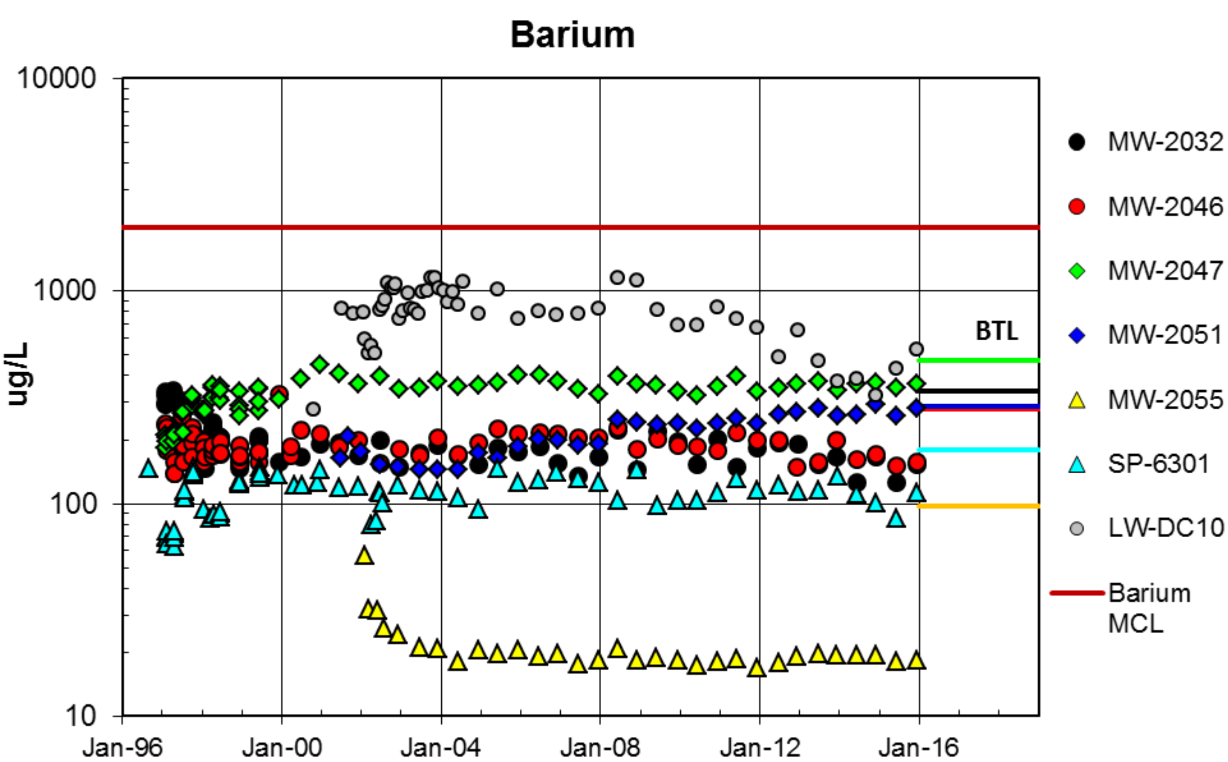

Figure 92. Barium Concentrations—Disposal Cell Monitoring Wells with BTLs

6.5 Site Inspection

6.5.1 Inspection Summary

The Weldon Spring Site, located in St. Charles, Missouri, was inspected December 1 and 2, 2015. The inspection was conducted in accordance with the *LTS&M Plan for the Weldon Spring, Missouri, Site* (DOE 2008c), and the updated inspection checklist. Representatives from DOE, the DOE contractor Navarro Research and Engineering, Inc., EPA, and MDNR participated in the inspection. A representative from MDC participated in the Southeast Drainage portion of the inspection. This inspection also served as the Five-Year Review inspection to support the site's CERCLA Five-Year Review Report.

The main areas inspected at the site were areas where ICs have been established, the Quarry, the disposal cell, LCRS, monitoring wells, and assorted general features.

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

An aerial survey of the disposal cell was flown in December 2014. This survey is required by the LTS&M Plan and checklist to be conducted every five years in conjunction with the 5-year review inspection. This aerial survey utilized the LiDAR (light detection and ranging) technology. Six-inch contours were generated from the LiDAR survey. The previous aerial surveys were conducted in 2005 and 2010 in conjunction with the previous Five-Year Reviews and in 2003 in conjunction with the first annual LTS&M inspection. The previous surveys generated 1-foot contours using photogrammetric methods. The survey results were discussed during the inspection.

The disposal cell was inspected by walking ten transects over the cell and around the cell perimeter. Hand-held GPS equipment was used to navigate the ten transects. Six areas of the cell which had been marked and located by GPS survey equipment during the 2003 annual inspection were located and observed for any signs of rock degradation. The LCRS was also inspected and found to be in good condition. Forty of the 106 groundwater-monitoring wells were inspected and were in good condition. Other site features including the prairie, site markers, and roads also were inspected.

As preparation for the Five-Year Review, the LTS&M requires that DOE contact MDNR to determine if any well registrations were issued for the groundwater restricted area. MDNR was contacted and in response to this request stated that there had been four wells and two soil borings that have been registered with the state for the area in question and all of them were located on the Army property.

At the time of the inspection 13 personnel from Navarro Research and Engineering, Inc. (Navarro), the Legacy Management Support contractor at the DOE office in Grand Junction, Colorado, were employed full-time at the site. Some of these employees also support other Legacy Management sites around the nation. Also employed at the site are part-time contractor and subcontractor employees.

This section of the report presents the results of the DOE annual/five year review inspection of the Weldon Spring Site. The following personnel from Navarro were the lead inspectors during the inspection:

- Terri Uhlmeyer
- Randy Thompson

The following support personnel from Stoller participated in the inspection:

- Chris Papinsick
- Tim Zirbes
- Rex Hodges
- Dave Parker
- Yvonne Deyo
- Darrell Landers

The following personnel observed the inspection and provided oversight:

- Ken Starr, DOE
- Hoai Tran, EPA, Region VII
- Patrick Anderson, MDNR
- Dan Carey, MDNR
- Raenhard Wesselschmidt, MDC (inspection of Southeast Drainage only)

The inspection was conducted in accordance with the *LTS&M Plan for the Weldon Spring, Missouri, Site* (DOE 2008c). The inspection checklist is included in Appendix C. The checklist was derived from the checklist included in the EPA CERCLA Five-Year Review guidance (EPA 2001).

The inspection base maps, which include the location of the photographs, are included as Figure 93 and Figure 94. The inspection photos are included in Appendix D.

6.5.2 Institutional Controls

Section 2.3.4 of the LTS&M Plan states "DOE will conduct a formal annual inspection of the physical locations addressed by ICs. DOE also will evaluate whether the ICs remain effective in protecting human health and the environment and, in coordination with EPA and MDNR, will take appropriate action if evidence indicates the controls are not effective."

Easements have been negotiated and finalized with surrounding state agency landowners for implementing use restrictions required on the state properties. The state agencies included MDC, MDNR-Parks, and MoDOT/St. Charles County. The easements are in place to restrict potential use of contaminated groundwater in the hydraulic buffer zone and also to restrict land use in the Southeast Drainage area and at the Quarry site. During the inspection, the final institutional control areas were inspected in accordance with the current information in the LTS&M Plan. Figure 95 and Figure 96 are the institutional control location maps from the LTS&M Plan.

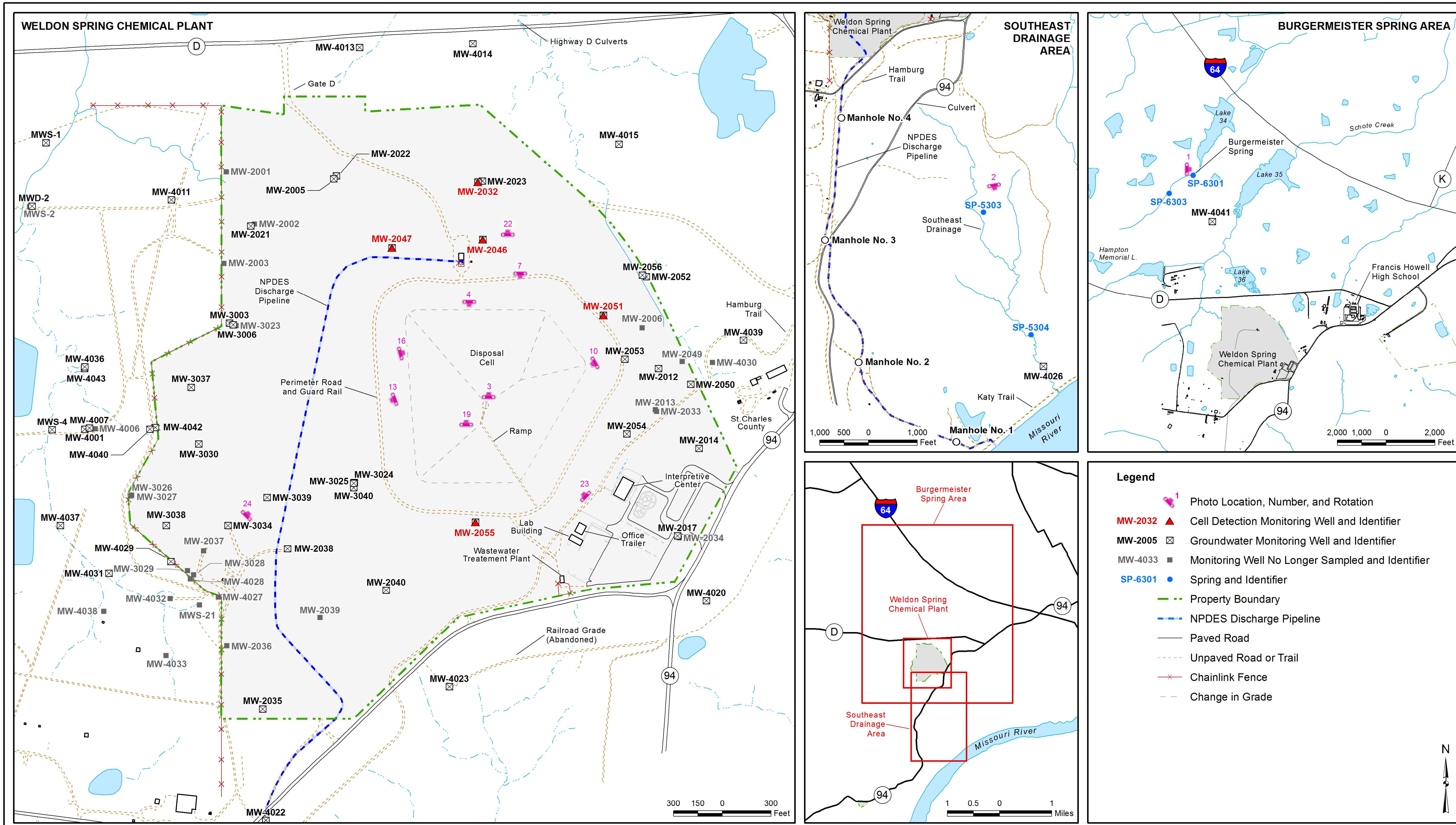

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Figure 93. 2015 Inspection Map for the Chemical Plant Area of the Weldon Spring, Missouri, Site

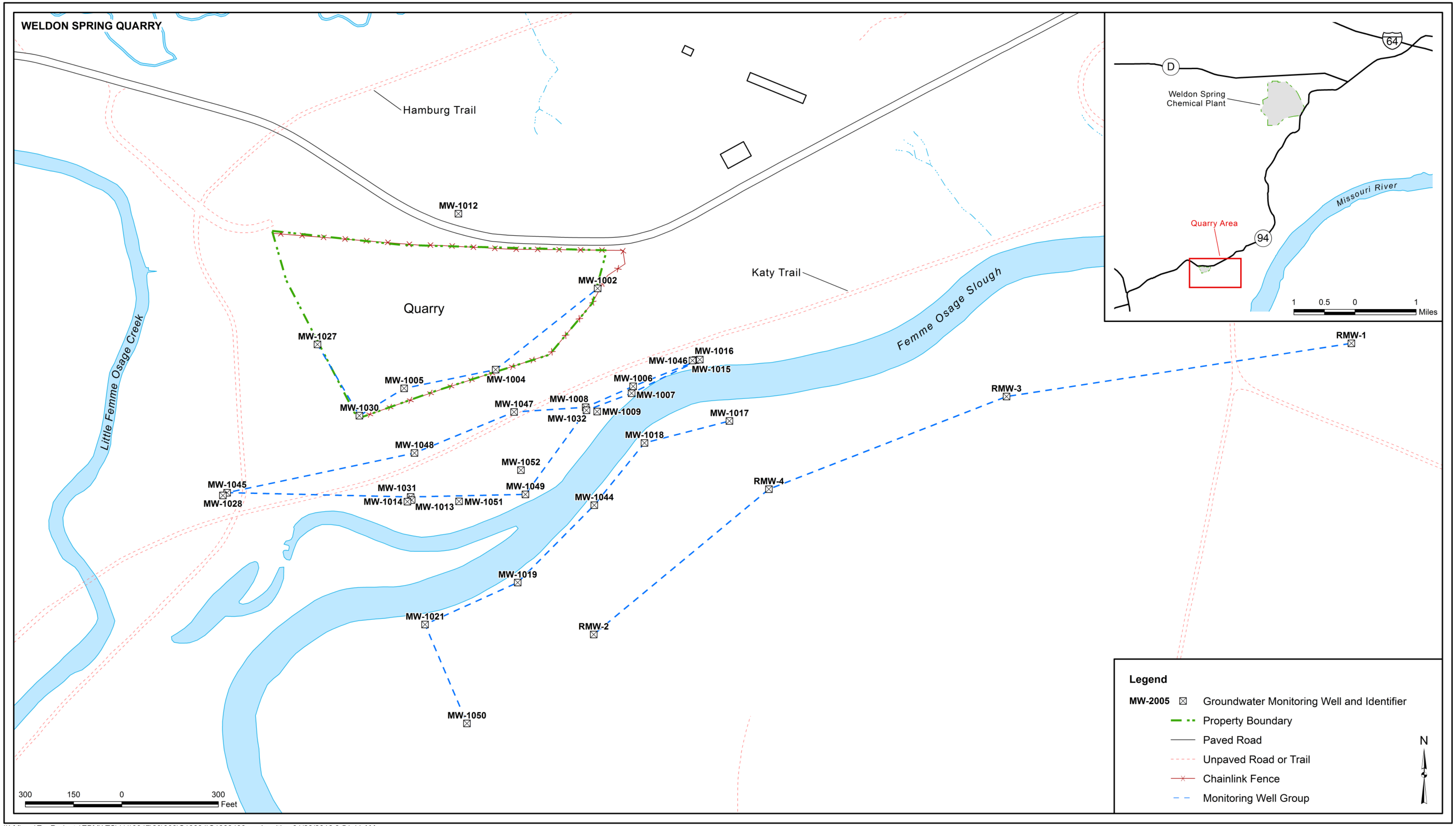

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Figure 94. Inspection Map for the Quarry Area of the Weldon Spring, Missouri, Site

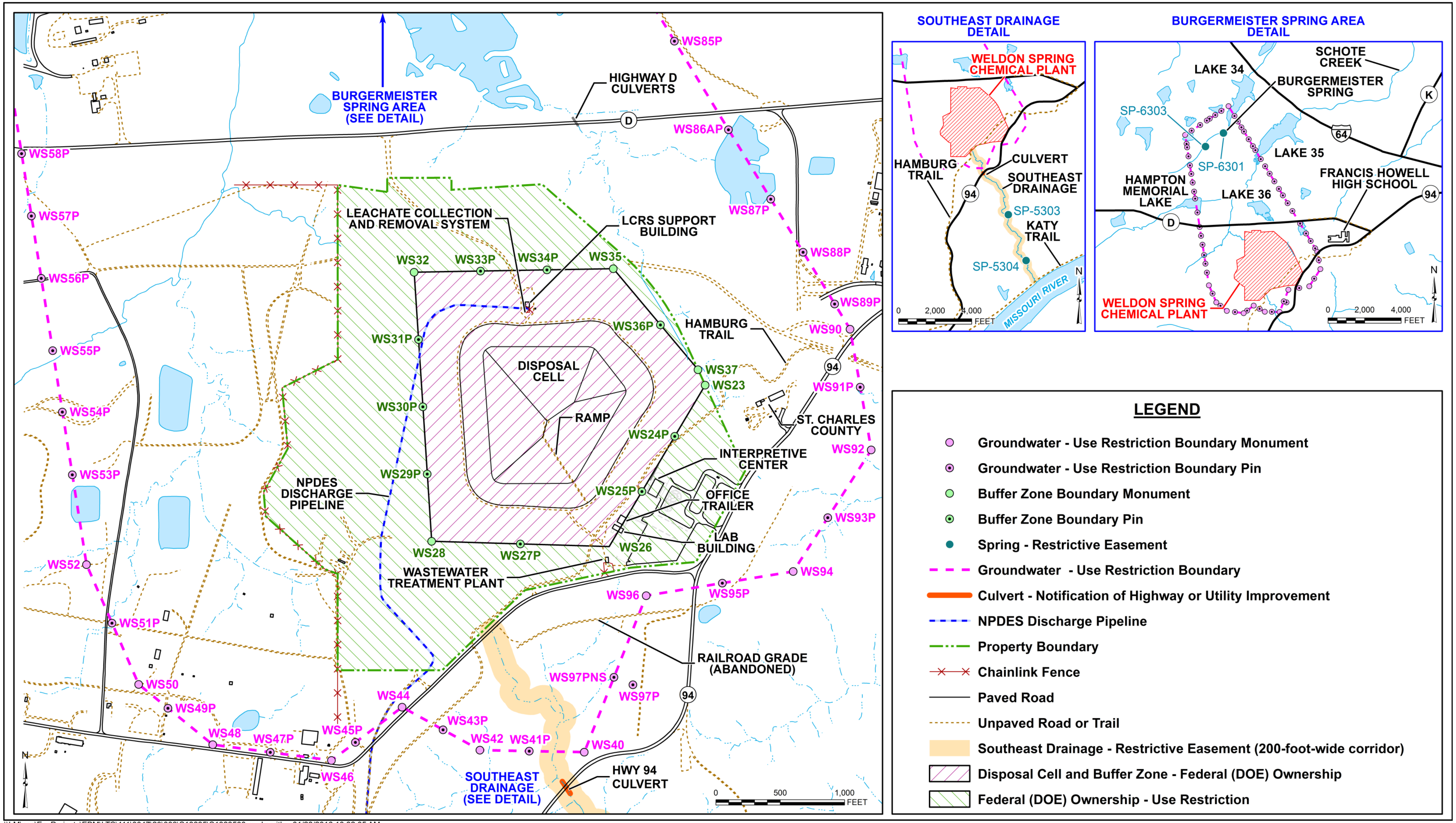

Figure 95. Institutional Controls Location Map for the Chemical Plant Area

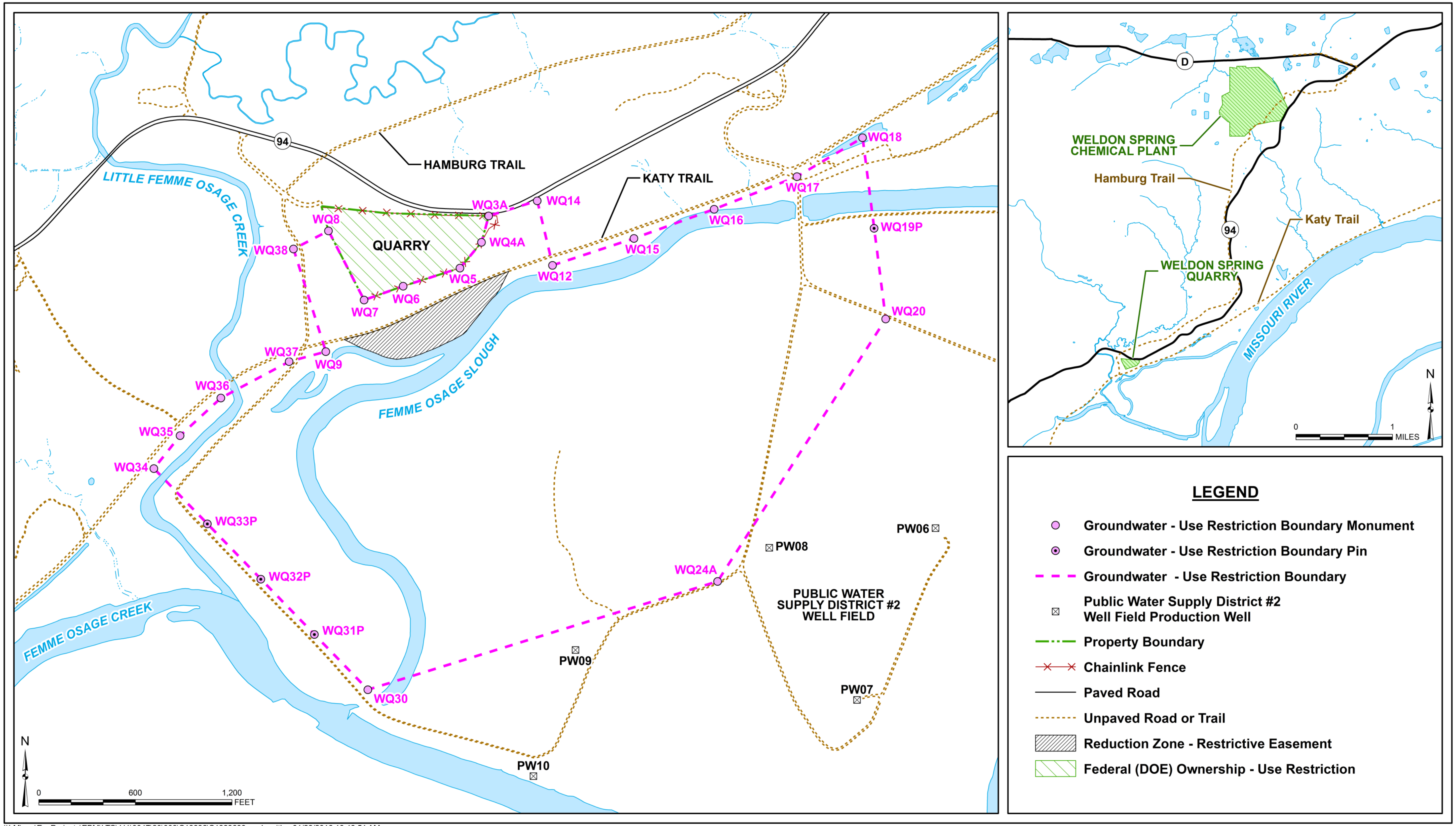

Figure 96. Institutional Controls Location Map for the Quarry Area

The institutional control and additional areas are listed below as they are stated in the inspection checklist.

Land and Shallow Groundwater Use Within the Chemical Plant Site and Buffer Zone

Inspection Criteria: Groundwater and land use is restricted on the Chemical Plant site. Inspect for indications of excavations into soil or bedrock and groundwater withdrawal or use in restricted areas. If any party has been granted use of portions of the Chemical Plant area, inspect to ensure that land use is in compliance with the terms of the restrictions within the notation.

Inspection Results: This area was inspected and observers found no indications of excavations into soil or bedrock, groundwater withdrawal, or groundwater use. No party has been granted use of portions of the former Chemical Plant area.

Groundwater Use in Areas Surrounding the Chemical Plant

Inspection Criteria: Groundwater use is restricted in areas on Army, MDC, and St. Charles County (formerly MoDOT) properties, as shown on Figure 94. Inspect affected areas for groundwater or spring water (Burgermeister Spring [Spring 6301] and Spring 6303) use. Inspect to ensure that land use continues to be in compliance with the terms of the license, easement, or permit and the restrictions contained therein.

Inspection Results: The surrounding area where groundwater use is restricted was inspected, including property owned by MDC and the Army. Inspectors observed no evidence of groundwater use, and current land use remains consistent with ICs on both properties. Burgermeister Spring 6301 (Photo 1) and Spring 6303 on MDC property were inspected, and there were no indications of spring water use. Spring 6303 was not flowing during the time of the inspection. The last time it was observed to be flowing was in 2013. All the monitoring wells inspected were appropriately secured.

Groundwater (Quarry)

Inspection Criteria: Figure 95 shows the Quarry groundwater restriction area boundary. Inspect affected areas for evidence of groundwater withdrawal or use in restricted areas. Inspect to ensure that land use continues to be in compliance with the terms of the easement and restrictions within the notation.

Inspection Results: The groundwater restricted area was inspected, and no evidence of groundwater withdrawal or use in the area was observed.

Land Use in Quarry Area Reduction Zone

Inspection Criteria: Figure 95 shows the restriction boundary. A naturally occurring reduction zone exists in soil south of the Katy Trail and north of the Femme Osage Slough. This area is restricted from excavations. Inspect for indications of excavations into soils in the uranium reduction zone. Inspect to ensure that land use continues to be in compliance with the terms of the easement and the restrictions contained therein.

Inspection Results: The Quarry reduction zone area was inspected, and no indications of excavation into soils or bedrock were observed. As required by the LTS&M Plan, information signage and contact numbers were posted on monitoring wells at the Quarry Area reduction zone. The labels indicate no digging is allowed in this area and include contact numbers for DOE and MDC. Land use remains consistent with planned ICs.

Southeast Drainage

Inspection Criteria: The Southeast Drainage is restricted for residential housing in a 200 ft corridor (100 ft from the center line on each side). Check for indications of residential use or construction in the Southeast Drainage (200 ft wide corridor) or other activity that would indicate nonrecreational use of the area. Check Springs 5303 and 5304 for residential, commercial, or agricultural use of spring water.

Inspection Results: The inspectors walked down the entire Southeast Drainage (Photo 2) and observed no indications of residential use, construction, or any other activity that would indicate non-recreational use of the area. The springs also were inspected, and no indications of residential, commercial, or agricultural use of the springs were observed. Both springs were observed to be flowing. Current land use remains consistent with planned ICs. Inspectors observed that some erosion is occurring under the culvert that crosses under the Hamburg Trail. Raenhard Wesselschmidt of MDC noted the condition during the inspection. John Vogel of MDC had been notified of this by email in 2011, 2012, 2013 and 2014.

State Route 94 Culvert

Inspection Criteria: Check for signs of disturbance of the affected area where the culvert passes beneath State Route 94 and in the utility rights-of-way in the affected area.

Inspection Results: The State Route 94 culvert was inspected. It was noted during the inspection that the culvert inlet was covered with leaves but no other debris. Stowe Johnson of MoDOT was emailed a picture of the culvert on December 1, 2015.

Pipeline from LCRS to Missouri River

Inspection Criteria: Inspect the entire length of the NPDES discharge pipeline and outfall for any disturbance or maintenance needs.

Inspection Results: The area of the pipeline was inspected on August 26, 2015, by DOE, MDNR and Navarro personnel. This inspection is documented in Appendix E and the report was provided to participants during the inspection. It was noted that no onsite disturbances of the pipeline or disturbances of the offsite areas of the pipeline and manholes were apparent. The pipeline area is inspected at least annually. This pipeline serves as a contingency for discharge of disposal cell leachate but has not been used for that purpose to date.

6.5.3 Disposal Cell

The disposal cell was inspected in accordance with the LTS&M Plan and the annual inspection checklist (Photo 3). The cell inspection was divided into 10 transects (Figure 97). The inspectors separated into two groups and walked five transects each, looking for depressions, shifts of cell plane vertices, and other indications of settlement. In previous annual reports, slight depressions or bulges that were noted during the inspection were included on Figure 97; however, due to the subjectivity of visually delineating surface anomalies of the rock-covered cell, the accuracy and relevance of the practice was questioned. DOE began investigating more objective options that may define these types of areas better than visual interpretations. LiDAR, a remote-sensing technology that employs light and radar, was conducted on the disposal cell in December 2014. DOE has determined that this technology will provide sufficient detail for assessing the disposal cell cover topography, with regulator concurrence as discussed below. Other items for inspection included vegetation, wet areas, apron drains, guardrails, the stairs, and the six rock test plot areas. The inspectors took photographs of these delineated rock test plot areas and compared them to photographs from the previous inspection of the same areas and observed no rock degradation. The test plot areas are shown from the original inspection in 2003 (2011 for Test Plot 6), 2013, and 2014 for comparison (Photos 4 through 21). A test plot (Test Plot 6) had been marked during 2011 in response to a request from MDNR during the 2010 inspection. This plot is located on the south face of the disposal cell (Figure 97).

In accordance with the inspection criteria included in the checklist, the inspectors also evaluated the cell cover for wet areas or water drainage and observed that none were present. The toe and apron drains were inspected and found to be functioning as designed. The guardrail and stairs were in good condition. No vegetation was found on the disposal cell during the inspection.

Aerial surveys are required by the LTS&M Plan to be performed in conjunction with the CERCLA Five-Year Reviews. The survey is required to be conducted with a vertical resolution no less precise than 0.5 feet and map and survey data to be produced with the cell surface represented by 1.0-foot contour intervals. The data are reviewed for indications of possible settlement. The first survey was performed in 2003 as a baseline and subsequent surveys were performed in 2005 and 2010, in conjunction with the CERCLA Five-Year reviews.

An aerial survey of the disposal cell was flown in December 2014 (Figure 98). This aerial survey utilized the LiDAR technology. Six-inch contours were generated from the LiDAR survey. The previous surveys generated 1-foot contours using photogrammetric methods. The survey results were discussed during the inspection. DOE informed the EPA and MDNR that they plan to conduct the aerial LiDAR survey every 2 years (at least initially) and have the aerial survey contractor compare the data and perform change detection between the surveys. DOE proposed that the detailed LiDAR survey and evaluation take the place of walking the transects on the disposal cell starting in 2016. As stated above, visually delineating surface anomalies during the transect walk have historically been subjective without any added value. The LiDAR survey is more objective and supported by technological data. The use of the LiDAR survey would also reduce the hazards to personnel performing the inspection of the disposal cell. It would still be planned to walk to the rock degradation areas and perform the routine inspection of these areas each year by comparing the test plot area to the previous year's photograph and photographing the test plot.

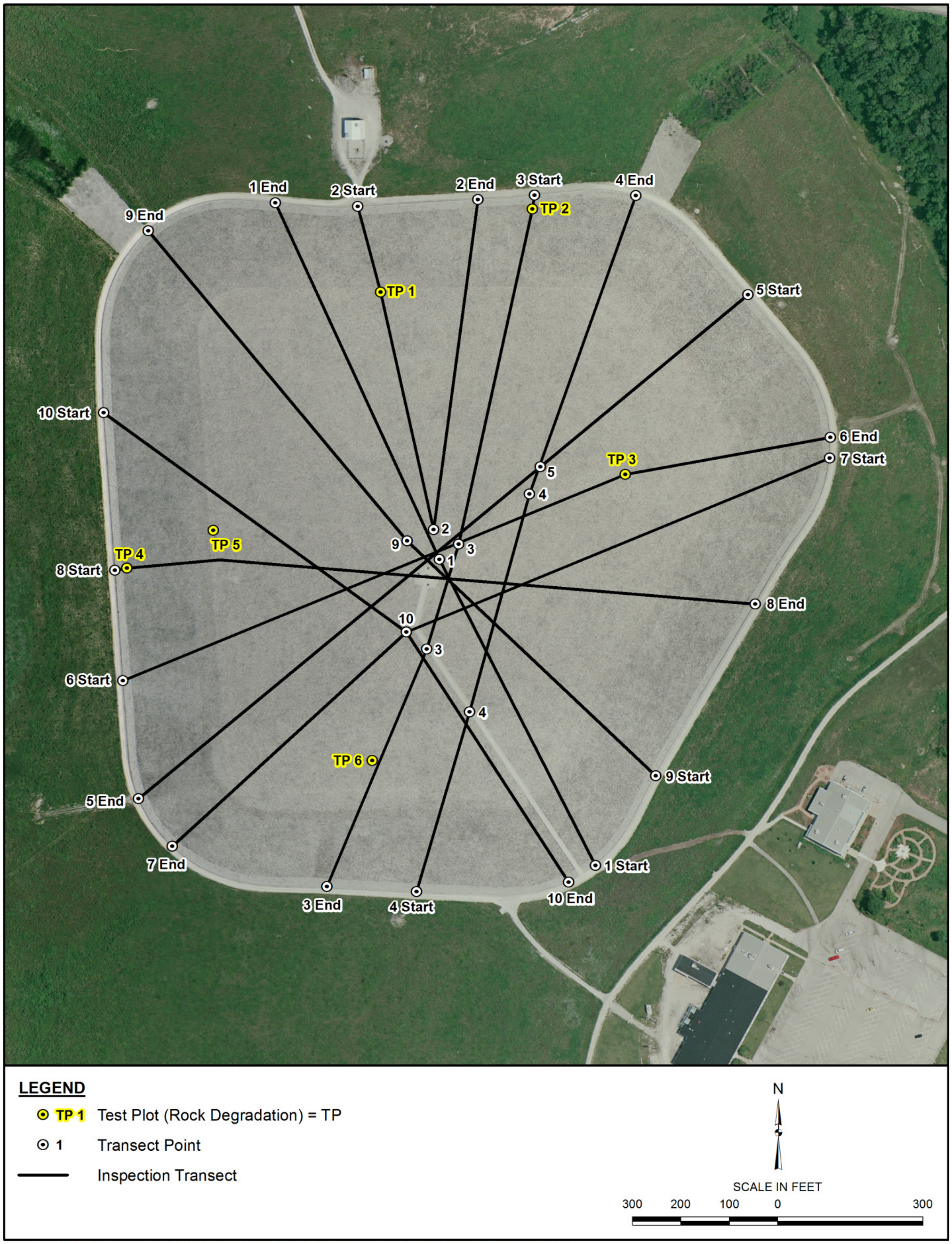

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Figure 97. Disposal Cell Inspection Transects and Rock Test Plot Locations at the Weldon Spring, Missouri, Site

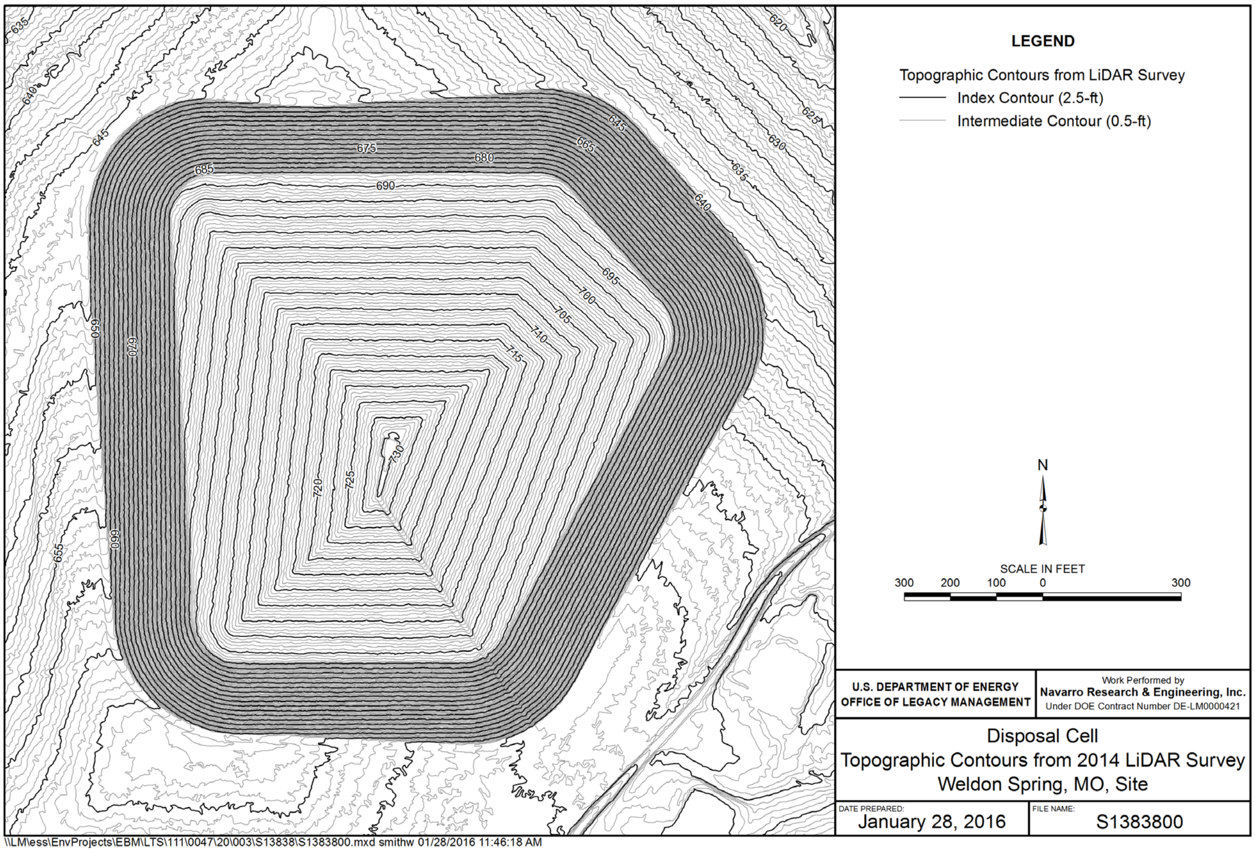

Figure 98. LiDAR Aerial Survey

EPA and MDNR were agreeable with the proposal. EPA suggested that DOE include this determination under the optimization section of this report (Section 7.1.3).

6.5.4 Leachate Collection and Removal System (LCRS)

Navarro staff discussed operation of the LCRS and the SOARS (System Operation and Analysis at Remote Sites) system with the inspection participants, presented the LCRS data and inspected the system. The leachate is pretreated for uranium and then disposed of by transferring the combined leachate hauling to the Metropolitan St. Louis Sewer District (MSD) Bissell Point Plant. The fences and doors were locked and were in good condition. The system was functioning as designed.

6.5.5 Erosion

6.5.5.1 Chemical Plant Area

The erosion areas were observed during the inspection (Photo 22). Erosion channels within the entire prairie have been mapped with GPS annually since 2007 (Figure 99). The information is used to track the nature and extent of erosion and to determine action, if necessary. During the inspection, it was noted that the erosion and plant growth in the erosion areas has improved over past years and is not considered an issue at this time.

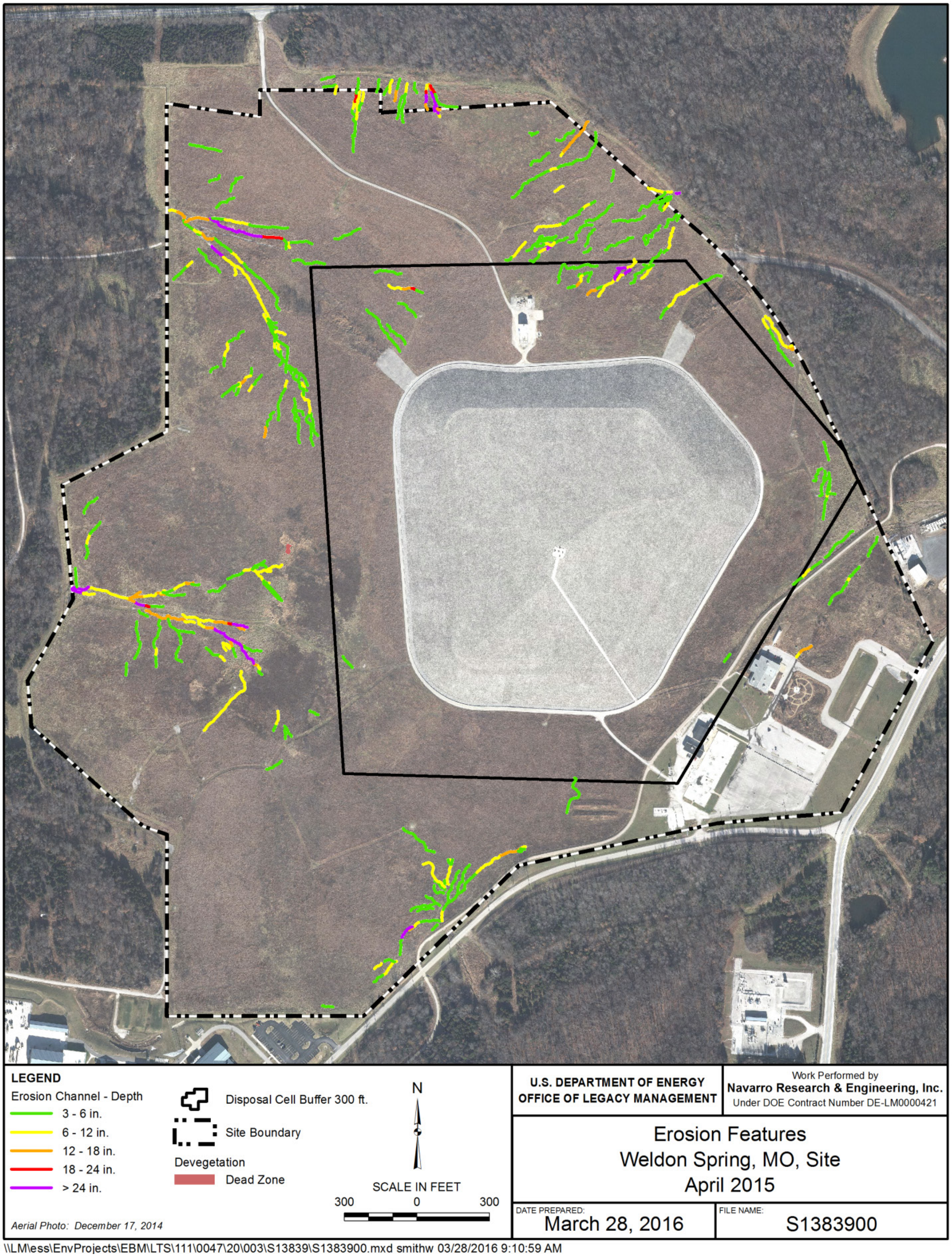

Figure 99. Erosion Features

6.5.5.2 Quarry Area

No erosion areas were noted during the inspection of the Quarry Area.

6.5.6 General Site Conditions

General site conditions as listed in the checklist were inspected and are discussed below.

6.5.6.1 Roads

The roads consist of asphalt roads leading into the property and a gravel road that extends around the disposal cell and to Gate D. The roads were in good condition.

6.5.6.2 Vandalism

Although the site is publicly accessible, signs are clearly posted at the disposal cell that the viewing platform is open during daylight hours only. Public use of the site continues to increase. Security patrols have been increased over the past five years for visibility and to reduce vandalism and increase safety at the site. Signs were also posted at the disposal cell entrance and the top of the disposal cell that state that video surveillance is being conducted.

On September 9, 2012, it was discovered that wells MW-3031 and MW-3037 had been vandalized. Upon inspection it was determined that the aluminum top caps had been broken off of both wells. Attempts to measure the static water level in MW-3031 revealed that a large rock had been forced down MW-3031 and was lodged in the casing approximately 4.5 ft from the top of the casing. It was decided to abandon this well. DOE sent a letter to the EPA and MDNR on October 2, 2012, discussing the past performance of MW-3031 and the decision to abandon the well. A drilling subcontractor performed the abandonment work on July 15, 2013. To assist in preventing this type of vandalism in the future, new steel well protective caps were fabricated and installed on all monitoring wells that had the aluminum top caps. Installation was completed on May 21, 2013.

6.5.6.3 Personal Injury Risks

No personal injury risks were observed.

6.5.6.4 Site Markers

The four information plaques on top of the cell were generally in good condition. The historical markers were inspected (Photo 23) and were in good condition. The actual signs had recently been replaced prior to the inspection.

The LTS&M Plan also requires No Trespassing signs to be posted on the LCRS fence along with the DOE 24-hour security telephone number (970-248-6070 or 877-695-5322) that the public can call for information. During the 2015 inspection, inspectors noted that these signs were posted on the LCRS fence and were in good condition.

6.5.7 Monitoring Wells

6.5.7.1 Disposal Cell Monitoring Well Network

Each of the wells in the disposal cell network (MW-2032, 2046, 2047, 2051, 2055) were inspected and found to be in good condition.

6.5.7.2 Chemical Plant Area Monitoring Well Network

The inspection checklist requires inspection of at least 10 percent of the wells from the former Chemical Plant monitoring well network. This network consists of 67 DOE-owned wells and 4 wells owned by the Army. This number does not include the five disposal cell wells, although some of those wells are monitored for the groundwater remedy. Twenty-seven wells were inspected (40 percent). The following wells were inspected: MW-2035, 2036, 2037, 2038, 2039, 2040, 3026, 3027, 3028, 3029, 3030, 3034, 3037, 3038, 3039, 4001, 4006, 4007, 4026, 4027, 4029, 4031, 4032, 4038, 4040, 4041, 4043.

6.5.7.3 Quarry Monitoring Well Network

The inspection checklist requires inspection of greater than 10 percent of the wells in the Quarry monitoring well network. The monitoring well network consists of 34 wells. The following 10 wells (29 percent) were inspected: MW-1006, 1008, 1009, 1012, 1014, 1017, 1018, 1044, 1052, RMW-4.

6.5.8 Onsite Document and Record Verification

The following onsite documents and records were available during the inspection:

- LTS&M Plan (DOE 2008c)
- NPDES permit: No. MO-0107701
- MSD agreement and records
- Teleconference and interview records

6.5.9 Contacts

In accordance with the checklist, inspectors notified several stakeholders prior to the inspection. The purpose of this notification is to keep contact with the stakeholders and determine if they have any issues or concerns. The following stakeholders were contacted:

- St. Charles County Sheriff
- Cottleville Fire District
- Francis Howell High School
- Simplex-Grinnell
- St. Charles County

The IC contacts also were notified about the inspection to maintain annual contact with the representatives relevant to IC issues. This annual contact is used to verify awareness of the ICs and to reiterate the requirements and restrictions with each representative. The representatives contacted are listed below.

- John Vogel, MDC
- Audrey Beres, MDC
- Danny Lyskowski, MDNR-Parks
- Quinn Kellner, MDNR-Parks
- John Downing, 88th Regional Support Command, U.S. Army
- Tom Blair, MoDOT
- Jim Wright, MoDOT
- Stowe Johnson, MoDOT
- Craig Tajkowski, St. Charles County Engineer

The St. Charles Planning and Zoning Department also was contacted, and they verified that no planning and zoning activities were currently taking place within one-quarter mile of the Chemical Plant and Quarry property. The Notation of Land Ownership and easements with the state property owners were verified to be filed and present at the St. Charles Recorder of Deeds office by checking the county website at www.sccmo.org.

Navarro Site Manager Yvonne Deyo and Environmental Data Manager Randy Thompson were interviewed as required by the inspection checklist.

All conversations and interviews were recorded on an Interview Record form adapted from the EPA Comprehensive Five-Year Review Guidance (EPA 2001). The forms for each of these contacts and interviews are attached as Appendix B.

6.5.10 Findings and Recommendations

No recommendations or findings were noted during the inspection.

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7.0 Technical Assessment

7.1 Chemical Plant Operable Unit

7.1.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer A: Yes, the remedy is functioning as intended by the decision documents.

7.1.1.1 Remedial Action Performance

The review of documents and environmental monitoring data and the results of the annual and Five-Year Review inspections indicate that the remedy for the CPOU, which consisted of controlling contaminant sources at the Chemical Plant and disposing of contaminated materials in an engineered onsite disposal facility, is functioning as intended. The disposal cell has remained stable and is in good condition, and based on annual inspections, and groundwater and leachate monitoring is performing as intended.

The site reached construction completion under CERCLA on August 22, 2005. The site also received the EPA Superfund Sitewide Ready for Anticipated Use (SWRAU) designation from EPA in a letter dated March 20, 2013. The SWRAU performance measure reports sites documented as ready for reuse when the entire construction-completed NPL site meets the following requirements:

- All cleanup goals in the RODs or other remedy decision documents have been achieved for media that may affect current and reasonably anticipated future land uses of the site, so that there are no unacceptable risks.
- All institutional or other controls required in the RODs or other remedy decision documents have been put in place.

After a review of all relevant site documents, including the RODs, the LTS&M Plan, five-year reviews, annual inspections and monitoring data, and ICs documentation, EPA determined that DOE has achieved the SWRAU performance measure for all DOE-owned land at the site. This includes the former Chemical Plant and Quarry areas and totals approximately 229 acres. The SWRAU measure was recorded as completed in the EPA Comprehensive Environmental Response, Compensation, and Liability Information System database on February 13, 2013.

7.1.1.2 System Operation and Maintenance

The LTS&M Plan includes system operation and operation-and-maintenance information for the site. DOE also performs annual inspections of site features, systems, and activities, such as the disposal cell, the LCRS, environmental monitoring, and ICs, and has found these areas to be functioning as intended.

7.1.1.3 Opportunities for Optimization

An aerial survey of the disposal cell was flown in December 2014. This aerial survey utilized the LiDAR technology to generate 6-inch contours. The previous surveys generated 1 ft contours using photogrammetric methods. The survey results were discussed during the inspection. DOE informed EPA and MDNR of the plan to conduct the aerial LiDAR survey every 2 years (at least initially) and have the aerial survey contractor compare the data and perform change detection between the surveys. DOE proposed that the detailed LiDAR survey and evaluation replace walking the transects on the disposal cell starting in 2016. Visually delineating surface anomalies during the transect walk has historically been subjective without any added value. The LiDAR survey is expected to be more objective and better supported by technological data. The use of the LiDAR survey would also reduce the hazards to personnel performing the inspection of the disposal cell. DOE would still plan to walk to the rock degradation areas and perform the routine inspection of these areas each year by comparing the test plot area to the previous year's photograph and photographing the test plot. EPA and MDNR concurred with the proposal. EPA suggested that DOE include this determination under this section of the report.

7.1.1.4 Early Indicators of Potential Issues

There are no early indicators of potential issues that could affect the protectiveness of the remedy.

7.1.1.5 Implementation of ICs and Other Measures

The information in this section is extracted from Section 3.0 of the LTS&M Plan (DOE 2008c).

This section summarizes information pertinent to the implementation of ICs to meet objectives of the use restrictions described in the ESD issued in February 2005 (DOE 2005b). The ESD clarified use restrictions necessary for the remedial actions specified in the CPOU, GWOU, and QROU RODs to remain protective over the long term. The areas requiring use restrictions are shown on Figure 100 and Figure 101.

Use Restrictions

The ESD prepared for the Weldon Spring Site presents use restrictions for specific areas. The areas are on either federally owned or state-owned properties. No privately owned property is affected by the use restrictions. The use restrictions for the Chemical Plant property are described below:

Disposal Cell and Buffer Area

The use restrictions listed below must be met throughout the disposal cell area, including its surrounding 300 ft buffer zone. This area is under federal DOE jurisdictional control. The use restrictions listed below shall be maintained until the remaining hazardous substances are at levels allowing for unlimited use and unrestricted exposure (UUUE). Due to the extremely long-lived nature of the radioactive constituents in the disposal cell, these restrictions are expected to be necessary for perpetuity. The objectives of the controls or restrictions are as follows:

1. Prevent activities on the disposal cell, such as the use of recreational vehicles, that could compromise the integrity of the cell cover (e.g., result in the removal or disturbance of the riprap).
2. Prevent activities in the buffer zone, such as drilling, boring, or digging, that could disturb the vegetation, disrupt the grading pattern, or cause erosion.

3. Retain access to the buffer area for continued maintenance, monitoring, and routine inspections of the cell and buffer area.
4. Prevent construction of any type of residential dwelling or facility for human occupancy on the disposal cell and buffer area, other than facilities to be occupied for activities associated with performing environmental investigation or the restoration and expansion of the existing Interpretive Center.
5. Maintain the integrity of any current or future remedies or monitoring systems.

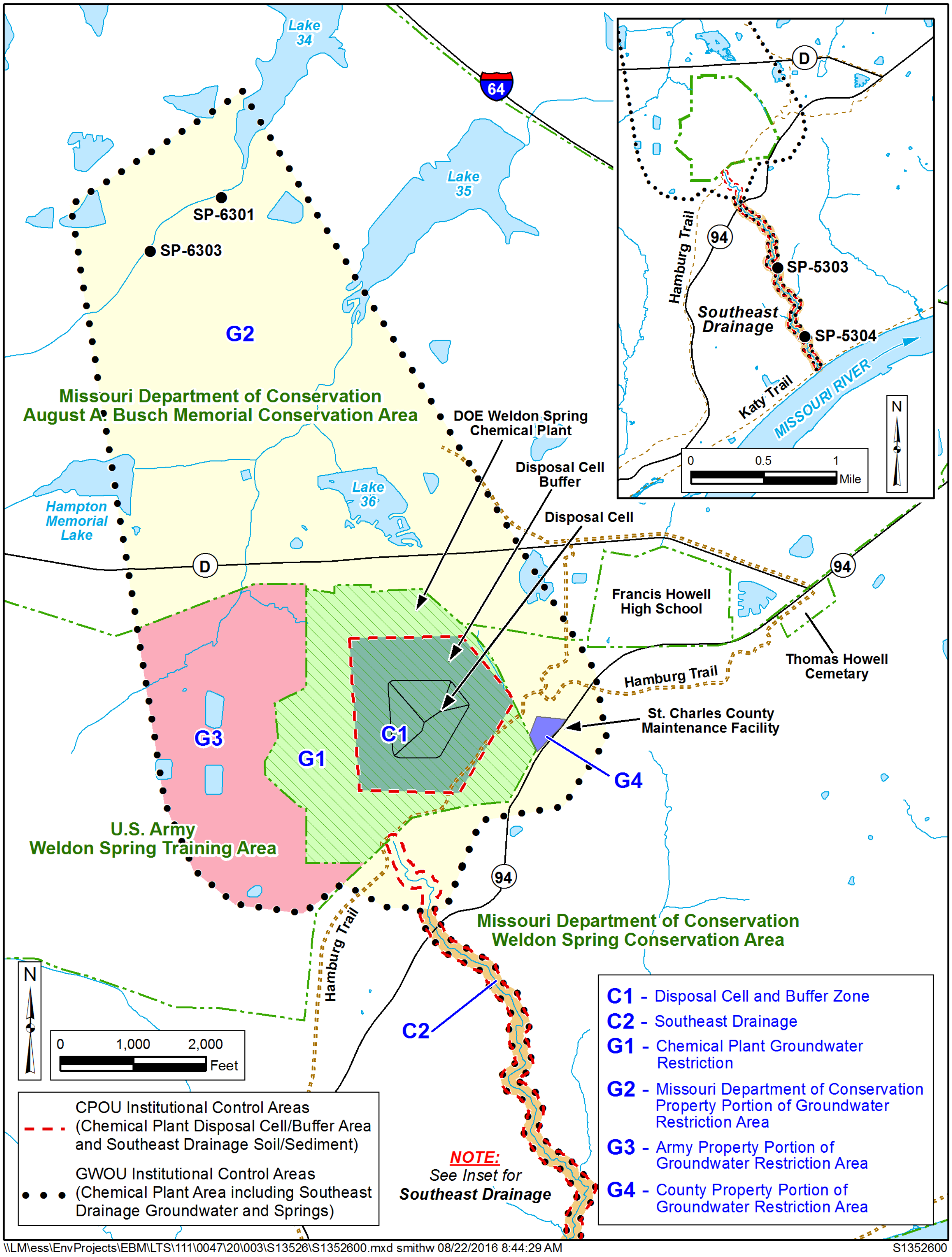

Figure 100. Institutional Control Areas for the Chemical Plant and Groundwater Operable Units

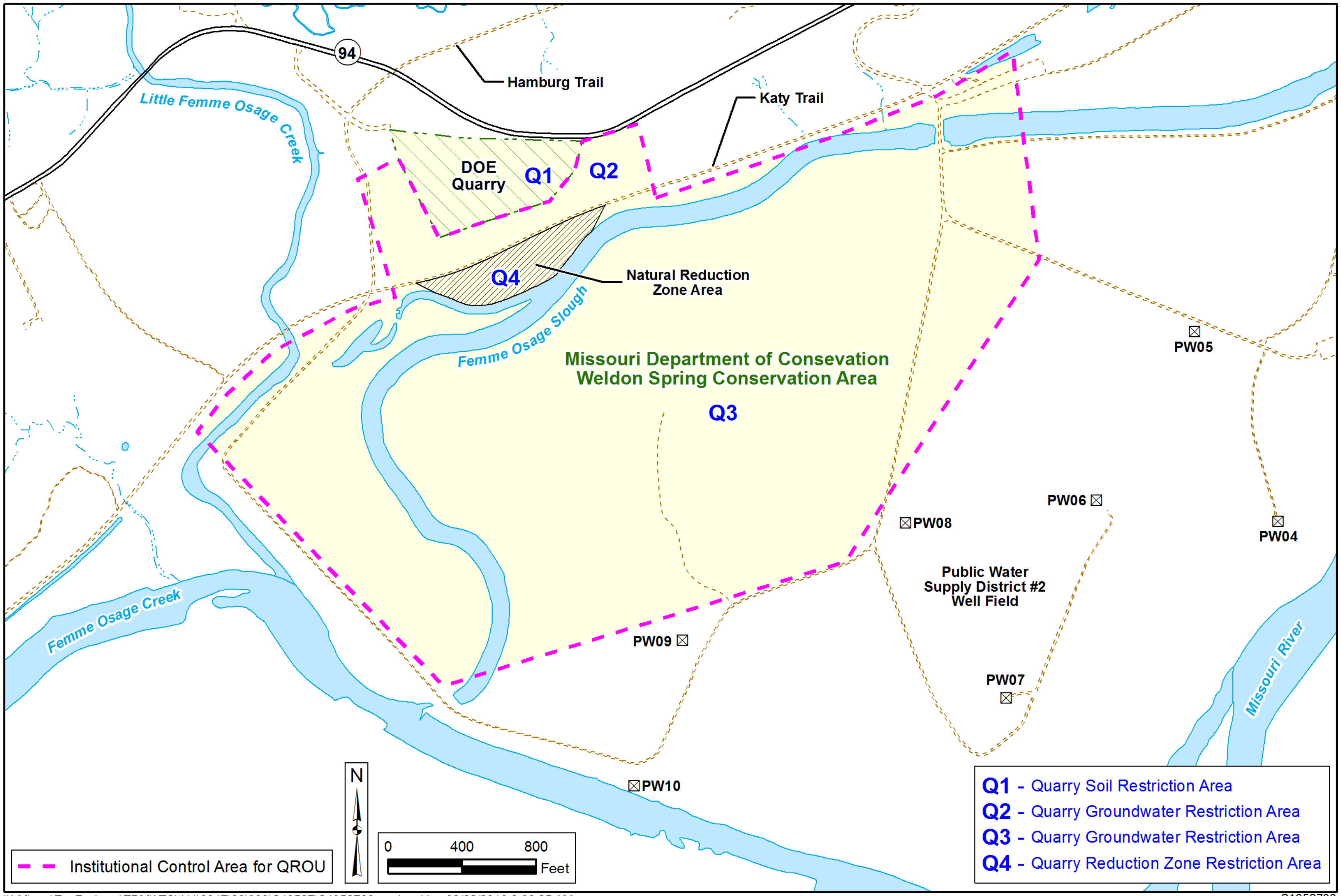

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Figure 101. Institutional Control Areas for the Quarry Residuals Operable Unit

Southeast Drainage Soil or Sediment

The use restrictions listed below must be met at the approximately 37-acre area covering the 200 ft corridor along the length of the Southeast Drainage: The restricted area is located on property that is owned by state entities. These restrictions will need to be maintained until the remaining hazardous substances are at levels allowing for UUUE, which is anticipated to be a period of decades or longer.

- Prevent the development and use of the Southeast Drainage property for residential housing, schools, childcare facilities, and playgrounds.

Types of ICs

Specific IC mechanisms have been identified to implement the use restrictions presented for each area. The ICs generally fall into one of the four categories identified by EPA guidance (EPA 2000). Multiple mechanisms are being used to provide "layering" for additional durability.

The EPA IC categories are as follows.

1. **Proprietary controls:** Are based on real property law and generally create legal property interests; include easements and covenants.
2. **Governmental controls:** Are generally implemented and enforced by state or local governments; include zoning restrictions, well drilling regulations, building permits, ordinances, and similar mechanisms that restrict land or resource use.
3. **Enforcement and permit tools with ICs components:** Can be used to enforce or restrict site activities; include CERCLA FFAs, CERCLA Unilateral Administrative Orders, and Administrative Orders on Consent.
4. **Informational devices:** Provide information that a site contains residual or capped contamination; include state registries, deed notices, information centers, markers, and advisories.

Summary of ICs Currently in Place

The following ICs are in place for the Weldon Spring Site:

1. DOE has exclusive jurisdictional control over the Chemical Plant and the Quarry. Federal ownership provides inherent authority for DOE to control land use based on its legislative jurisdiction and take action against unapproved uses, but also entails statutory and regulatory obligations. Numerous requirements are placed on federal agencies that manage land to ensure the protection of human health and the environment. Per DOE Order 430.1B, *Real Property Asset Management*, DOE is required to provide an inventory of the specific ICs implemented to restrict use of the property in DOE's Facilities Information Management System (FIMS). The maintenance of a real property asset inventory system is designed to communicate the presence of land use restrictions to current federal management personnel and to ensure that this information is readily available to possible future users of the land. As part of the protocol for maintaining this database, FIMS data must be (a) maintained as complete and current throughout the life cycle of real property assets, including real-property related ICs; and (b) archived after disposal of real property assets) with those

necessary for long-term maintenance and surveillance identified, reviewed, and retained accordingly.

CERCLA Section 120(h)(3) requires for property transfers to be accompanied by a covenant warranting that "all remedial action necessary to protect human health and the environment with respect to any such substance remaining on the property has been taken before the date of transfer" and that "any additional remedial action found to be necessary after the date of transfer shall be conducted by the United States." Upon transfer, the deed or other agreement governing the transfer must contain clauses that indicate the following information: (a) necessary restrictions on the use of the property to ensure protection of human health and the environment (e.g., maintenance of ICs), and (b) restrictions on the use necessary to ensure that the required remedial investigations, response actions (e.g., monitoring, implementation of ICs), and oversight activities (e.g., LTS&M activities) will not be disrupted.

2. DOE has committed to perpetual care of the disposal cell and buffer zone as specified in the Chemical Plant ROD, which is enforceable under the FFA.
3. A notation has been entered on the ownership record filed at the St. Charles County Recorder's Office (deed notice). The notation explains the restrictions on groundwater use and residential development of the Chemical Plant and Quarry Areas. The notice acts as an informational device in the event ownership is transferred at some point in the future.
4. The Interpretive Center serves as a community information resource, which depicts the history of the area and details the progression of the cleanup process. Information is available on the construction of the engineered disposal cell and the residual groundwater contamination.
5. Historical markers have been placed along the Hamburg Trail, and informational plaques are accessible at the top of the engineered disposal cell. The historical markers depict significant events and locations along the trail related to the displacement of the population during the early 1940s to accommodate the federal government's World War II efforts. The markers also note significant events at their respective locations related to DOE cleanup efforts and encourage the reader to learn more by visiting the DOE Interpretive Center. Similarly, the plaques at the top of the disposal cell contain information regarding the surroundings and the history of St. Charles, as well as information regarding the cleanup and waste materials buried within the disposal cell.
6. Missouri regulates the construction of wells pursuant to 10 CSR Chapter 3, "Well Construction Code," Section 3.010(1)(A)4, which states that "a well shall be constructed so as to maintain existing natural protection against pollution of water-bearing formations and to exclude all known sources of contamination from the well including sources of contamination from adjacent property." 10 CSR 3.030(2) states, "Minimum Protective Depths of Well Casing. All wells shall be watertight to such depths as may be necessary to exclude contaminants. A well shall be constructed so as to seal off formations that are likely to pose a threat to the aquifer or human health." Well Construction Code 10 CSR 3.090(1)(A) says, "All persons engaged in drilling domestic wells in Area 1, a limestone or dolomite area shall set no less than 80 ft of casing, extending not less than 30 ft into bedrock. Example: if 60 ft of residual (weathered rock) material is encountered in drilling before bedrock, then 90 ft of casing must be set." These regulations combine to have the effect of preventing the construction of wells that would allow for consumption of

contaminated groundwater by preventing the well from drawing water from groundwater from a depth less than 80 ft, which includes the surficial contaminated zone.

7. DOE has real estate licenses with MDC that allow access for the purpose of monitoring and maintaining groundwater wells, drilling and plugging wells, usage of the effluent water pipeline, and entering through the north gate.
8. DOE has real estate licenses with MDNR that allow access along portions of the Katy Trail for the purpose of monitoring and maintaining groundwater wells, drilling and plugging wells, using the effluent water pipeline, and collecting samples along portions of the Katy Trail.
9. A Memorandum of Understanding (MOU) with the Army regarding cooperation with DOE's remedy implementation is in place. The MOU gives DOE permission to access Army property for the purpose of implementing remedial actions, which includes monitoring and maintaining groundwater wells, drilling and plugging wells, and inspecting for consequential land or resource use changes. The revised MOU, signed in 2009 by both parties, is also specific with respect to the necessary groundwater use restrictions for property under Army control.
10. A "Special Use Area" Designation Under the State Well Drillers' Act was finalized in the Missouri regulations and became effective in August 2007 (10 CSR 23-3.100[8]). This is a special regulation that DOE and the Army pursued. It designated DOE and the Army's groundwater restricted areas as special areas that require additional drilling protocols and construction specifications, imposed by MDNR, on any future domestic wells.
11. An easement with the MDNR Division of State Parks restricts the use of groundwater on areas of their property along the Katy Trail and grants right of access to DOE for purposes of monitoring and characterization.
12. An easement with MDC (which was finalized in July 2011) restricting use of the contaminated groundwater and the hydraulic buffer zone on MDC property, and also to restrict land use in the Southeast Drainage and at the Quarry reduction zone
13. An easement with MoDOT (which was finalized in May 2012) restricting the use of groundwater to investigative purposes and restricting the use of the property from being used in a way that could disturb or interfere with the integrity of any potential monitoring systems.
14. The use restrictions and the ICs identified in the LTS&M Plan are enforceable under the FFA.

The institutional controls which were required by the *Explanation of Significant Differences, Weldon Spring Site* (DOE 2005b) were all completed with the finalization of the easement with MoDOT in 2012.

Easements

DOE has finalized easements with three of the surrounding affected state-agency landowners for implementing the use restrictions required on state properties. An easement is a real property interest that conveys certain rights from the grantor (fee simple land owner) to the grantee. In the case of the Weldon Spring Site, DOE has finalized easements for the purpose of restricting use of the contaminated groundwater and the hydraulic buffer zone, and also to restrict land use in the Southeast Drainage and at the Quarry reduction zone. The easements will also ensure DOE access to monitoring locations for sampling and maintenance and, where applicable, provide that DOE is notified of use inconsistent with the terms of the easements.

DOE has acquired the easements in accordance with DOE policy and procedures. The completed easements have been recorded with St. Charles County.

7.1.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

Answer: Yes, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy are still valid.

7.1.2.1 Changes in Standards and To Be Considereds (TBCs)

Section 1.5, *Current Regulatory Requirements,* of the LTS&M Plan discusses the ARARs that apply to the post-remediation aspect of the project, and states the following:

> 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 Disposal Cell Groundwater Monitoring Plan (Appendix K) 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 Sections 2.7.4, 2.9.2, and Appendixes I and J. Subpart N also includes requirements to maintain the integrity of the final cover, including making repairs as necessary, which is addressed in Section 2.6.

There have been no changes to standards on TBCs that could affect the remedy.

The ARARs for the Chemical Plant are listed in Table 51.

Table 51. Chemical Plant ARARs

ARAR/Citation	Description	Status	Comments
RCRA Subtitle F and N; 40 CFR 264	Regulates groundwater monitoring and post-closure care	Relevant to post-closure care	Groundwater monitoring, leachate collection being conducted in accordance with these requirements

7.1.2.2 Exposure Pathways, Toxicity and Risk Assessment

The contaminated soil and other wastes generated from the CPOU cleanup are now permanently disposed of at an engineered disposal cell constructed at the Chemical Plant. Wastes generated from cleanup of the Quarry Area have likewise been disposed of in the disposal cell. At the time of its closure, the cell contained approximately 1.13 million cubic meters (1.48 million cubic yards) of waste.

The following is excerpted from the ESD (DOE 2005b) and summarizes the remediation approach and residual risks:

> The 1993 CPOU ROD specifies that "perpetual care be taken of the committed land within the disposal cell footprint because waste would retain its toxicity for thousands of years." It stipulates that the cell cover be inspected and that the groundwater be monitored. This ROD also specified that "following completion of the site cleanup activities, an assessment of the residual risks based on actual site conditions will be performed to determine the need for any future land use restrictions. This assessment would consider the presence of the onsite disposal cell, the buffer zone, the adjacent Army site, and any other relevant factors necessary to ensure that appropriate measure are taken to protect human health and the environment for the long term.
>
> As part of the remedy selected for the CPOU, soil contamination was cleaned up by removing to depth and disposing of contaminated soils in the onsite disposal cell. Soil cleanup goals were established in the CPOU ROD that were intended to be as low as reasonably achievable given the design limitations pertaining to safe field excavation techniques and field survey capabilities. Recreational use was considered to be the reasonably anticipated future land use. A standard conservative recreational visitor scenario as defined in the CPOU Baseline Risk Assessment (DOE 1992d was considered to be representative of recreational use. The exposure assumptions used were consistent with those recommended for a recreational scenario in EPA Risk Assessment Guidance for Superfund[1] (RAGS). Risk calculations based on the soil cleanup goals showed cumulative risk to the recreational visitor was within the acceptable risk range. Recognizing that the actual post cleanup condition might be different than what was anticipated by the cleanup goals, the ROD specified that a post-remediation risk assessment would be performed following cleanup and that a final decision on the need for any future land use restrictions would be based on the actual residual condition.
>
> The soil excavations were conservatively designed to remove contamination to depth to achieve the established cleanup goals or better. The post-remediation risk assessment (DOE 2002b) used post cleanup confirmation data to evaluate the cumulative risk posed by exposure to soil from all contaminants. The assessment is believed to overestimate risks because it did not take into consideration the backfilling and reworking of the soils following excavation. The assessment confirmed that the potential risks to recreational visitors are within the acceptable risk range.
>
> The post-remediation risk assessment also evaluated the risk to a suburban resident. A standard conservative suburban residential scenario as defined in the CPOU Baseline Risk Assessment was used. Following recommendations in EPA guidance (RAGS, Exposure Factors Handbook), the exposure assumptions (e.g., contact rate, exposure frequency and duration variables) used as input to this estimate were based on statistical data representing the 95th or, if not available, the 90th percentile value for these variables. This approach provides risk estimates for reasonable maximum exposure (RME) to a resident receptor. The calculated risk to the suburban resident was generally greater than 1×10^{-4} but less than 1×10^{-3} and therefore slightly exceeds the acceptable risk range. However, the risk to the suburban resident from exposure to naturally occurring background concentrations of radionuclides in soils is 5.3×10^{-4} or essentially the same risk posed by residual concentrations in the remediated areas. In other words, there is no significant incremental increase in risk from exposure to the remediated areas for a suburban

[1] EPA 2009

resident. For purposes of this site and this ESD, the standard conservative suburban residential scenario is considered representative of unlimited use and unrestricted exposure (UUUE), the EPA policy threshold for determining whether ICs are appropriate.

These calculated risks are cumulative of all contaminants; however, the risks are primarily due to the radionuclides associated with the uranium ores. The CPOU ROD considered the standards for residual Ra-226 found in 40 CFR 192, Subpart B to be relevant and appropriate (RAR) to the cleanup of these radionuclides. The ROD was issued in 1993 prior to the issuance of EPA Directive 9200.4-25, Use of Soil Cleanup Criteria *[in]* 40 CFR 192 as Remediation Goals for CERCLA Sites. A review of the expectations set forth by EPA in this guidance confirms 1) these standards would be considered RAR were the decision to be made today, i.e., the contamination and its distribution was consistent with the outlined expectations; and 2) the actual residual concentrations for radium and thorium combined are much less than the concentrations identified in the guidance as meeting the health-based standard.

The following is an explanation of risk information:

To guide plans for managing contaminated sites, EPA established an acceptable risk range that represents the increased probability (above a background rate) of a hypothetical person developing cancer over their lifetime from assumed exposures to site contaminants. This acceptable range for an incremental lifetime cancer risk is between one in a million (1×10^{-6}, or 0.000001) and one in ten thousand (1×10^{-4}, or 0.0001).

Table 52 lists the contaminants of concern in soils at the CPOU which were included in the post-remediation risk assessment (DOE 2002b). While not inclusive of all soil COCs listed in Table 5, these are the constituents that accounted for nearly all residual risk at the site and for which cleanup criteria were established in the ROD (DOE 1993). Risk calculations in the CPOU post-remediation risk assessment showed that external exposure to radium-226 and radium-228 in CPOU soils accounted for the majority of carcinogenic site risks (higher than 1×10^{-4} but less than 1×10^{-3} for residential exposure) and were comparable to background risk levels. External exposure to uranium-238 and ingestion of uranium and arsenic in site soils could also result in risks greater than 1×10^{-6} under a residential scenario. Other pathways and constituents resulted in much lower risks. Residual risks for all constituents and pathways under a visitor scenario were less than 1×10^{-5}. Potential exposures to noncarcinogenic constituents were well below a hazard index of 1 for both residential and visitor exposures.

A Hazard Index is the sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. A hazard quotient is the ratio of a single substance exposure level over a specified time period to a reference dose for that substance derived from a similar exposure period. Based on EPA's risk guidelines, a maximum acceptable hazard index is 1.

Table 52. CPOU Toxicity Value Summary

Constituent	Pathway	C or N	Post-Remediation Toxicity Values	Current Toxicity Values	Source	Change
Radium-226+D	Ingestion[f]	C	7.5E-10	6.77E-10	PRG	Decrease
	External[a]	C	8.49E-06	8.37E-06	PRG	Decrease
	Inhalation[f]	C	1.16E-08	2.82E-08(S)	PRG	Increase
Radium-228+D	Ingestion[f]	C	2.29E-09	1.98E-09	PRG	Decrease
	External[a]	C	4.53E-06	4.04E-06	PRG	Decrease
	Inhalation[f]	C	5.23E-09	4.37E-08(S)	PRG	Increase
Thorium-230	Ingestion[f]	C	2.02E-10	1.66E-10	PRG	Decrease
	External[a]	C	8.19E-10	8.45E-10	PRG	Increase
	Inhalation[f]	C	2.85E-08	3.41E-08(F)	PRG	Increase
Uranium-238+D	Ingestion[f]	C	2.10E-10	1.97E-10	PRG	Decrease
	External[a]	C	1.14E-07	1.19E-07	PRG	Increase
	Inhalation[f]	C	9.35E-09	2.37E-08(S)	PRG	Increase
Uranium	Ingestion[c]	N	3.0E-03	3.0E-03	IRIS	No change
Arsenic	Ingestion[b]	C	1.5	1.5	IRIS	No change
	Inhalation[d]	C	0.0043	0.0043	IRIS	No change
	Ingestion[c]	N	0.0003	0.0003	IRIS	No change
	Inhalation	N	Not considered	1.5E-05[g]	Cal EPA	Added
Chromium III	Ingestion[c]	N	1.5	1.5	IRIS	No change
Chromium VI	Inhalation[d]	C	0.012	0.084	RSL	Increase
	Inhalation	N	1.0E-04	1.0E-04	IRIS	No change
	Ingestion[c]	N	0.003	0.003	IRIS	No change
	Ingestion[b]	C	Not considered	5.0E-01	NJ	added
Lead	Residual soil risks assessed through modeling					
Thallium	Ingestion[c]	N	0.00008	0.00001	PPRTV	Decrease
PAHs	Ingestion[b]	C	7.3[e]	7.3[e]	IRIS	No change
PCBs	Ingestion[b]	C	2.0	2.0	RSL	No change
2,4,6-TNT	Ingestion[b]	C	0.03	0.03	IRIS	No change
	Ingestion[c]	N	5E-04	5E-04	IRIS	No change

Notes:
[a] risk/yr per pCi/g.
[b] slope factor; (mg/kg-d)$^{-1}$.
[c] reference dose (mg/kg-d).
[d] unit risk (µg/m^3)$^{-1}$.
[e] slope factor for benzo*[a]*pyrene used for all B2 PAHs.
[f] risk/pCi.
[g] Reference concentration (mg/m^3).

Abbreviations:
+D = plus daughter isotopes
C or N = carcinogenic or noncarcinogenic
F = particulate aerosols that represent fast absorption to the blood
IRIS = EPA's Integrated Risk Information System [http://www.epa.gov/iris; last accessed December 2015]
µg/m^3 = micrograms per cubic meter
mg/kg-d = milligrams per kilogram per day
pCi/g = picocuries per gram
NJ = New Jersey Department of Environmental Protection
PPRTV = Provisional Peer-Reviewed Toxicity Value (EPA 2012)
PRG = values from EPA's Radionuclide Preliminary Remediation Goal calculator (EPA 2015)
RSL = EPA's Regional Screening Level Summary Table (November 2015)
S = particulate aerosols that represent slow absorption to the blood

Table 52 includes toxicity values used in the post-remediation risk assessment. Since the last Five-Year Review, EPA has issued guidance on radiation risk assessment for CERCLA sites (EPA 2014). In this guidance, EPA recommends using toxicity values (i.e., slope factors) included in their preliminary remediation goal (PRG) calculators to estimate radiation risks for CERCLA sites. The slope factors currently provided in EPA's radionuclide PRG calculator are from Oak Ridge National Laboratory (ORNL 2014) and are more recent than the values used in the post-remediation risk assessment, which were obtained from EPA's health effects assessment summary tables (HEAST; EPA 2002). Table 68 includes EPA's PRG values for comparison to HEAST values. For chemicals, EPA's Regional Screening Level (RSL) summary tables and website (http://www.epa.gov/risk/regional-screening-table) were consulted for any changes in toxicological values since the last Five-Year Review.

For radionuclides, all slope factors currently in EPA's PRG calculator are slightly different than those from HEAST. Half of the values are slightly higher and half are slightly lower. Most of the higher values are for the inhalation pathway, which is insignificant compared to the external exposure pathway. Most of the lower values are for external exposure and ingestion pathways and would result in slightly lower estimated risks. Using revised slope factors would probably result in an overall calculated lower residual risk than in the post-remediation risk assessment. Exposure assumptions used in the risk assessment still remain valid. However, the fact that the cleanup achieved levels comparable to background for radionuclides means that they are as low as is reasonably achievable, regardless of exposure assumptions and toxicity values. Unless currently unknown radiological contamination is discovered in the future, conditions are as protective as is feasible.

Only two toxicity values for chemicals (chromium VI and thallium) are different from those used in the post-remediation assessment and would not affect post-remediation risk estimates, as these are not primary site constituents. There were no changes in toxicological values for chemicals in soil at the CPOU since the last Five-Year Review. Exposure assumptions are still valid, and site conditions remain protective.

No consensus toxicity values are available for lead in soil. Instead, EPA currently recommends a screening level of approximately 400 mg/kg for residential soils. The CPOU ROD established a cleanup criterion for lead of 450 mg/kg with an ALARA (as low as reasonably achievable) goal of 240 mg/kg (DOE 1993). After cleanup, modeling was used to assess the protectiveness of post-remediation residual lead in soils based on estimated children's blood lead levels (BLL). At the time it was EPA's policy that there should be no greater than a 5% probability that an individual child's BLL would exceed 10 micrograms per deciliter (µg/dL). The Centers for Disease Control and Prevention (CDC) updated recommendations on children's BLL in January 2012 (CDC 2012). The CDC lowered their recommended screening level from 10 µg/dL to 5 µg/dL for children ages 1 to 5 for identifying children with elevated BLL. Modeling results included in the post-remediation risk assessment indicated that children's BLLs would be ≤3.5 µg/dL (with less than a 1% probability of exceeding 10 µg/dL) for exposures to soil in all portions of the CPOU. Residual lead levels in soils are therefore still considered to be protective.

EPA issued vapor intrusion guidance in June 2015 for assessing potential impacts to indoor air and made available a vapor intrusion screening level calculator and user guide. More than 100 constituents that had not previously been considered as VOCs were given that designation in

EPA's regional screening level (RSL) tables and included in their Vapor Intrusion Screening Level (VISL) calculator (EPA 2013). Additionally, EPA issued a supplement (EPA 2012) to their Five-Year Review Guidance (EPA 2001) for assessing protectiveness at vapor intrusion sites. The vapor intrusion exposure pathway was not previously evaluated for the CPOU. A number of constituents from Table 5 were identified as VOCs in EPA's VISL calculator. These include: acenaphthene, anthracene, fluorene, naphthalene, nitrobenzene, and pyrene. Of these, only naphthalene and nitrobenzene have inhalation toxicity data. None of these VOCs were specifically addressed in the CPOU ROD. Based on the baseline risk assessment for the CPOU (DOE 1992) and data in Table 5, concentrations of the VOC constituents were all relatively low. None of the VOC constituents was identified as a groundwater COC. While soil gas sampling was not conducted as part of site characterization, available data do not suggest that the vapor intrusion pathway is of potential concern. In the absence of any new information that would indicate higher concentrations or more widespread distribution, residual VOCs in soil are not likely to pose a threat through the vapor intrusion pathway even if buildings were constructed in the CPOU area.

DOE concluded in the ESD that there is no need to restrict land use in the Chemical Plant Area based on exposure to soils. This conclusion still remains valid based on updated information. This assessment applies to land use only. This assessment does not apply to the soils and sediments in the Southeast Drainage or issues related to groundwater contamination.

The Southeast Drainage is narrow and wooded with limited access. One of the objectives of the cleanup was to limit ecological damage to the drainage. It was determined that the soil cleanup goals developed for the CPOU, described above, were not appropriate for cleanup of this area. Risk-based cleanup goals were developed for the drainage that were designed to be protective for recreational use and for a modified residential scenario involving a child living near the drainage and using it periodically for play activities. Post-cleanup soil and sediment sampling was conducted, and a post-cleanup risk assessment was performed to confirm that the drainage is protective for these uses and, therefore, protective for any reasonably anticipated land use. However, residual soil and sediment contamination remains in some locations within the drainage at levels exceeding those that would support UUUE as represented in this case by a standard conservative suburban residential exposure scenario described above. Therefore, land use restrictions are needed in the drainage to prevent residential use or other uses inconsistent with recreational use. As noted above, the Southeast Drainage is located on property owned by state entities.

Risk-based cleanup criteria for the Southeast Drainage were based on achieving a risk level of 1×10^{-5} for recreational use of the area by a recreation visitor (child/hunter). Risk drivers were radionuclides, primarily radium-226, radium-228, thorium-230, and uranium-238. Pathways include soil ingestion and direct gamma exposure. The post-remediation risk assessment (ANL 1999) did not provide calculations or toxicity values, but referenced the methodology and assumptions used in a previous risk assessment (DOE 1996). To determine if risks based on current radionuclide slope factors are comparable to those in the post-remediation risk assessment, EPA's PRG calculator was used with data and assumptions from the post-remediation risk assessment for the Southeast Drainage. Risks resulting from the post-remediation risk assessment and the PRG calculator are provided in Table 53. (The hunter and child exposure scenarios were established in the EE/CA for the Southeast Drainage. For a hunter scenario, it was assumed that exposure to the contaminated area would occur for 1 hour per event at a frequency of 20 events per year for a duration of 10 years. For the child scenario, it was assumed that exposure to the contaminated area would occur for 1 hour per event at a frequency 90 events per year for a duration of 10 years. Soil ingestion and gamma exposure were included.)

Table 53. Comparison of Post-Remediation Risks for the Southeast Drainage with Risks Calculated Using EPA's PRG Calculator

Segment of SE Drainage	Post-Remediation Child[a]	Post-Remediation Hunter[a]	EPA PRG Child[b]	EPA PRG Hunter[b]
A	2×10^{-5}	5×10^{-6}	1.27×10^{-5}	2.82×10^{-6}
B	2×10^{-5}	5×10^{-6}	1.26×10^{-5}	2.81×10^{-6}
C	1×10^{-5}	3×10^{-6}	6.67×10^{-6}	1.48×10^{-6}
D	8×10^{-6}	2×10^{-6}	4.69×10^{-6}	1.04×10^{-6}

Notes:
[a] Total risks (ingestion, external exposure) from DOE 1999.
[b] Total risks (ingestion, external exposure) from EPA PRG Calculator using soil data and assumptions from DOE 1999.

A comparison of post-remediation and PRG risks in Table 53 indicates that they are similar in magnitude. All risks are slightly lower based on the PRG calculator. Therefore, the exposure assumptions and toxicity data used in the EE/CA (DOE 1996) and post-remediation risk assessment (DOE 2002b) of the Southeast Drainage are still valid as are the corresponding cleanup levels and remedial objectives. Because contaminant concentrations remain above levels that would permit UUUE, the most important factor for maintaining protectiveness in the Southeast Drainage is land use. As long as this area remains undeveloped and receives only recreational use, residual contaminant levels will be protective.

Ecological Risk

Numerous ecological investigations have been conducted at the Weldon Spring Site. A 1995 report (DOE 1995a) summarized studies that took place from 1987 until that time; a later letter report included a summary of more recent studies (ANL 2004). The investigations generally included sampling and analysis of various contaminated media and comparison against "safe" benchmark values. Quantitative and qualitative biological surveys were also conducted and included sampling and examination of plants, reptiles, birds, and small mammals to determine if any adverse effects could be observed. Mammals and fish were collected for tissue sampling, and toxicity testing was conducted to determine the potential for effects on aquatic life.

Sitewide biouptake studies were conducted to determine the potential effects of area fish and game consumption on an "avid sportsman" (DOE 1995a). Biouptake modeling was conducted using uptake factors and assumptions from the literature. In addition, fish, small mammals, and waterfowl were sampled to see how modeled tissue concentrations (based on concentrations of contaminated media and literature uptake factors) compared to actual observations. Results revealed that modeled dose estimates were greater than measured dose estimates by factors from 3 to 10—indicating the conservatism of model assumptions. Risks to humans calculated using modeled values were within EPA's acceptable risk range. It was determined that further biota monitoring was not needed to ensure protectiveness.

The baseline (preremediation) risk assessment for the CPOU (DOE 1992d) indicated that concentrations of some site-related constituents were present at levels that could potentially cause adverse effects in ecological receptors. However, no such adverse effects were actually observed in the fauna that were sampled, with the possible exception of the former raffinate ponds area (DOE 1992b); those ponds were subsequently remediated and exposures were eliminated.

Maximum surface water concentrations observed in the Southeast Drainage exceeded benchmarks and were further evaluated for ecological risks through toxicity testing (DOE 1996); limited toxicity was found at one location. Surveys of terrestrial wildlife indicated diverse communities and no adverse impacts. While aquatic communities were more limited, this was attributed to the intermittent nature of the drainage as opposed to site-related contamination. Uranium concentrations as high as 1,800 µg/L (about 1,200 pCi/L based on a site-specific conversion factor) were reported in the past in the Southeast Drainage—exceeding levels at which toxic effects have been observed (DOE 1992b). However, since that time uranium concentrations have declined. Sampling results from 2015 indicate that concentrations are less than 100 pCi/L (Figure 23).

There have been no significant changes in exposure assumptions, toxicity, or ecological risk assessment methodology that would call into question the protectiveness of the CPOU remedy (including the Southeast Drainage) from an ecological risk perspective. Concentrations in relevant media have been reduced through the remediation that has taken place.

7.1.2.3 Progress Toward RAOs

Section 7.1.1.1 includes a status on progress towards RAOs.

7.1.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Answer C: No other information has come to light that could call into question the protectiveness of the remedy.

7.2 Groundwater Operable Unit

7.2.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer A: Yes, the remedy is functioning as intended by the decision documents

7.2.1.1 Remedial Action Performance

The performance of the MNA remedy is assessed through the sampling of the Objective 2 monitoring wells. Objective 2 wells are within the areas of impact and monitor both the weathered and unweathered units of the Burlington-Keokuk Limestone. Objective 2 of the MNA strategy is to verify that contaminant concentrations are declining or remaining stable as expected and that cleanup standards will be met in a reasonable time frame.

Detection monitoring consists of sampling to fulfill Objectives 3, 4, and 5 of the MNA strategy. Wells along the fringes and downgradient (both laterally and vertically) of the areas of impact are monitored to ensure that lateral and vertical migration remains within the current area of impact and that expected lateral downgradient migration (due to dispersion) within the paleochannels is minimal or nonexistent. Springs and a surface water location on Dardenne Creek are also monitored as part of this program, as these are the closest groundwater discharge points for the shallow aquifer in the vicinity of the Chemical Plant. These locations are monitored to ensure that concentrations remain protective of human health and the environment and that water quality continues to improve in the springs.

Contaminant Trending Summary

Overall, groundwater impact is contained within the upper portion of the shallow aquifer (weathered and upper unweathered units of the Burlington-Keokuk Limestone). Decreases are attributed to source removal and attenuation mechanisms. Concentrations of uranium, nitrate, TCE, and nitroaromatic compounds are decreasing in most Objective 2 wells in the weathered unit. Statistically downward trends indicate that cleanup objectives will likely be attained in the weathered unit within the estimated time frames in the remedial design documents and the revised Baseline Concentrations Report (DOE 2008d). Locations that exhibit increasing concentrations are generally located along the leading edge of the area of impact. Some locations were expected to show temporary increases due to ongoing dispersion; however, concentrations are not expected to exceed historical maximums previously seen in the areas of highest impact.

Detection monitoring indicates that impacted groundwater is remaining within the paleochannels and is migrating along expected flow pathways. The levels of COCs in the springs are decreasing and are less than the cleanup objectives in Burgermeister Spring and SP-6303 (dry since 2013), except for uranium in Burgermeister Spring. This spring is the primary discharge point for groundwater from the Chemical Plant site, and while it continues to exceed the cleanup objective for uranium, levels are decreasing. It is expected that the average uranium levels in Burgermeister Spring will be below the cleanup objective in the next 20 years, and the maximum uranium will be below the cleanup objective in 30 years if the long-term trend over the last 25 years continues.

Uranium levels in the Southeast Drainage springs continue to exceed the cleanup objective. Contaminated groundwater from the Chemical Plant site is not the source of uranium in these springs; rather, surface water lost to the stream channel is flushing uranium from residually contaminated sediments within the bedrock fractures.

Uranium Levels in the Raffinate Pits Area

Uranium levels within the less-permeable unweathered unit are increasing due to desorption of uranium from residual materials and due to reduced recharge deeper into the aquifer system that has limited flushing. Recharge that does enter the system is more likely to move horizontally through the weathered unit than vertically into the unweathered unit due to greater horizontal hydraulic conductivity and the lack of a vertical driving force to move the groundwater downward, as was previously exerted by water in the Raffinate Pits.

While uranium levels in the Raffinate Pits area have increased in the unweathered unit since implementation of the MNA remedy for uranium, overall, the remedy remains protective. Groundwater flow directions are unchanged in the Raffinate Pits area. Impacted groundwater is contained within the paleochannel in this area and is migrating along the expected pathways. Dilution and dispersion continue to reduce uranium levels in the weathered unit. Uranium levels are not trending downward in the unweathered unit; the reduction in infiltration has limited the amount of flushing in the aquifer, and increased uranium levels are the result of desorption of residual uranium from contaminated materials in this portion of the shallow aquifer. Discharge from the unweathered unit into the weathered unit is monitored at MW-4036 and MW-4043. Uranium levels in "Objective 3–far" wells remain low, and levels in Burgermeister Spring, while variable, are declining.

The DOE and the regulators are currently working to resolve this issue.

Evaluation of Baseline Concentrations and Data Assessment Methods

The Baseline Concentrations Report (DOE 2008d) was updated and revised in July 2008. The primary objective of the report was to evaluate monitoring data collected from July 2004 through May 2006 to establish baseline concentrations for the COCs for each well and spring in the MNA network. Baseline monitoring was performed to acquire a comprehensive set of data to reevaluate the MNA remediation time frames developed in 2002 during the remedial design phase of the GWOU and assess the long-term monitoring program. Also, that report presented the methodology for review and evaluation of future MNA data.

The monitoring network was designed to provide data to show that natural attenuation processes are acting as predicted or to trigger the implementation of contingencies. Methods to review and interpret data that will satisfy the monitoring objectives were defined in the revised Baseline Concentrations Report. Performance of the MNA remedy will be gauged against long-term trends in the Objective 2 wells. This progress will be reviewed and documented every 5 years in conjunction with the CERCLA Five-Year Review. This review includes trending analysis for the past 5 years of data.

7.2.1.2 System Operation and Maintenance

The operation and maintenance activities for the Weldon Spring Site are specified in the LTS&M Plan, which was revised in December 2008. Environmental monitoring and evaluation of data are performed in accordance with the procedures and methods outlined in the LTS&M Plan. DOE also performs annual inspections of LTS&M activities, environmental monitoring, and ICs and has found these activities to be functioning as intended.

7.2.1.3 Opportunities for Optimization

Transducers were installed in seven wells at the site, typically at locations with paired weathered and unweathered bedrock wells. Water levels in the wells are recorded 12 times a day. The data will be used to evaluate the hydraulic connection between the two units.

7.2.1.4 *Early Indicators of Potential Issues*

There are no early indicators of potential issues.

7.2.1.5 *Implementation of ICs and Other Measures*

The following are the use restrictions listed in the LTS&M Plan for the GWOU. The ICs that are in place and planned for the Weldon Spring Site are discussed in the CPOU section (Section 7.1.1.5). The ICs that specifically apply to the GWOU are the Missouri Well Installation Special Area designation rulemaking; the easements with MDC, MoDOT, and the MDNR Division of State Parks; and the MOU with the Army.

The use restrictions listed below must be met in the entire area of approximately 1,140 acres shown in Figure 100 where groundwater use needs to be restricted until concentrations of the COCs meet drinking water or risk-based standards that allow for UUUE. The period of time necessary for contaminants to attenuate to these levels has been estimated at approximately 100 years. The size of the restricted area includes a 1,000 ft buffer area that accounts for the groundwater gradient and flow conditions at the site. The restricted area includes properties under federal jurisdictional control (DOE and the Army) as well as properties owned by state entities.

The objectives of the controls or restrictions are as follows:

1. Prevent the use of the contaminated shallow groundwater and spring water for drinking water purposes. The contaminated shallow groundwater occurs in the weathered and unweathered portions of the upper limestone unit (Burlington-Keokuk). The contaminated groundwater and spring water system occurs within the limits of the hydraulic buffer zone identified in Figure 100. The springs are identified in the figure as SP-6301, SP-6303, SP-5303, and SP-5304. This restriction will need to be maintained over a period of decades or longer.
2. Limit the use of all groundwater within the outlined restricted area to investigative monitoring only. The boundary of the restricted area extends beyond the area of contamination and is intended to provide a buffer against potential hydraulic influences on the area of contamination by preventing such things as pumping wells being located near the contaminated area. This restriction includes the shallow groundwater system and also extends vertically to all groundwater systems that underlie the contaminated groundwater. This restriction will need to be maintained over a period of decades or longer.
3. Retain access to the area for continued monitoring and maintenance of groundwater wells and springs.
4. Maintain the integrity of any current or future remedies or monitoring systems.

7.2.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

Answer B: Yes, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection are still valid.

7.2.2.1 Changes in Standards and TBCs

Table 54 lists the cleanup standards for the Chemical Plant area GWOU established in the ROD, which are the contaminant-specific ARARs that apply to the GWOU. As stated in the ROD, these standards are considered protective of human health and the environment under unlimited use and unrestricted exposure.

Table 54. Cleanup Standards for the Chemical Plant GWOU Established in the ROD

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

Notes:
[a] Based on site-specific conversion factor; equivalent to 30 µg/L standard.
[b] Missouri Water Quality Standard.
[c] Risk-based concentration equivalent to 10^{-5} for a resident scenario.
[d] Risk-based concentration equivalent to 10^{-6} for a resident scenario.

Federal and state water quality standards specified in the ROD have not changed. Although the slope factor for TCE has increased (as noted in Table 55), the drinking water standard remains the same and corresponds to a risk level for residential tap water of approximately 1×10^{-5}. The State of Missouri has established a standard for 2,4,6-TNT of 2 µg/L, which is lower than the risk-based value specified in the ROD. The two risk-based ROD values were compared with EPA's risk-based concentrations in the RSL tables. The 10^{-6} risk-based concentration for 2,4,6-TNT for residential tap water is 2.5 µg/L, slightly lower than the GWOU risk-based standard, even though they are based on the same slope factor. This is likely due to the fact that EPA has changed some default assumptions for calculating the RSLs based on updated exposure factors (EPA 2011). In particular, the default assumption for daily drinking water ingestion is 2.5 liters instead of 2 liters—resulting in higher intakes and slightly lower risk-based values. The risk-based concentration for 2,6-DNT established in the ROD was based on the slope factor in IRIS for a mixture of 2,4- and 2,6-DNT. This slope factor has not changed, and EPA's risk-based concentration for a 2,4/2,6-DNT mixture is the same as that established in the ROD. However, as noted in Table 55, a new PPRTV has been established for 2,6-DNT alone and is included in EPA's RSL tables. A 10^{-5} risk-based level for residential tap water based on the PPRTV is 0.49 µg/L—less than one-half the ROD value. This does not affect the protectiveness of the remedy because groundwater use is currently restricted. Based on EPA's RSL calculator, the ROD concentration for 2,6-DNT of 1.3 µg/L would correspond to a residential tap water risk level of 2.68×10^{-5}, still within the acceptable risk range. However, a nitrobenzene goal of 13 µg/L or less (lower than the State standard) would need to be met for a non-cancer hazard quotient of 1. If changes in groundwater use are considered after attainment of ROD cleanup levels, potential groundwater risks would depend on the distribution and concentrations of all contaminants.

7.2.2.2 Exposure Pathways, Toxicity, and Risk Assessment

Human Health

A review of assumptions incorporated into the risk assessments documented in the *Remedial Investigation for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area, Weldon Spring, Missouri* (DOE 1997a) and *Feasibility Study for Remedial Action for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area, Weldon Spring, Missouri* (DOE 1998c) was also performed. The review included the following risk assessment aspects: risk assessment methodology, exposure scenarios, exposure assessment input parameters, and toxicity values. Institutional controls are in place that currently restrict land and groundwater use. The most likely current scenario for exposure to groundwater is through recreational use with possible exposure at the springs. However, the cleanup levels established for groundwater were based on a residential use scenario. While this scenario is unlikely, it is a consideration in the discussion of groundwater cleanup goals.

As noted previously, EPA has finalized guidance on the vapor intrusion pathway since the last Five-Year Review (EPA 2015). The vapor intrusion pathway was not evaluated previously for the GWOU. The only groundwater COC that is of potential concern for a vapor intrusion pathway is TCE. Based on EPA's VISL calculator, a non-cancer screening level concentration for TCE in groundwater at a hazard quotient of 1 for commercial use is 34 µg/L (using a site-specific upper end temperature of 16^{o} C). (The non-cancer screening level is lower than the cancer screening level of 120 µg/L at a 10^{-5} risk level.) Based on the most recent groundwater sampling results, all detected concentrations were above this screening level.

As noted in the last Five-Year Review, there are no habitable structures in the vicinity of the TCE-contaminated groundwater, so the vapor intrusion pathway is currently incomplete and the remedy is protective. Institutional controls for the CPOU prohibit the future construction of residences and allow only buildings that are mission-related. Therefore, while residences are prohibited, it is possible that a mission-related structure could be built over the TCE-contaminated groundwater. Based on EPA's screening levels, such a use might be unacceptable. However, based on the limited available data, further characterization might be prudent if such use is considered in the future. The inhalation pathway is not considered further in this discussion of groundwater, as it is inconsequential for a recreational visitor. However, this pathway may require further analysis if changes in land or water use are contemplated.

The toxicity values used to characterize risks for the GWOU COCs for the water ingestion pathway (TCE, uranium, nitrate, 2,4-DNT, 2,6-DNT, 2,4,6-TNT, 1,3-DNB, and NB) were reviewed. Table 55 compares the toxicity values included the GWOU ROD and the last Five-Year Review with their current values from EPA's RSL tables. Values for uranium, nitrate, 2,4,6-TNT, 1,3-DNB, and NB have not changed since the last Five-Year Review, when values were shown to be protective. New toxicity values have been established for ingestion of TCE and 2,6-DNT. The slope factor for TCE has been incorporated into EPA's Integrated Risk Information System (IRIS); the slope factor for 2,6-DNT is a provisional peer-reviewed toxicity value (PPRTV). The slope factors for both of these constituents are higher than those used in the ROD, indicating a greater toxicity than previously assumed.

Section 7.2.1.5 indicates that controls are intended to prevent the use of shallow groundwater and spring water for drinking water purposes. While groundwater use can be prevented by putting well drilling restrictions in place, it is much more difficult to prevent the use of surface water, particularly in areas that do not receive heavy use. Under current site conditions, the only potentially complete exposure pathway to groundwater is that of a recreational visitor to the Weldon Spring Conservation Area possibly coming into contact with spring water in the Southeast Drainage. The only site-related constituent that has been regularly detected in this area is uranium. The 2014 Annual Site Environmental Report (DOE 2015) included an estimated total effective dose equivalent (TEDE) to a hypothetical individual assumed to frequent the Southeast Drainage of the Weldon Spring Conservation Area. The calculation of dose equivalent is based on a recreational user of the Conservation Area who drank from spring location SP-5304 (maximum observed concentration in 2014).

7.2.2.3 Progress Towards RAOs

The uranium monitoring program at the former Chemical Plant was evaluated in response to uranium concentrations exceeding fixed trigger levels at three impacted area unweathered unit wells (DOE 2014b). Uranium levels in the three wells have also demonstrated an increasing long-term trend. The primary objective of the report was to evaluate historical data along with data collected during the 2-year (February 2012–February 2014) special study sampling period to establish an MNA monitoring program for the unweathered bedrock unit of the Burlington-Keokuk Limestone at the site. During the special study, 13 locations (wells and springs) were sampled at an increased frequency of six times a year.

The study recommended establishing a separate uranium fixed trigger value for the unweathered unit impacted area (i.e., former source/Raffinate Pit areas). The relatively high unweathered unit uranium concentrations in the impacted areas near the former Raffinate Pits will attenuate much more slowly than contamination in the weathered unit. The original fixed trigger for uranium in impacted areas was set prematurely, before data for recently installed unweathered unit wells were available. The study also concluded that quarterly sampling for impacted area wells was sufficient to capture changes that may occur. Subsequent to the study, it was recommended that all 16 wells classified as unweathered unit wells be included in the uranium sampling network.

From the above discussions, it can be concluded that the remediation objectives are still valid and that under the current exposure scenario the remedy remains protective. Institutional controls play a key role in maintaining protectiveness until final remedial objectives for groundwater can be met. Final remedy protectiveness cannot be assessed until groundwater remediation is completed.

Table 55. Review of Toxicity Values Used in Risk Assessments for the GWOU and QROU

Constituents of Concern	Toxicity Values In GWOU ROD	2011 Toxicity Values	Current Toxicity Values	Change Since 2011
Uranium (chemical) Uranium (radiological) U-234 U-235+D U-238+D	0.003 mg/kg-d 4.4 × 10−11/pCi 4.5 × 10−11/pCi 6.2 × 10−11/pCi	0.003 mg/kg-d 7.1 × 10−11/pCi 7.2 × 10−11/pCi 8.7 × 10−11/pCi	0.003 mg/kg-d 7.07 × 10−11/pCi 7.18 × 10−11/pCi 8.70 × 10−11/pCi	Unchanged Unchanged Unchanged Unchanged
Nitrate	1.6 mg/kg-d	1.6 mg/kg-d	1.6 mg/kg-d	Unchanged
TCE	0.011 [(mg/kg-d)−1]	0.0059 [(mg/kg-d)−1][a]	0.046 [(mg/kg-d)−1] 0.0005 mg/kg-d	Revised (increased) New
2,4-DNT	0.002 mg/kg-d 0.68 [(mg/kg-d)−1]	0.002 mg/kg-d 0.68 [(mg/kg-d)−1][b]	0.002 mg/kg-d 0.31 [(mg/kg-d)−1][a]	Unchanged Revised (decreased)
2,6-DNT	0.001 mg/kg-d 0.68 [(mg/kg-d)−1]	0.001 mg/kg-d 0.68 [(mg/kg-d)−1][b]	0.0003 mg/kg-d 1.5 [(mg/kg-d)−1][c]	Revised (decreased) Revised (increased)
2,4,6-trinitrotoluene	0.0005 mg/kg-d 0.03 [(mg/kg-d)−1]	0.0005 mg/kg-d 0.03 [(mg/kg-d)−1]	0.0005 mg/kg-d 0.03 [(mg/kg-d)−1]	Unchanged Unchanged
1,3-DNB	0.0001 mg/kg-d	0.0001 mg/kg-d	0.0001 mg/kg-d	Unchanged
Nitrobenzene	0.0005 mg/kg-d	0.002 mg/kg-d	0.002 mg/kg-d	Unchanged

Notes:
[a] California Environmental Protection Agency value.
[b] Slope factor for these constituents is IRIS slope factor for 2,4- and 2,6-DNT mixture.
[c] PPRTV

Abbreviations:
mg/kg-d = milligrams per kilogram per day
pCi = picocuries

The exposure scenario assumptions particular to this dose calculation include the following: (1) the reasonably maximally exposed individual drank 1 cup (0.2 liter [L]) of water from the spring 20 times per year (equivalent to 1.05 gallons [4.0 L] of water for the year); and (2) the maximum uranium concentration in water samples taken from spring locations during 2014 was at SP-5304 in the Southeast Drainage (87.3 pCi/L). This concentration was assumed to be present in all of the water ingested by the reasonably maximally exposed individual. The calculations resulted in a TEDE of 0.094 millirem (mrem). This value represents less than 0.1 percent of the DOE standard of 100 mrem 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 (BEIR 1990).

Using these same exposure assumptions, the maximum concentration (87.3 pCi/L and 0.129 mg/L), and the toxicity data from Table 55 results in an added risk of approximately 2×10^{-8} per year of exposure and a hazard quotient of 0.0059. These results indicate that likely exposures to spring water are protective.

Ecological Risks

It was previously noted that numerous ecological studies have been conducted across the Weldon Spring site (DOE 1995a, ANL 2004). Specific to the GWOU, sediment and surface water at Burgermeister Spring exhibited some elevated concentrations, prompting toxicity testing with those media (DOE 1997c). Toxicity was detected for some samples based on reduced survival of test organisms; however, no spatial relationship was observed between toxicity gradients and the spring. It was concluded that the toxicity could be due to some other source. Biotic surveys indicated no ill effects on invertebrate, fish, and amphibian communities, and it was suggested that the communities have adapted and are tolerant of any contamination in the area. Uptake modeling indicated no risks to terrestrial receptors. The ecological risk assessment conducted as part of the GWOU baseline risk assessment concluded that groundwater associated with the Chemical Plant does not pose an unacceptable risk to aquatic or terrestrial biota, particularly due to the small and intermittent nature of most of the springs.

There have been no changes in exposure assumptions, toxicity, or risk assessment methodology that would call into question the protectiveness of the remedy from an ecological risk perspective. Concentrations in relevant media have been reduced through the remediation that has taken place. Uranium concentrations remain elevated, but observations at the site suggest this is not having an adverse impact on the ecological communities at the site.

7.2.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Answer C: No other information has come to light that could call into question the protectiveness of the remedy.

7.3 Quarry Residuals Operable Unit

7.3.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer A: Yes, the remedy is functioning as intended by the decision documents.

7.3.1.1 Remedial Action Performance

Long-term monitoring at the Quarry is designed to (1) monitor uranium levels south of the Femme Osage Slough to ensure that they remain protective of human health and the environment, and (2) monitor uranium and 2,4-DNT levels within the area of groundwater impact north of the slough until they attain target levels that have been identified as having a negligible impact on the groundwater south of the slough (DOE 2000a). Groundwater north of the Femme Osage Slough will be monitored until a target level of 300 pCi/L for uranium is attained. In addition, groundwater south of the slough will be monitored to ensure protection of human health and the environment.

Missouri River Alluvium

Monitoring results from the Missouri River alluvial groundwater indicate that the average uranium levels were less than the statistical background value in the alluvium. The geochemical data continue to indicate that a strongly reducing environment is prevalent in the groundwater immediately south of the slough, as shown by high dissolved iron concentrations, low sulfate concentrations, and low ORP values. This environment is not favorable for the migration of uranium if it were to pass beyond the reduction zone north of the slough.

Area of Uranium and 2,4-DNT Impact

Uranium levels within the area of impact are decreasing in the bedrock wells along the Quarry rim and in some wells north of the Femme Osage Slough. These decreases are the result of bulk waste removal and restoration activities in the Quarry proper that reduced and possibly prevented infiltration of precipitation and storm water into the residually contaminated fracture system in the Quarry proper. The distribution of uranium in groundwater is still predominantly controlled by the precipitation of uranium along the oxidizing–reducing front north of the Femme Osage Slough. Uranium levels in some alluvial wells north of the slough were previously reported as increasing, but when viewed over the long term, they have been stable. Trends interpreted from short-term data sets are artifacts of their significant variability in uranium results. Uranium levels continue to remain low in monitoring wells screened in the reducing portion of the area north of the slough

The attainment objective for uranium in 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 (DOE 2000b). The 90th percentile associated with data from the Line 1 and 2 wells was 1,470 pCi/L for 2015, a significant increase from 2014 when it had dropped to 875 pCi/L from the 2010 value of 1,193 pCi/L. This metric is strongly influenced by the uranium levels in the Line 2 alluvial wells. Increases in the uranium levels appear to be loosely correlated to wet years following dry periods. Uranium impact in this area still poses a potential impact to the groundwater quality in the Missouri River alluvium south of the Femme Osage Slough.

Only two discrete areas in the Quarry Area exhibit 2,4-DNT impact in groundwater. Nitroaromatic concentrations have been highly variable but are generally decreasing since removal of the bulk wastes in the Quarry. The average 2015 concentrations in groundwater are below the cleanup standards and pose little potential impact on the groundwater in the Missouri River alluvium. The attainment objective for the long-term monitoring of 2,4-DNT in 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 (DOE 2000b). The 90th percentile associated with the data from the 2,4-DNT monitoring network was 0.0354 µg/L in 2015, which is below the attainment objective.

A review of the geochemical data north of the slough indicates that although the area of highest impact has an oxidizing environment, reducing conditions are prevalent along the northern edge of the slough. This is consistent with the uranium data where low levels are detected, especially along the edge of the slough where very low sulfate and high dissolved iron concentrations are also observed. The location of this reduction area was consistent during the review period, and the attenuation of uranium in this area continues.

7.3.1.2 System Operation and Maintenance

DOE has finalized the LTS&M Plan, which includes system operation and operation and maintenance information for LTS&M. DOE also performs annual inspections of LTS&M activities, environmental monitoring, and ICs, and found these activities to be functioning as intended.

7.3.1.3 Opportunities for Optimization

None at this time.

7.3.1.4 Early Indicators of Potential Issues

There are no early indicators of potential issues.

7.3.1.5 Implementation of ICs and Other Measures

The following are the use restrictions listed in the LTS&M Plan (DOE 2008c) for the QROU. The ICs that are in place and planned for the Weldon Spring Site are discussed in the CPOU section (Section 7.1.1.5). The ICs that specifically apply to the QROU are the Missouri Well Installation Special Area designation rulemaking and the easements with MDC and the MDNR Division of State Parks.

The use restrictions listed below must be met at the specific areas shown in Figure 101. The use restrictions must be maintained until the remaining hazardous substances are at levels allowing for UUUE.

1. Prevent the development and use of the Quarry for residential housing, schools, childcare facilities, and playgrounds. Prevent drilling, boring, digging, or other activities in the Quarry proper that disturb the vegetation, disrupt the grade, expose the Quarry walls, or cause erosion of the clean fill that was used to restore the Quarry. This restriction should be maintained for the long term. The 9-acre Quarry is under DOE jurisdictional control.
2. Prevent the use of the contaminated shallow groundwater for drinking water purposes. The contaminated shallow groundwater underlies the Quarry and extends to the marginal alluvium north of the slough, as indicated in Figure 101. This restriction will need to be maintained over a period of decades or longer.
3. Limit the use of all groundwater within the outlined restricted area shown in Figure 101 to investigative monitoring only. The boundary of the restricted area extends beyond the area of contamination and is intended to provide a buffer against potential hydraulic influences on the area of contamination by preventing such things as pumping wells being located near the contaminated area. This restriction includes the shallow groundwater system and also extends vertically to all groundwater systems that underlie the contaminated groundwater. This restriction will need to be maintained over a period of decades or longer, until uranium concentrations in Quarry groundwater north of the slough are at 300 pCi/L or lower. With the exception of the 9-acre Quarry, this restricted area is owned by state entities. This area covers approximately 202 acres.
4. Prevent drilling, boring, digging, construction, earth moving, or other activities in the location identified as the Quarry natural reduction zone area that could result in disturbing the soils at this location or exposing subsurface soils (i.e., soils deeper than [about] 5 ft below the surface). The soil in this area at a depth of 5 ft or greater contains geochemical properties that allow reduction processes to naturally occur, resulting in the precipitation of uranium from Quarry groundwater north of the Femme Osage Slough and thereby minimizing uranium migration to the well field. The restrictions must be maintained over a period of decades or longer, until uranium concentrations in Quarry groundwater north of

the slough are 300 pCi/L or lower. This area is located on property owned by a state entity and is approximately 4.7 acres in size.

5. Retain access to the area for continued monitoring and maintenance of groundwater wells.
6. Maintain the integrity of any current or future remedies or monitoring systems.

7.3.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

Answer B: Yes, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection are still valid.

7.3.2.1 Changes in Standards and TBCs

Section 1.5, *Current Regulatory Requirements,* in the LTS&M Plan discusses the ARARs that apply to the post-remediation aspect of the project, and it states the following:

> The 30 µg/L standard for uranium in groundwater outlined in 40 CFR 192.02 was considered as a potential ARAR for the quarry groundwater during development of the Feasibility Study (DOE 1998a) and Proposed Plan (DOE 1998b). The groundwater north of the slough is impacted; however, it is not considered to be a usable groundwater source. Conversely, the Missouri River alluvium south of the slough is currently not impacted and is presently being used as a potable water source. Because groundwater north of the slough is not a useable source, 40 CFR 192.02 is not considered an ARAR for that groundwater. However, 40 CFR 192.02 would likely be an ARAR for any remedial action considered for the useable groundwater source south of the slough in the unlikely event of contaminant migration from north of the slough. The Missouri Water Quality Standard for 2,4-DNT (0.11 µg/L) is also a chemical-specific ARAR for quarry groundwater.

There are no changes in standards or TBCs that affect the protectiveness of the remedy.

7.3.2.2 Exposure Pathways, Toxicity and Risk Assessments

Human Health

A review of assumptions incorporated into the risk assessments documented in the *Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring Missouri* (DOE 1998b) and the *Feasibility Study for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring Missouri* (1998d) was also performed. The review included the following risk assessment aspects: risk assessment methodology, exposure scenarios, exposure assessment input parameters, and toxicity values. The remediation and ICs have resulted in the severing of all exposure pathways.

A post-remediation risk assessment was conducted for the QROU (ANL 2003) to estimate risks associated with residual contamination at the site and compare it to preremediation risks estimated in the baseline risk assessment. Risks were calculated for exposures at Femme Osage Slough, the Quarry proper, and soils outside the Quarry for both a recreational visitor and a resident using assumptions from the original baseline risk assessment (DOE 1997b). Toxicity data were not provided in the post-remediation risk assessment, but it is assumed that data were the same as those used in the CPOU post-remediation risk assessment (DOE 2002b) and that data and calculations remain valid. The calculations indicated that risks to recreational visitors and residents are acceptable (resident risks were comparable to background; recreational visitor risks were lower). Risks were dominated by external exposure to radium-226 and -228.

As discussed for the CPOU, recent EPA guidance recommends the use of PRG calculator toxicity values in evaluating radiological risks. Assuming that the QROU post-remediation risk assessment used the same toxicity values as the CPOU post-remediation risk assessment, the slope factors for external exposure to radium-226 and -228 currently in EPA's PRG calculator are slightly lower, therefore slightly lowering corresponding risks. No other changes to the risk assessment methodology recommended by EPA for CERCLA sites have occurred since the publication of the QROU documentation that would significantly affect the conclusions of the post-remediation risk assessment. Exposure scenarios and exposure assessment input parameters are also still valid as land uses assumed for the risk assessments are still representative of current and expected future land use (i.e., recreational visitor scenario). In addition, as for the GWOU, ICs are also being implemented to ensure that current land uses remain unchanged.

Ecological Risk

It was previously noted that numerous ecological studies have been conducted across the Weldon Spring site (DOE 1995a, ANL 2004). Specific to the QROU, the baseline (preremediation) risk assessment indicated that some contaminants were present at levels above "safe" values for ecological receptors (DOE 1997b). However, no such adverse effects were actually observed in the fauna that were sampled; furthermore, most of the QROU was determined to not provide good habitat for ecological receptors based on its physical characteristics. The exceptions are Femme Osage Slough and Little Femme Osage Creek. Radionuclides in tissues of small mammals collected from the Quarry were comparable to those from the reference areas. Internal and external examinations of small mammals did not show any sign of abnormalities that could be attributed to site contamination. Fish sampling was conducted every 2 years in Femme Osage Slough and area lakes for a number of years in the 1990s and did not detect any abnormal results. Sampling was discontinued in the late 1990s.

Remediation has addressed most of the potential ecological risks associated with the QROU. There have been no changes in exposure assumptions, toxicity, or risk assessment methodology that would call into question the protectiveness of the remedy from an ecological risk perspective. Concentrations in relevant media have been reduced through the remediation that has taken place.

7.3.2.3 Progress Towards RAOs

Section 7.3.1.1 includes a status on progress towards RAOs.

7.3.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Answer C: No other information has come to light that could call into question the protectiveness of the remedy.

8.0 Issues

There were no issued identified during this five-year review that would prevent the remedies from being protective of human health and the environment.

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9.0 Recommendations and Follow-Up Actions

There were no issued identified during this five-year review that would prevent the remedies from being protective of human health and the environment, therefore no recommendations and follow-up actions are applicable.

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10.0 Protectiveness Statements

This Five-Year Review found the remedy for the entire site to be protective of human health and the environment for all the operable units.

10.1 Chemical Plant Operable Unit

The remedy that has been implemented at the CPOU is protective of human health and the environment. Contaminant sources are contained in an onsite disposal facility at the Chemical Plant. The environmental monitoring data and annual inspections continue to verify that the disposal cell is functioning as intended.

The remedy that has been implemented at the Southeast Drainage is protective of human health and the environment. The remedy consisted of removing contaminated soils and sediment to levels that are protective under the current land use. The drainage has recovered from the removal activities and is stable. ICs are used to maintain appropriate land and resource use and ensure that the remedy remains protective over the long term.

10.2 Groundwater Operable Unit

The remedy for the GWOU will be protective of human health and the environment upon attainment of groundwater cleanup goals, through MNA, which is expected to require approximately 100 years to achieve. The clean up time for Burgermeister Spring is predicted to be much shorter than the 100 year time frame. In the interim, exposure pathways that could result in unacceptable risks are being controlled and ICs are in place to prevent the groundwater from being used in the restricted area.

10.3 Quarry Bulk Waste Operable Unit

The remedy for the QBWOU is protective of human health and the environment. The action consisted of excavating the bulk wastes from the Quarry and placing them in controlled temporary storage pending final placement in the onsite disposal cell at the Chemical Plant. Excavating the wastes from the Quarry eliminated the potential for direct contact with the waste material and removed the source of ongoing contaminant migration to groundwater.

10.4 Quarry Residuals Operable Unit

The remedy for the QROU is protective of human health and the environment through long-term monitoring with ICs. The remedy consists of long-term groundwater monitoring and ICs to maintain appropriate land and resource use and ensure that the remedy remains protective over the long-term.

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11.0 Next Review

This is the fifth statutory Five-Year Review for this site. The next Five-Year Review for the Weldon Spring Site is required 5 years from the signature date of this review.

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Appendix A

Community Involvement

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Department of Energy
Washington, DC 20585

October 28,2015

Mr. Hoai Tran
Remedial Project Manager
Superfund Division
U.S. Environmental Protection Agency Region 7
11201 Renner Blvd.
Lenexa, KS 66219

Ms. Tiffany Drake
Federal Facilities Section
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

Subject: 2015 Annual Inspection of the Weldon Spring, Missouri, Site

Dear Mr. Tran and Ms. Drake:

The U.S. Department of Energy (DOE) plans to conduct the annual inspection of the Weldon Spring site on December 1 and 2, 2015. In accordance with the *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Weldon Spring, Missouri, Site*, DOE is required to notify the U.S. Environmental Protection Agency and the Missouri Department of Natural Resources 30 days in advance of the inspection. The agenda for the annual inspection is enclosed. The upcoming Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Review Report for the site will be discussed in a meeting on December 3, 2015.

Please also note that the agenda is subject to change due to unforeseen circumstances, such as weather conditions.

If you have any questions, please contact me at (303) 410-4801 or ken.starr@lm.doe.gov, or you may contact Yvonne Deyo at (636) 300-2612 or yvonne.deyo@lm.doe.gov. Please address any correspondence to:

U.S. Department of Energy
Office of Legacy Management
11025 Dover Street, Suite 1000
Westminster, CO 80021-5573

Sincerely,

Kenneth I. Starr
2015.10.27
15:00:53 -06'00'

Kenneth I. Starr, PE
DOE Weldon Spring
Site Manager

Printed with soy ink on recycled paper

Enclosure:
As stated

cc w/enclosure:
J. Vogel, MDC
T. Geraghty, PWSD#2
P. Anderson, MDNR
Q. Kellner, MDNR, Division of State Parks
S. Johnson, MoDOT
R. Tilley, St. Charles County
Y. Deyo, Navarro
R. Thompson, Navarro
T. Uhlmeyer, Navarro
File: WEL 0030.02

2015 WELDON SPRING, MISSOURI, SITE ANNUAL INSPECTION AGENDA

Tuesday, December 1, 2015

8:30–9:00 a.m.

Review agenda, inspection teams, and safety-related work issues. Review findings/corrective actions from last year's inspection. Inspectors/observers will divide into two separate groups. Team 1 (team leader: Terri Uhlmeyer) will cover the Chemical Plant Area and surrounding properties. Team 2 (team leader: Randy Thompson) will cover the Southeast Drainage and the Quarry Area.

9:00–11:30 a.m.

Team 1: Inspect land and shallow groundwater use on Army property and DOE property:

- Monitoring wells along Army property roads
- Army roads by driving roads in institutional control area and noting any land disturbance
- Disposal cell buffer zone
- Monitoring wells on DOE Chemical Plant property
- Erosion areas in prairie

Team 2: Inspect land and shallow groundwater use on Missouri Department of Conservation (MDC) property, Weldon Spring Conservation Area:

- Southeast Drainage from Hamburg Trail to Missouri River, including springs 5303 and 5304
- Highway 94 culvert

11:30 a.m.–12:30 p.m.

Lunch

12:30–4:00 p.m.

Team 1: Inspect land and shallow groundwater use on MDC property, August A. Busch Conservation Area:

- Burgermeister Spring (Spring 6301)
- Spring 6303
- MW-4041 on MDC property

Team 2: Inspect land and shallow groundwater use on MDC property, Weldon Spring Conservation Area, and DOE property:

- DOE quarry property (quarry rim wells)
- DOE quarry property (quarry proper)
- Reduction zone area
- Public Water Supply District #2 well field area

2015 WELDON SPRING, MISSOURI, SITE ANNUAL INSPECTION AGENDA (continued)

4:00–4:30 p.m.

- Summarize observations and prepare for next day

Wednesday, December 2, 2015

8:30–9:00 a.m.

Review previous day's findings and current day's inspection objectives. Inspectors/observers divide into two separate groups to cover five transects each on the disposal cell. The team leaders will be Terri Uhlmeyer and Randy Thompson.

9:00–11:30 a.m.

Inspect disposal cell for potential settlement, rock degradation, vegetation
Team 1: Walk five transects
Team 2: Walk five transects

11:30 a.m.–12:30 p.m.

Lunch

12:30 p.m.–1:00 p.m.

Discussion of Leachate Collection and Removal System (LCRS) data and erosion monitoring data

1:00–2:00 p.m.

Inspection of LCRS (no confined-space entry planned)

2:00–4:00 p.m.

Document and paperwork review

4:00–5:00 p.m.

Discussion of any 2015 inspection findings or observations

Notice of U.S. Department of Energy Weldon Spring Site CERCLA Five-Year Review

Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization act of 1986, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. The U.S. Department of Energy Office of Legacy Management (DOE-LM) has initiated the fifth Five-Year Review at the Weldon Spring Site. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment.

The Weldon Spring Site is the location of a former TNT production plant and uranium processing facility, located in St. Charles, Missouri. The site consists of the Chemical Plant (219.50 acres) and the Quarry (8.66 acres).

The U.S. Environmental Protection Agency placed the Quarry and Chemical Plant areas on the National Priorities List (NPL) on July 30, 1987, and March 30, 1989, respectively. The Weldon Spring Site was remediated under the CERCLA. Construction of an engineered disposal cell on the Weldon Spring Chemical Plant property began in 1997. Approximately 1.48 million cubic yards of waste materials including building debris, asbestos- containing materials, treated raffinate sludge, contaminated soils, drums, process equipment, and bulk wastes from the remediation of the Quarry were disposed of in the cell. Disposal activities were completed in 2001.

The remedy for the Chemical Plant area consists of monitored natural attenuation of the groundwater and institutional controls. The remedy at the Quarry consists of long-term monitoring of the groundwater and institutional controls. The contaminants of concern at both areas include nitroaromatics and radiological constituents. The Chemical Plant contaminants of concern also include trichloroethylene and nitrates. DOE-LM is currently maintaining the Site under its Long-Term Surveillance and Maintenance Program.

A brief survey as well as information about the Weldon Spring Site and the Administrative Record is available at the Weldon Spring Site Interpretive Center and the Weldon Spring Site's website (www.lm.doe.gov/weldon). A collection of certain records is also located at the Middendorf-Kredell Library on Highway K in O'Fallon, Missouri. The five-year review is scheduled to be completed by September 2016.

Questions or requests for information can be submitted to:

Yvonne Deyo
Project Manager
Navarro Inc.
7295 Highway 94 South
St. Charles, MO 63304
636-300-2612 or
Yvonne.Deyo@LM.doe.gov
Or
Ken Starr
Weldon Spring Site Manager
U.S. Department of Energy Office of Legacy Management
11025 Dover Street
Suite 1000
Westminster, CO 80021
303-410-4801 or
Ken.Starr@LM.doe.gov

PUBLIC NOTICE AUCTION

If payment is not received, PS OrangeCo, Inc. will sell the entire contents of rental spaces at the following locations to the highest bidder on: November 24th, 2015, starting at 8:30 a.m. The undersigned will sell personal property including furniture, clothing, tools, and/or other household items. (Auctions will start at the 3rd Street Property and run in order as listed.)

1250 S Third Street, St. Louis, MO 63104
•G121 Whitley, G71 Larkin, 905 Abernathy, F54 Hall, F7 Rauth, C108 Burke, C2 Scales, G69 Wadley, G140 Morris, E24 Hudson, A7 Engelke, C48 Redd, C44 Redd, G4 Gines, C6 Collins, E38 Hudson, D7 Brown, C122 Gyulay, G68 Jones, C3 Harley, D5 Fraction, C35 Abernathy, G77 Shipp, C692 Richmond, G86 Haron

11 North Vandeventer Ave St Louis MO 63108
•110 Clinton, 141 Kaelin, 495 Johnson, 277 Shakoor, 591 Bell, 628 Freeny, 177 Hayes, 265 Dillard, 578 Anderson, 159 Edwards, 421 Troupe-Mu, 151 Clark, 121 Williams, 246 Barnes, 122 Moss, 206 Gibb, 520 Cole, 592 Van Norman, 408 Adams, 199 Walker, 157 Williams, 594 Porter, 622 McCarron, 588 Donaldson, 116 Kent, 657 Gamblin

[illegible]

PUBLIC NOTICE AUCTION

If payment is not received, PS OrangeCo, Inc. will sell the entire contents of rental spaces at the following locations to the highest bidder on: November 25th, 2015, starting at 8:30 a.m. The undersigned will sell personal property including furniture, clothing, tools, and/or other household items. (Auctions will start at the Ellisville, MO property and run in order as listed.)

16230 Truman Road, Ellisville, MO 63011
• B008 Carte

831 Meramec Station Road, Valley Park, MO 63088
•B286 Burr, B157 Klauman, B014 Vaughn

2211 Barrett Station RD. Ballwin. MO 63021
•B209 Manendez, B033 Wilkson, B047 Gold, B414 Wintermantle DDS

3850 Forder Road, St. Louis, MO 63129
•E008 Blake, L007 Hopperton, M011 Mcpherson, M076 Parr, H027 Merriweather, L003 Gardner, E019 Berringer

3040 Reavis Barracks St Louis MO 63125

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WELDON SPRING SITE *FIVE-YEAR REVIEW* SURVEY

Community involvement is considered an integral part of Weldon Spring Site management and the Five-Year Review process.

Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review.

The Department of Energy (DOE) is currently conducting the fifth Five-Year Review at the Weldon Spring Site. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment.

DOE would like to solicit any input or comments you may have about the Weldon Spring Site and the cleanup as part of the fifth Five-Year Review. Please complete the survey below:

Name (Optional) ____

City, State ____

What is your overall impression of the Weldon Spring Site cleanup project (general sentiment)?

____
____
____
____

What effects have the completion of the site cleanup project had on the surrounding community?

____
____
____
____

Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

____
____

How did you learn about the site?

Do you feel well informed about the site's activities and progress?

If not, how would you suggest the site keep the community adequately informed?

Do you have any comments, suggestions, or recommendations regarding the site's management?

Do you have any comments, suggestions, or recommendations regarding the site's activities?

Any other comments or suggestions?

Department of Energy
Washington, DC 20585

October 20, 2015

Distribution:

Subject: Weldon Spring Site Five-Year Review

The Department of Energy (DOE) would like to notify you that it has initiated the fifth Five-Year Review at the Weldon Spring, Missouri, Site.

The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to also protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review.

Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring, Missouri, Site and its cleanup. DOE has proposed a brief survey that the public is invited to complete about the project. The survey is available on our website http://www.lm.doe.gov/Weldon/2015_Weldon_Spring_Site_Five-Year_Review_Survey.pdf. This will help us to incorporate your views in the Five-Year Review report, which is scheduled to be completed by September 2016.

If you have any questions about the Five-Year Review for the site, contact me at (303) 410-4801 or ken.starr@lm.doe.gov, or Yvonne Deyo at (636) 300-2612 or yvonne.deyo@lm.doe.gov. Please send any correspondence to:

U.S. Department of Energy
Office of Legacy Management
11025 Dover Street, Suite 1000
Westminster, CO 80021

Sincerely,

Kenneth I. Starr
2015.10.19
07:31:14 -06'00'

Kenneth I. Starr
DOE Weldon Spring
Site Manager

Printed with soy ink on recycled paper

cc:
Y. Deyo, Navarro
T. Uhlmeyer, Navarro
File: WEL 0100.02

From: LMWebsite_NOREPLY@lm.doe.gov
To: Uhlmeyer, Terri (CONTR)
Subject: Weldon Spring Site Five-Year Review Survey
Date: Monday, October 26, 2015 2:59:36 PM

Data from form "2015_Weldon Spring Site Five-Year Review Survey" was received on 10/26/2015 3:59:30 PM.

Field	Value
Name	Wayne Anthony
City, State	St. Charles County, MO
overall impression	good
effects of site operations	little to none
community concerns	No
incidents or activities	No
well informed	somewhat
comments or suggestions	No

Email "Weldon Spring Site Five-Year Review Survey" originally sent to terri.uhlmeyer@lm.doe.gov from LMWebsite_NOREPLY@lm.doe.gov on 10/26/2015 3:59:30 PM.

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Appendix B

Interview Forms

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INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 9:00 AM**	**Date: 11/23/2015**
Type: ___ Telephone _x_ Visit ___ Other **Location of Visit: Administration Building**	__ Incoming __ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: Yvonne Deyo	**Title: Site Manager**	**Organization: Navarro**

Telephone No: 636-300-2612 **Fax No: 636-300-2626** **E-Mail Address: Yvonne.Deyo@lm.doe.gov**	**Street Address: 7295 Hwy. 94 South** **City, State, Zip: St. Charles, MO 63304**

Summary Of Conversation

I interviewed Yvonne Deyo, the Navarro Site Manager at the Weldon Spring Site. The interviewing of the Site Manager is a requirement included in the Annual Inspection Checklist. Most of the interview questions were from the CERCLA Five-year Review Guidance.

1. **Current status of the project:** Long-term surveillance and maintenance.
2. **Any problems encountered with the remedies?** None at this time.
3. **Are the remedies functioning as expected?** Yes.
4. **Any vandalism or trespassing issues?** As discussed in past Annual Inspection interviews, public use of the site is frequent. However, nighttime access of the disposal cell viewing platform and other undesirable behaviors have been substantially reduced due a private security firm's seasonal patrol coverage of the site during evening hours. Protective well caps have been installed on monitoring wells to prevent vandalism. No site-related vandalism has been noted this year.
5. **What is the current on-site presence? Describe staff and activities.** There are 13 full-time contractor employees and numerous part-time contractor and subcontractor employees. Activities include long-term surveillance and maintenance operations, project management, data evaluation, operation of the Interpretive Center, preparation of site-related regulatory documents, support of site IT and telephone issues, landscape management and general administrative support. On-site staff also provide support to other DOE sites such as Mound, Fernald, and Pinellas and to other LMS programmatic areas. Environmental sampling personnel support sampling activities at other sites in the Legacy Management system. The LMS contractor continues to support operation and maintenance of the DOE-owned and leased on-site facilities.
6. **Are there any issues associated with the site at this time?** None concerning site protectiveness to the environment or the public.
7. **Any suggestions or comments regarding annual inspection?** The inspection continues to provide a useful mechanism to have regulators on-site to evaluate site protectiveness to the environment and the public.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 2:00 pm**	**Date: 11/20/15**
Type: _x_ Telephone ___ Visit ___ Email **Location of Visit: NA**	__ Incoming _x_ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:		
Name: John Downing	**Title: Materials Handler**	**Organization: Army**

Telephone **Cell No: 314-402-1836** **E-Mail Address:**	**Street Address: 7301 Hwy. 94 South** **City, State, Zip: St. Charles, MO 63304**

Summary Of Conversation

I contacted John Downing at the Weldon Spring Army site by telephone on November 20, 2015, and notified him that DOE would be conducting the annual LTS&M inspection at the Weldon Spring Site on December 1 and 2, and that we would be on Army property on the morning of the 1st. I told him we would be driving around on the Army site and inspecting our wells. We discussed access to the Army property and how to contact him the morning of the inspection so that he is aware of who is on-site.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 1:00 pm**	**Date: 11/23/15**
Type: ___ Telephone _x_ Visit ___ Other **Location of Visit:** Weldon Spring Site	__ Incoming __ Outgoing	

Contact Made By:

Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:

Name: Randy Thompson	**Title: Site/Operation Manager**	**Organization: Navarro**
Telephone No: 636-300-2640 **Fax No: 636-300-2626** **E-Mail Address: Randy.Thompson@lm.doe.gov**	**Street Address: Weldon Spring Site** **City, State, Zip:**	

I interviewed Randy Thompson, Operations Manager, who is responsible for sampling programs at the Weldon Spring Site. The interviewing of the data (operations) manager is a requirement included in the Annual Inspection Checklist.

1. **What is the current status of data validation/reporting?** Data validation and review is completed for sample data through September 2015. The data validation and review is being worked for samples collected during October 2015. Data for the November/December sampling are still in the analysis/reporting phase at the laboratories.
2. **How is the data reported?** After data merge, validation and review, the qualification flags are applied and the data is then available on the LM/Weldon Spring website the next day. We continue to prepare data validation reports and the quality control data are summarized in the annual report.
3. **What is the current status of the data on the website? Are we meeting our 90-day commitment as stated in the LTSM?** Yes, we are meeting our 90-day commitment. The data are reviewed and validated through September 2015 and are available online. The October through December 2015 data have either not reported or are being validated. Data will be released once the validation process is completed.
4. **Are there any trends that show contaminants increasing or decreasing?** Trend analysis is performed annually by site hydrogeologist and results are summarized within the Annual Report.

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INTERVIEW RECORD

Site Name: Weldon Spring Site		EPA ID No.: MO6210022830	
Subject: Annual Inspection		Time: 11:28am	Date: 11/30/15
Type: ___ Telephone ___ Visit _x_ Email Location of Visit: NA		__ Incoming _x_ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	Title: Compliance Manager	Organization: Navarro

Individual Contacted:		
Name: Mark Boehle	Title: Assistant Fire Chief	Organization: Cottleville Fire Dept

Telephone No: 636-447-6655 ext. 8703 Fax No: E-Mail Address: maboehle@cottlevillefpd.org	Street Address: PO Box 385 City, State, Zip: Cottleville, MO 63338

Summary Of Conversation

I contacted Mark Boehle of the Cottleville Fire Department and sent him the following information via email:

Mark, I am contacting you regarding the upcoming Department of Energy – Weldon Spring Site annual long-term surveillance and maintenance inspection, which is scheduled for December 1-2, 2015. As part of the inspection we contact stakeholders to maintain contact with them and to determine if they have any concerns or issues about the site. There have been no major changes to the site at this time. There are still plans to build a new building, but DOE is still in the early planning stages. Please respond and let me know us know if you have any questions, issues or concerns.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
7. Any other general comments?

Mark responded:

Terri,

I don’t have any questions or concerns at this time as we have not had any issues at the site that I am aware of.

Thanks,

Mark

INTERVIEW RECORD

Site Name: Weldon Spring Site		**EPA ID No.: MO6210022830**
Subject: Annual Inspection	**Time: 10:15 am**	**Date: 11/24/15**
Type: _x_ Telephone ___ Visit ___ Other **Location of Visit:**		__ Incoming _x_ Outgoing

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: Wayne Anthony	**Title:**	**Organization: St. Charles Planning and Zoning Department**
Telephone No: 636-949-7900 x7221 **Fax No:** **E-Mail Address:**	**Street Address:** **City, State, Zip:**	

Summary Of Conversation

I contacted Wayne Anthony of the St. Charles Planning and Zoning Department. Mr. Anthony had been the project's previous contact in this department in regards to the county's master plan. I informed Mr. Anthony that DOE would be conducting their annual LTS&M inspection on December 1 and 2, 2015 and I asked him if there were any planning and zoning activities currently in the one-quarter mile surrounding the chemical plant and quarry properties. Mr. Anthony stated that he did not know of any activities in the area. I informed Mr. Anthony of preliminary plans for a new building at the site. Mr. Anthony also let me know that he would probably be retiring in the spring and his possible replacement would be Robert Meyers with the extension 7225.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 10:06 am**	**Date: 11/5/15**
Type: __ Telephone ___ Visit _x_ Email **Location of Visit: NA**	__ Incoming _x_ Outgoing	

Contact Made By:

Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:

Name: Ryan Tilley	**Title: Director, Division of Environmental Health and Protection**	**Organization: St. Charles County**

Telephone No: 636-949-7406 **Fax No:** **E-Mail Address: RTilley@sccmo.org**	**Street Address: 201 North Second Street, Suite 537** **City, State, Zip: St. Charles, MO 63301**

Summary Of Conversation

I contacted Ryan Tilley, Director, Division of Environmental Health and Protection for St. Charles County by email. The email stated the following:

Ryan, I am contacting you regarding the upcoming Department of Energy – Weldon Spring Site annual long-term surveillance and maintenance inspection, which is scheduled for December 1 and 2, 2015. You were copied on the notification letter with the agenda which was dated October 28, 2015. As part of the inspection we contact stakeholders to maintain contact with them and to determine if they have any concerns or issues about the site. Please respond and let me know us know if you have any questions, issues or concerns.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
7. Any other general comments?

Ryan responded that he had no questions or concerns.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.:MO6210022830**	
Subject: Annual Inspection	**Time: 10:30 am**	**Date: 11/5/15**
Type: _x_ Telephone ___ Visit ___ Other **Location of Visit:**	__ Incoming _x_ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: Nicole	**Title:**	**Organization: Simplex/Grinnell**
Telephone No: 888-746-7539 **Fax No:** **E-Mail Address:**	**Street Address:** **City, State, Zip:**	

Summary Of Conversation

I contacted Simplex/Grinnell, the alarm company for the project, and talked to Nicole. I verified that they had the correct three people as contacts and that they also had the correct work, home and cell number for each person.

INTERVIEW RECORD

Site Name: Weldon Spring Site		**EPA ID No.: MO6210022830**
Subject: Annual Inspection	**Time: 10:30 am**	**Date: 11/24/15**
Type: _x_ Telephone ___ Visit ___ Other **Location of Visit: NA**		__ Incoming _x_ Outgoing

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: Jim Hudson	**Title: Captain**	**Organization: St. Charles County Sheriff Office**
Telephone No: 636-949-7325 **Fax No: 636-949-7525** **E-Mail Address:**	**Street Address:** **City, State, Zip:**	

Summary Of Conversation

I contacted Captain Jim Hudson of the St. Charles County Sheriff's Office and informed him that the annual LTS&M inspection would be taking place on December 1 and 2, 2015. I had talked to Captain Hudson the last eleven years and reminded him that we would be contacting the Sheriff's office annually to keep in contact with them and check to see if they had any issues or concerns. Captain Hudson said he did not know of any concerns at this time. We discussed the use of security patrols and signs which have helped curtail vandalism at the site.

INTERVIEW RECORD

Site Name: Weldon Spring Site		**EPA ID No.: MO6210022830**
Subject: Annual Inspection	**Time: 9:54 am**	**Date: 12/1/15**
Type: ___ Telephone ___ Visit _x_ Email **Location of Visit: NA**	__ Incoming _x_ Outgoing	

Contact Made By:

Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:

Name: Dave Wedlock/Jeremy Boettler	**Title: Principal/Director of Facilities and Operation**	**Organization: Francis Howell High School**

Telephone No: 636-851-4080 /314-220-2746 **Fax No:** **E-Mail Address: dave.wedlock@fhsdsschools.org /jeremy.boettler@fhsdsschools.org**	**Street Address: 7001 Hwy 94 South** **City, State, Zip: St. Charles, MO 63304**

Summary Of Conversation

Dr. Wedlock, I am contacting you regarding the upcoming Department of Energy – Weldon Spring Site annual long-term surveillance and maintenance inspection, which is scheduled for December 1 and 2, 2015. As part of the inspection we contact stakeholders to maintain contact with them and to determine if they have any concerns or issues about the site. Please respond and let me know us know if you have any questions, issues or concerns. If there is another individual on your staff that you would like to contact, please let me know.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
7. Any other general comments?

Dr. Wedlock responded that Jeremy Boettler, the Director of Facilities and Operations was the new contact. I copied Mr. Boettler on the email and stated the following:

Jeremy, Just to let you know the Department of Energy contacts its stakeholders at the time of the annual inspection of the site to determine if they have any questions or concerns. The annual inspection this year is December 1-2, 2015.

Please respond and let me know if you have any questions, issues or concerns.

Mr. Boettler responded that they did not have any questions or issues.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 8:52 am**	**Date: 11/16/15**
Type: ___ Telephone ___ Visit _x_ Email **Location of Visit: NA**	__ Incoming _x_ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: Audrey Beres	**Title: Policy Coordinator**	**Organization: Missouri Department of Conservation**

Telephone No: 573-522-4115 x3346 **Fax No:** **E-Mail Address:**	**Address: P.O. Box 180** **City, State, Zip: Jefferson City, Mo 65102**

Summary Of Conversation

I contacted Audrey Beres of the Missouri Department of Conservation (MDC) by email.

Audrey, I am contacting you to notify you of the Department of Energy Weldon Spring Site annual inspection which will take place on December 1 and 2, 2015. This is considered our long-term surveillance and maintenance (LTS&M) inspection which we have conducted every year since we completed remediation of the site. This is actually our 13th LTS&M inspection. We use this time to walk over the areas that we have institutional controls in place to ensure that the restrictions are not being violated. We also inspect the disposal cell, check monitoring wells, go through records and different inspection type activities. We also use this time to maintain contact with certain stakeholders, nearby property owners and institutional control contacts, such as yourself. We just like to remind the IC contacts about the ICs we have in place, such as the easement that was signed (and is currently being revised) and the licenses that we recently renewed and check if there are any concerns or issues. I have been in contact with John Vogel and John or someone from his staff usually participates in the walk down the southeast drainage. Please respond to this email or call me to let me know if you have any questions, concerns or issues. Thanks.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so,

please give details.

4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.

5. Do you feel well-informed about the site's activities and progress?

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

7. Any other general comments?

Audrey responded that she did not have any questions or concerns.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 11:21 am**	**Date: 11/20/15**
Type: ___ Telephone ___ Visit _x_ Email **Location of Visit: NA**	__ Incoming _x_ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: Craig Tajkowski	**Title: County Engineer**	**Organization: St. Charles County**

Telephone No: 636-949-7305 **Fax No:** **E-Mail Address: ctajkows@sccmo.org**	**Address: 201 N. 2nd St, Ste. 429** **City, State, Zip: St. Charles, Mo 63301**

Summary Of Conversation

I contacted Craig Tajkowski of St. Charles County by email. They have taken over the former MoDOT facility and the groundwater restriction easement on that property was transferred from the MoDOT to the county.

Craig, I am contacting you to notify you of the Department of Energy Weldon Spring Site annual inspection which will take place on December 1 and 2, 2015. This is considered our long-term surveillance and maintenance (LTS&M) inspection which we have conducted every year since we completed remediation of the site. This is actually our 13th LTS&M inspection . We use this time to walk over the areas that we have institutional controls in place to ensure that the restrictions are not being violated. We also inspect the disposal cell, check monitoring wells, go through records and different inspection type activities. We also use this time to maintain contact with certain stakeholders, nearby property owners and institutional control contacts, such as yourself. We just like to remind the IC contacts about the ICs we have in place, such as the easement that was signed with MoDOT and transferred to the County and check if there are any concerns or issues. Please respond to this email or call me to let me know if you have any questions, concerns or issues. Thanks.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Craig's responses are included below:

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)? I do not have enough knowledge or experience with the site to have an impression.
2. What effects have the site operations had on the surrounding community? Unknown

3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details. No

4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details. No

5. Do you feel well-informed about the site's activities and progress? Information seems available, but I have had no personal or professional need to closely track that information.

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation? No

7. Any other general comments? None

I included a link to the Weldon Spring Site website in my response.

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 4:07 pm**	**Date: 11/6/15**
Type: __ Telephone ___ Visit _X_ Email **Location of Visit: Weldon Spring Site**	__ Incoming _x_ Outgoing	

Contact Made By:		
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**
Individual Contacted:		
Name: John Vogel	**Title: Wildlife Regional Supervisor**	**Organization: August A. Busch Memorial Conservation Area, Missouri Dept. of Conservation**

Telephone No: 636-300-1953 ext. 4131 **Fax No:** **E-Mail Address: John.Vogel@mdc.mo.gov**	**Street Address: 2360 Hwy D** **City, State, Zip: St. Charles, MO 63304**

Summary Of Conversation

I contacted John Vogel, to notify him of the annual inspection that was going to take place on December 1-2, 2015. The email stated:

John, I am contacting you regarding the upcoming Department of Energy – Weldon Spring Site annual long-term surveillance and maintenance inspection, which is scheduled for December 1 and 2, 2015. You were copied on the notification letter with the agenda which was dated October 28, 2015. As part of the inspection we contact stakeholders to maintain contact with them and to determine if they have any concerns or issues about the site. We also touch base about the institutional control areas to ensure that landowners remain aware of the institutional controls on their properties. As you know we have the current easement with MDC. I also wanted to check about any hunting seasons at that time. Please respond and let me know if you or a representative will attend the inspection or if you have any questions, issues or concerns. Thanks!

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016.

John responded:

Hi Terri-

I believe that Raenhard Wesselschmidt will be attending the Southeast Drainage inspection this year. During the inspection, squirrel season will be open on the area, but that has been the case during past inspections and we have not had any conflicts, so I don't expect any this year. My answers to the questions are below:

Thanks,
John

His response to the questions are below:

1. **What is your overall impression of the project (general sentiment)?**

   I think the project was a quality project to clean up the surrounding area and ensure long-term protection of the natural resources.

2. **What effects have the site operations had on the surrounding community?**

   Site operations have had a positive impact on the surrounding community. The interpretive programs offered at the site are a benefit to the community. In addition, many community members use the site as an access point to the local trail systems.

3. **Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.**

   I am not aware of any community concerns regarding the site or its operation/administration. From time to time, our office does receive questions regarding the safety of recreating on the area due to radioactivity concerns, but I think the Weldon Spring Interpretive Center does a good job of addressing those concerns.

4. **Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.**

   I am not aware of any events or incidents at the site.

5. **Do you feel well-informed about the site's activities and progress?**

   I do feel well-informed about the site's activities. Regular e-mail correspondence, conversations with site employees, and mailings are appreciated.

6. **Do you have any comments, suggestions, or recommendations regarding the site's management or operation?**

   I would like to pose the question of whether or not the annual inspection of the Southeast Drainage is really needed. It is my understanding that the purpose of the inspection is to confirm no residential structures have been built within 200-feet of the drainage. Speaking on behalf of the property owner, the Missouri Department of Conservation, I am comfortable in saying our agency would know if a residential structure was to be built in the area. Our agency has no plans to construct any residential structures in the drainage, nor would we allow anyone else to construct a residential structure. I don't really see the need to invest the time each year during the annual inspection to do the Southeast Drainage walk. I would think the time could be better spent on other portions of the annual inspection. Department of Conservation staff are still willing to participate in this portion of the annual inspection as long as we continue to do it.

7. Any other general comments?

   Thank you for continuing to communicate with the Department of Conservation.

INTERVIEW RECORD

Site Name: Weldon Spring Site		**EPA ID No.: MO6210022830**
Subject: Annual Inspection	**Time: 8:24 am**	**Date: 11/10/15**
Type: ___ Telephone ___ Visit _x_ Email **Location of Visit: NA**		__ Incoming _x_ Outgoing

Contact Made By:

Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:

Name: Quinn Kellner	**Title: Natural Resource Manager** **Jones-Confluence State Park**	**Organization: MDNR-Parks**

Telephone No: 636-899-1135 **Fax No:** **E-Mail Address: Quinn.kellner@dnr.mo.gov**	**Street Address: PO Box 67** **City, State, Zip: West Alton, MO 63386**

Summary Of Conversation

I contacted Quinn Kellner, MDNR-Parks and emailed him about the LTS&M annual inspection at the Weldon Spring site on December 1 and 2, 2015. He had been previously notified by copy of the regulator 30-day notification letter and a copy of the agenda. The email stated:

Quinn, just wanted to contact you regarding the upcoming Department of Energy – Weldon Spring Site annual long-term surveillance and maintenance inspection, which is scheduled for December 1-2, 2015. You were copied on the notification letter with the agenda which was dated October 28, 2015. As part of the inspection we contact stakeholders to maintain contact with them and to determine if they have any concerns or issues about the site. Please respond and let me know us know if you have any questions, issues or concerns.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below is a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Quinn's response to the questions are below:

1. What is your overall impression of the project (general sentiment)? That the remediation is very well monitored and documented thoroughly. A significant effort is made to fully inform the public and stakeholders about the status of the site.
2. What effects have the site operations had on the surrounding community? Other than the need for access to sampling sites on land that I manage, I have had limited experience with project operations. I did participate in one annual inspection.
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details. Not aware of any concerns.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details. No events to report.

5. Do you feel well-informed about the site's activities and progress? Yes. 6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation? None. 7. Any other general comments?

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**	
Subject: Annual Inspection	**Time: 2:10 pm**	**Date: 11/30/15**
Type: _x_ Telephone ___ Visit _x_ Email **Location of Visit: NA**	_ξ_ Incoming _x_ Outgoing	

Contact Made By:

Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:

Name: Stowe Johnson	**Title: Sr. Environmental Specialist**	**Organization: Missouri Department of Transportation**

Telephone No: 573-522-5562 **Fax No:** **E-Mail Address: Stowe.Johnson@modot.mo.gov**	**Address: P.O. Box 270** **City, State, Zip: Jefferson City, Mo 65102**

Summary Of Conversation

I contacted Stowe Johnson of the Missouri Department of Transportation by email and emailed the following information to him:

As discussed in the past several years, I represent the Department of Energy as a contractor at the Weldon Spring Site and every year we conduct an annual long-term surveillance and maintenance (LTS&M) inspection at the Site. We also use this time to contact our stakeholders and surrounding property owners to maintain contact with them and to determine if they have any concerns or issues about the site. Our inspection this year will be December 1 and 2, 2015.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
7. Any other general comments?

Regarding our history and relationship with MoDOT, the culvert on Highway D was removed by DOE as the

shoulders were widened, so that is no longer a concern for DOE and will no longer be inspected. We still have the culvert on Hwy 94 where we have fixed radiological contamination inside the culvert. We cut a part of that off for MoDOT a couple years ago. We were also successful in getting the easement signed with MoDOT on the property that is next to the site. This property was transferred to St. Charles County, therefore we will be contacting them regarding the easement. I would appreciate it if you could respond to this email and let me know if there are any issues or concerns.
Thanks!

Stowe contacted me by telephone on November 30, 2015, and informed me that MoDOT did not have any concerns or issues. We discussed the culvert and I let him know that if we saw any issues during the inspection that we would contact him.

INTERVIEW RECORD

Site Name: Weldon Spring Site		**EPA ID No.: MO6210022830**	
Subject: Annual Inspection		**Time: 8:17 am**	**Date: 11/6/15**
Type: ___ Telephone ___ Visit _x_ Email **Location of Visit: NA**		__ Incoming _x_ Outgoing	
Contact Made By:			
Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**	
Individual Contacted:			
Name: Tom Evers/James Wright	**Title: St. Charles County Area Engineer**	**Organization: Missouri Department of Transportation**	
Telephone No: 636-240-5277 **Fax No:** **E-Mail Address:** **Thomas.Evers@modot.mo.gov/James.Wright@modot.mo.gov**		**Address: 6780 Old Hwy. N** **City, State, Zip: St. Charles, Mo 63304**	

Summary Of Conversation

I contacted Tom Evers of the Missouri Department of Transportation by email and emailed the following information to him:

As discussed in the past several years, I represent the Department of Energy as a contractor at the Weldon Spring Site and every year we conduct an annual long-term surveillance and maintenance (LTS&M) inspection at the Site. We also use this time to contact our stakeholders and surrounding property owners to maintain contact with them and to determine if they have any concerns or issues about the site. Our inspection this year will be December 1 and 2, 2015.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
7. Any other general comments?

Regarding our history and relationship with MoDOT, the culvert on Highway D was removed by DOE as the shoulders were widened, so that is no longer a concern for DOE and will no longer be inspected. We still have the culvert on Hwy 94 where we have fixed radiological contamination inside the culvert. We cut a part of that off for MoDOT a couple years ago. We were also successful in getting the easement signed with MoDOT on the property that is next to the site. This property was transferred to St. Charles County, therefore we will be contacting them regarding the easement. I would appreciate it if you could respond to this email and let me know if there are any issues or concerns.
Thanks!

Tom responded that his position with MoDOT had changed and he is no longer the Area Manager for St. Charles County. He copied James Wright the person replacing him on the email.

INTERVIEW RECORD

Site Name: Weldon Spring Site		EPA ID No.: MO6210022830
Subject: Annual Inspection	Time: 12:50 pm	Date: 11/5/15
Type: ___ Telephone ___ Visit _x_ Email Location of Visit: NA		__ Incoming _x_ Outgoing

Contact Made By:		
Name: Terri Uhlmeyer	Title: Compliance Manager	Organization: Navarro
Individual Contacted:		
Name: Tom Blair	Title: Assistant District Engineer	Organization: Missouri Department of Transportation
Telephone No: 314-453-1803 Fax No: E-Mail Address: Thomas.blair@modot.mo.gov	Street Address: 1590 Woodlake Dr. City, State, Zip: Chesterfield, Mo 63017	

Summary Of Conversation

I contacted Tom Blair of the Missouri Department of Transportation by email and emailed the following information to him:

As discussed in the past several years, I represent the Department of Energy as a contractor at the Weldon Spring Site and every year we conduct an annual long-term surveillance and maintenance (LTS&M) inspection at the Site. We also use this time to contact our stakeholders and surrounding property owners to maintain contact with them and to determine if they have any concerns or issues about the site. Our inspection this year will be December 1 and 2, 2015.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or

operation?

7. Any other general comments?

Regarding our history and relationship with MoDOT, the culvert on Highway D was removed by DOE as the shoulders were widened, so that is no longer a concern for DOE and will no longer be inspected. We still have the culvert on Hwy 94 where we have fixed radiological contamination inside the culvert. We cut a part of that off for MoDOT a couple years ago. We were also successful in getting the easement signed with MoDOT on the property that is next to the site. This property was transferred to St. Charles County, therefore we will be contacting them regarding the easement. I would appreciate it if you could respond to this email and let me know if there are any issues or concerns.

Thanks!

INTERVIEW RECORD

Site Name: Weldon Spring Site	**EPA ID No.: MO6210022830**
Subject: Five Year Review	**Time: 2:00 pm** / **Date: 1/6/16**
Type: __ Telephone ___ Visit ___ Email **Location of Visit: N/A**	__ Incoming _x_ Outgoing

Contact Made By:

Name: Terri Uhlmeyer	**Title: Compliance Manager**	**Organization: Navarro**

Individual Contacted:

Name: Patrick Anderson	**Title:**	**Organization: Remediation and Radiological Assessment Unit, Federal Facilities Section, Missouri Department of Natural Resources**

Telephone No: 573-751-3087 **Fax No:** **E-Mail Address: patrick.anderson@dnr.mo.gov**	**Street Address:**

Summary Of Conversation

I contacted Patrick Anderson from the Missouri Department of Natural Resources by email regarding the Five-Year Review. Patrick works in the Federal Facilities Section.

Patrick, I am contacting you regarding the upcoming Department of Energy – Weldon Spring Site annual long-term surveillance and maintenance inspection, which is scheduled for December 1-2, 2015. You were copied on the notification letter with the agenda which was dated October 28, 2015. As part of the inspection we contact stakeholders to maintain contact with them and to determine if they have any concerns or issues about the site. Please respond and let me know us know if you have any questions, issues or concerns.

Also, this inspection will serve as the Weldon Spring Site Fifth Five-Year Review inspection. The purpose of a Five-Year Review is to ensure that the remedy that was implemented to clean up the site continues to protect human health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that clean-up actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. Community involvement is an integral part of the Five-Year Review process and DOE is soliciting your input or suggestions regarding the Weldon Spring Site and its cleanup. Below are a list of questions provided by Environmental Protection Agency (EPA) guidance for the Five-Year Review that we are requesting that you respond to. The Five-Year Review Report is scheduled to be completed by September 2016. Thanks!

Five-Year Review Questions

1. What is your overall impression of the project (general sentiment)?
2. What effects have the site operations had on the surrounding community?
3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
5. Do you feel well-informed about the site's activities and progress?
6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
7. Any other general comments?

Patrick's responses are below:

1. What is your overall impression of the project (general sentiment)?
-Overall, this project is running well. There are good lines of communication between the stakeholders. However, more frequent interaction between site management and state and federal agencies would allow for the completion of any outstanding issues.

2. What effects have the site operations had on the surrounding community?
-In general, current site operations have had a positive effect on the community. It provides unique educational opportunities to local schools and meeting locations for various clubs and interest groups.

3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
-As interest in other radiologically contaminated sites in the St. Louis area has increased in the past few years, interest in the Weldon Spring site has also increased. However, no specific community concerns have been raised.

4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency response from local authorities? If so, please give details.
-Awareness of vandalism and other activities comes from the open lines of communication between the stakeholders and their use. It is our understanding the majority of issues of vandalism and trespassing at the site stem from juveniles moving around the topmost layer of rocks, leaving behind litter at the top of the disposal cell, or rendering a monitoring well useless. It has been noted by the site managers that an increased use of the interpretive center after hours and use of a private security patrol has increased the level of security, thereby having the effect of also decreasing the episodes of vandalism and trespassing after hours.

5. Do you feel well-informed about the site's activities and progress?
-Yes

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
-Please continue to keep all communication lines open. Communication has been very helpful in understanding and preventing problems. A quarterly conference call between site management and state and federal regulatory agencies may also be helpful to discuss any issues that arise or require additional discussion.

7. Any other general comments?
-None at this time.

Appendix C

Inspection Checklist

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Annual Site Inspection Checklist

Purpose of the Checklist

This checklist has been developed from the EPA guidance document *Comprehensive Five Year Review Guidance* dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 2.3 of the *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site*. The checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually during the Weldon Spring Site annual surveillance and maintenance inspection. The checklist will also be used to assist in compiling information for the five-year review.

<table>
<tr><th colspan="2">I. SITE INFORMATION</th></tr>
<tr><td>Site name: DOE Weldon Spring Site</td><td>Date(s) of inspection:</td></tr>
<tr><td>Location: St. Charles, MO</td><td>EPA ID: MO6210022830</td></tr>
<tr><td>Agencies accompanying DOE for portions of the annual inspection:
☑ EPA, Region 7
☑ MDNR
☑ Other (list): MDC (SE Drainage)</td><td>Weather:
40s
sunny</td></tr>
<tr><td colspan="2">Remedy Includes:
Disposal Cell
Institutional controls
Monitored Natural Attenuation
Long Term Monitoring
Other</td></tr>
<tr><td colspan="2">Inspectors Terri Uhlmeyer (Navarro) Randy Thompson (Navarro)
Participants Ken Starr (DOE)
Hoai Tran (EPA)
Patrick Anderson (MDNR)
Dan Carey (MDNR)
Chris Papinsick (Navarro)
Dave Parker (Navarro)
Rex Hodges (Navarro)
Yvonne Deyo (Navarro)
Kevin McCarthy (Navarro)
Darrell Landers (Navarro)
Tim Zirbes (Navarro)
Raenhard Wesselschmidt (MDC)</td></tr>
</table>

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II. INTERVIEWS (Check all that apply)

1. **Local Site Manager** Yvonne Deyo (Name) Site Manager (Title) 11/23/15 (Date)
   Interviewed ☑ at site ☑ at office ☐ by phone Phone no. 636-300-2612
   Problems, suggestions; ☑ Report attached

2. **Environmental Data Manager** Randy Thompson (Name) Operations Manager (Title) 11/23/15 (Date)
   Interviewed ☑ at site ☑ at office ☐ by phone Phone no. 636-300-2640
   Check to ensure that environmental data is reviewed and trended.
   Problems, suggestions; ☑ Report attached

3. **Other Staff (as applicable)** N/A (Name) ______ (Title) ______ (Date)
   Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ______
   Problems, suggestions; ☐ Report attached

4. **Local response agencies:** Contact to notify of annual inspection and to determine if there are any concerns or issues.

   Agency: St. Charles County Sheriff **Contact Name:** Captain Jim Hudson
   Date Contacted: 11/24/15
   Email: N/A **Phone No.** 636-949-7325
   Problems; suggestions; ☑ Report attached

   Agency: Cottleville Fire Department **Contact Name:** Mark Boehle, Assistant Fire Chief
   Date Contacted: 11/30/15
   Email: maboehle@cottlevillefpd.org **Phone No.** 636- 447-6655, ext. 8703
   Problems; suggestions; ☑ Report attached

   Agency: SimplexGrinnel (LCRS and Interpretive Center Alarm Company)
   Contact Nicole (Name) ______ (Title) 11/5/15 (Date) 888-746-7539 (Phone no.)
   Problems; suggestions; ☑ Report attached

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5. **Stakeholders:** Contact to notify of annual inspection and to determine if there are any concerns or issues.

Agency: Francis Howell High School **Contact Name:** Robert Gaugh, Assistant Principal
Date Contacted: 12/1/15
Email: Robert.Gaugh@fhsdschools.org **Phone No.** ~~636-851-4700~~ 314-220-2746
Problems; suggestions; ☑ Report attached New contact: Jeremy Boettler

Agency: St. Charles County **Contact Name:** Ryan Tilley, Environmental Public Health Manager
Date Contacted: 11/5/15
Email: rtilley@sccmo.org **Phone No.** 636-949-7406
Problems; suggestions; ☑ Report attached

6. **Other interviews** ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **Documents**
☑ Surveillance and Maintenance Plan ☐ Readily available ☑ Up to date ☐ N/A
Remarks

2. **Permits and Service Agreements**
☑ NPDES Permits ☑ Readily available ☐ Up to date ☐ N/A
☑ MSD agreement and records ☑ Readily available ☐ Up to date ☐ N/A
☐ Other permits ☐ Readily available ☐ Up to date ☐ N/A
Remarks

3.

4.

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IV. INSTITUTIONAL CONTROLS	
Institutional Control (IC) Inspections	
1.	**Land and Shallow Groundwater Use within the Chemical Plant Site and Buffer Zone** Groundwater and land use is restricted on the Chemical Plant Site. Inspect for indications of excavations into soil and groundwater withdrawal or use in restricted areas. If any party has been granted use of portions of the Chemical Plant or Quarry area, inspect to ensure that land use is in compliance with the terms of the restrictions within the notation. Note any observations: No evidence of excavations or groundwater Use. Inspected noted wells on the property. Inspected erosion areas. Maintenance on all wells looked good. Erosion is improving by vegetation filling in.
2.	**Groundwater Use in Areas Surrounding the Chemical Plant** Groundwater use is restricted in areas on Army, MDC and St. Charles County (formerly MoDOT properties. Inspect affected areas for evidence of groundwater or spring water use (Burgermeister Spring and Spring 6303). Inspect to ensure that land use continues to be in compliance with the terms of the license, easement, or permit and the restrictions contained therein. Note any observations: Inspected wells on Army property and wells and springs on Conservation property. No evidence of spring or groundwater use.
3.	**Groundwater (Quarry)** Groundwater use is restricted in areas. Inspect affected areas for evidence of groundwater withdrawal or use in the area of impact. Inspect to ensure that land use continues to be in compliance with the terms of the license and the restrictions contained therein. Note any observations: No evidence of groundwater use. Inspected wells on property.
4.	**Land Use in Quarry Area Reduction Zone** Land use is restricted in the Quarry Area Reduction Zone. A naturally occurring reduction zone exists in soil south of the Katy Trail and north of the Femme Osage Slough. Inspect for indications of excavations into soils in the reduction zone. Inspect to ensure that land use continues to be in compliance with the terms of the easement and the restrictions contained therein. Note any observations: No evidence of excavation. "No Dig" Labels were present on the wells in reduction zone.
5.	**Southeast Drainage** The Southeast Drainage is restricted for residential housing in 200 foot corridor, Check for indications of residential use or construction in the Southeast Drainage (200-foot-wide corridor), or other activity that would indicate nonrecreational use of the area. Check Springs 5303 and 5304 for residential, commercial, or agricultural use of spring water. Note any observations: No evidence of residential use or construction. Inspected springs. No evidence of spring use.

6. **State Route 94 Culvert**

Check for signs of disturbance of the affected region where the culvert passes beneath State Route 94 and in the utility rights-of-way in the affected area. Observe culvert that has been cut.

Note any observations: The culvert inlet was covered in leaves.

7. **Pipeline from LCRS to Missouri River**

Inspect the entire length of the pipeline and outfall for any disturbances or maintenance needs.

Note any observations: The pipeline was inspected on Aug. 26, 2015. There was no evidence of disturbances. The report is attached as an Appendix.

Institutional Control Annual Contact Log

In accordance with the LTS&M Plan, the following will be contacted to verify cognizance of institutional controls and real estate agreements. Fill in all that apply.

1. **Agency:** Missouri Department of Conservation
Contact Name: John Vogel, Wildlife Regional Supervisor
Address: August A. Busch Memorial Conservation Area, 2360 Highway D, St. Charles, MO 63304
Institutional Control and Real Estate Licenses to Verify: Chemical Plant Groundwater Use Restriction, Quarry Area Groundwater Use Restriction, Quarry Reduction Zone Land Use Restriction, Southeast Drainage Residential Use Restriction, North Gate Access, Well Sampling Access Agreement, Effluent Discharge Pipeline, Hamburg Trail Use Agreement.

Date Contacted: 11/6/15

Email: john.vogel@mdc.mo.gov Phone No. 636-300-1953, ext. 4131

Problems; suggestions; ☑ Report attached

2. **Agency:** Missouri Department of Conservation
Contact Name: Audrey Beres, Policy Coordinator
Address: P.O. Box 180, Jefferson City, MO 65102
Institutional Control and Real Estate Licenses to Verify: See No. 1

Date Contacted: 11/16/15

Email: audrey.beres@mdc.mo.gov Phone No. 573-522-4115, ext. 3346

Problems; suggestions; ☑ Report attached

3. **Agency:** Missouri Department of Natural Resources
Contact Name: ~~Mary Bryan, Real Estate Manager~~ Danny Lyskowski
Address: P.O. Box 176, Jefferson City, MO 65102
Institutional Controls and Real Estate Licenses to Verify: Quarry Area Groundwater Use Restriction, Southeast Drainage Residential Use Restriction, Well Sampling Access Agreement, Effluent Discharge Pipeline

Date Contacted: 12/8/15

Email: ~~mary.bryan~~ Danny.Lyskowski@dnr.mo.gov Phone No. 573-751-~~7987~~ 7634

Problems; suggestions; ☑ Report attached

4. **Agency:** Missouri Department of Natural Resources
Contact Name: Quinn Kellner, Natural Resource Manager, Jones-Confluence Point State Park
Address: P.O. Box 67, West Alton, MO 63386
Institutional Controls and Real Estate Licenses to Verify: Quarry Area Groundwater Use Restriction, Southeast Drainage Residential Use Restriction, Well Sampling Access Agreement, Effluent Discharge Pipeline

Date Contacted: 11/10/15

Email: quinn.kellner@dnr.mo.gov Phone No. 636-899-1135

Problems; suggestions; ☑ Report attached

5. **Agency:** Missouri Department of Transportation
Contact Name: Tom Blair, Asst. District Engineer
Address: 1590 Woodlake Dr., Chesterfield, MO 63017
Institutional Controls to and Real Estate Licenses to Verify: Chemical Plant Groundwater Use Restriction (transfer to St. Charles County), and discuss the Missouri State Highway 94 Culvert.

Date Contacted: 11/5/15

Email: tom.blair@modot.mo.gov Phone No.: 314-340-4203

Problems; suggestions; ☑ Report attached

6. **Agency:** Missouri Department of Transportation
Contact Name: Stowe Johnson, Sr. Environmental Specialist
Address: P.O. Box 270, Jefferson City, MO 65102
Institutional Controls to and Real Estate Licenses to Verify: Chemical Plant Groundwater Use Restriction (transferred to St. Charles County), and discuss Missouri State Highway 94 Culvert.

Date Contacted: 11/30/15

Email: stowe.johnson@modot.mo.gov Phone No.: 573-522-5562

Problems; suggestions; ☑ Report attached

7. **Agency:** Missouri Department of Transportation
Contact Name: Jim Wright, St. Charles County Area Engineer
Address: 6780 Old Hwy. N. St. Charles, MO 63304
Institutional Controls to and Real Estate Licenses to Verify: Chemical Plant Groundwater Use Restriction (transferred to St. Charles County), and discuss Missouri State Highway 94 Culvert.

Date Contacted: 11/6/15

Email: James.Wright@modot.mo.gov Phone No.: 636-240-5277

Problems; suggestions; ☑ Report attached

8. **Agency**: St. Charles County
Contact Name: Craig Tajkowski, County Engineer
Address: 201 N. 2nd St., Ste. 429, St. Charles, MO 63301
Institutional Controls to and Real Estate Licenses to Verify: Chemical Plant Groundwater Use Restriction (former MoDOT property)

Date Contacted: 11/20/15

Email: ctajkows@sccmo.org Phone No. 636-949-7305

Problems; suggestions; ☑ Report attached

9. **Agency:** U.S. Dept. of Army
Contact Name: John Downing, Materials Handler
Address: Weldon Spring Training Area, 7301 Hwy 94 S. St. Charles, MO 63304
Institutional Controls to and Real Estate Licenses to Verify: Chemical Plant Groundwater Use Restriction, Memorandum of Understanding

Date Contacted: 11/20/15

Email: john.downingjr@usar.army.mil Phone No. 314-402-1836

Problems; suggestions; ☑ Report attached

10. **Agency:** St. Charles County Recorder of Deeds
Address: 201 N 2nd, St. Charles, MO 63301
Institutional Controls to and Real Estate Licenses to Verify: Recorded real estate restrictions at the Recorder of Deeds Office or on the Internet at www.sccmo.org

Date verified: 11/16/15

Problems; suggestions; ☐ Report attached

11. **Agency:** St. Charles County Planning and Zoning Department
Contact Name: Wayne Anthony
Address: 201 N 2nd, St. Charles, MO 63301
Institutional Controls to and Real Estate Licenses to Verify: Awareness of Restrictions

Date Contacted: 11/24/15

Email: ____________ Phone No. 636-949-7900, ext. 7221

Problems; Report attached ☑ suggestions; ____________

General

1. **Land Use Changes On Site** ☐ Yes ☑ No
Remarks____________

2. **Land Use Changes Off Site that could affect site** ☐ Yes ☑ No
Remarks____________

VI. GENERAL SITE CONDITIONS

1. **Roads** ☑ Location shown on site map Roads adequate ☑ Yes ☐ No
Remarks____________

2. **Vandalism** ☐ Location shown on site map Vandalism noted ☐ Yes ☑ No
Remarks____________

3. **Personal Injury Risks** Housekeeping maintained ☑ Yes ☐ No
Remarks____________

4.	**Site Markers (Four Information Plaques on Top of Cell, Historical Markers, and Other Information Markers)** ☐ Location shown on site map Legible and Secure ☑ Yes ☐ No In Good Condition ☑ Yes ☐ No Remarks	
5.	**Guard Rail Around Cell** ☑ Location shown on site map Secure ☑ Yes ☐ No Remarks	
6.	**Stairs to Top of Cell** ☑ Location shown on site map Stairs in good condition ☑ Yes ☐ No Handrail stable and in good condition ☑ Yes ☐ No Remarks Handrail painted this year	
7.	**Other Site Conditions:** Remarks	
	VII. EROSION	
1.	**Chemical Plant Areas** ☑ Location shown on site map Erosion evident ☑ Yes ☐ No Depth Remarks Erosion shown on Figure	
2.	**Quarry Area** ☐ Location shown on site map Erosion evident ☐ Yes ☑ No Depth Remarks	

VIII. CHEMICAL PLANT DISPOSAL CELL

1. **Settlement /Bulges** ☐ Location shown on site map New settlement noted ☐ Yes ☑ No

A. Annually: Walk along the grade break at the top of the side slopes, around the cell perimeter, and along 10 transects across the cell surface. Inspect for local depressions, regional departures from planar surfaces, and shifts in intersections (vertices) of cell surface planes. Inspect for vertical shear of the cover layers indicated by sudden, abrupt steps that exceed an approximately 6-inch change of surface level over no more than 10 feet distance.

B. During 5-Year Review Inspections (Beginning 2005 and at 5-year Intervals): Conduct an aerial mapping survey with a vertical resolution not less precise than 0.5 feet. Produce and record maps and survey data for the cell surface represented by 1.0 foot contour intervals. Evaluate the data for indications of settlement. Consider the position and spacing of contour lines as indications of elevation change and possible settlement.

Remarks The inspectors walked the 10 transects. Conducted aerial LiDAR survey in December 2014. Plan to conduct every 2 years to replace transect walk.

2. **Rock Cover** Signs of degradation ☐ Yes ☑ No Signs of intrusion ☐ Yes ☑ No

A. Annually: During settlement monitoring inspection also visually inspect for departures from original rock conditions or from the previous inspection. Note observable discoloration on areas larger than 2,500 square feet, presence of finer materials at surface and apparent rock gradation changes. Document rock conditions annually with photographs.

B. During 5-Year Review Inspections (Beginning 2005 and at 5-year Intervals): Inspect cell cover for gradation changes by walking 10 transects across the cell.
Concentrations of degraded, split, or weathered pieces of limestone will be mapped, photodocumented and visually assessed as a percentage of rock exposed within each mapped area. If degraded rock is evenly distributed, inspectors will estimate the overall percentage of degraded rock. If the amount of degraded rock appears to be increasing, based on a review of previous annual rock quality assessments, additional monitoring or gradation testing will be performed. If rock does not appear degraded, photodocumentation of several GPS located areas will establish rock conditions for future reference.

Remarks The six rock degradation test plot photos were compared to previous years photos. The rocks had not degraded or changed.

3. **Vegetative Growth** Weeds or Plants on Cell ☐ Yes ☑ No

Remarks

4.	**Wet Areas/ Water Damage** Wet areas ☐ Yes ☑ No ☐ Location shown on site map Areal extent______ Ponding ☐ Yes ☑ No ☐ Location shown on site map Areal extent______ Seeps ☐ Yes ☑ No ☐ Location shown on site map Areal extent______ Remarks______
5.	**Toe/Apron Drains** Proper drainage ☑ Yes ☐ No Silting ☐ Yes ☑ No Erosion ☐ Yes ☑ No Remarks______
6.	**Slope Instability** ☐ Location shown on site map Evidence of slope instability ☐ Yes ☑ No Remarks______
7.	**Leachate Collection and Removal System** ☑ Fence/Gates/Locks in good condition ☑ Functioning ☑ Routinely sampled ☑ Good condition ☑ No Trespassing sign posted ☑ Correct Phone Numbers Posted Data Issues ☐ Yes ☑ No Flow Rate Issues ☐ Yes ☑ No Remarks______
8.	**Condition of 300 Ft. Buffer Zone** Erosion ☑ Yes ☐ No Remarks Shown on erosion figure. No issue of affecting the disposal cell.
9.	**Condition of Prairie** Erosion ☑ Yes ☐ No Remarks The prairie condition is good. No areas of runaway erosion.

IX. GROUNDWATER MONITORING

1.	**Disposal Cell Monitoring Well Network** ☑ Properly secured/locked ☑ Good condition ☑ Properly maintained ☑ Correct ID on each well Remarks MW-2032, 2046, 2047, 2051, 2055 100% of Disposal cell wells inspected.

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2. **Chemical Plant Groundwater Monitoring Well Network**

☑ Properly secured/locked ☑ Correct ID on each well
☑ Good condition ☑ Properly maintained

List wells checked by number (> 10% of wells) MW-2035, 2036, 2037, 2038, 2039, 3026, 3027, 3028, 3029, 3030, 3034, 3037, 3038, 3039, 4001, 4006, 4007, 4026, 4027, 4029, 4031, 4032, 4040, 4041, 4043

Remarks

3. **Quarry Monitoring Well Network**

☑ Properly secured/locked ☑ Correct ID on each well
☑ Good condition ☑ Properly Maintained

List wells checked by number (> 10% of wells) MW-1006, 1008, 1009, 1012, 1014, 1017, 1018, 1044, 1052, RMW-4

Remarks

X. OVERALL OBSERVATIONS

Implementation of the Remedies

Describe issues and observations relating to whether the remedies are effective and functioning as designed.

Nothing to note, No issues

Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedies.

No issues

Early Indicators of Potential Remedy Problems
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of one or more of the remedies may be compromised in the future. No issues
Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedies. Use of LiDAR to replace walking of transects.

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Appendix D

Inspection Photos

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Photo 1: Burgermeister Spring

Photo 2: Southeast Drainage

Photo 3: Disposal Cell Inspection

Photo 4: 2003 Cell Cover test Plot TP1: north edge of north facet

Photo 5: 2014 Cell Cover test Plot TP1: north edge of north facet

Photo 6: 2015 Cell Cover test Plot TP1: north edge of north facet

Photo 7: 2003 Cell Cover test Plot TP2: bottom of north side slope

Photo 8: 2014 Cell Cover test Plot TP2: bottom of north side slope

Photo 9: 2015 Cell Cover test Plot TP2: bottom of north side slope

Photo 10: 2003 Cell Cover test Plot TP3: northeast ridgeline

Photo 11: 2014 Cell Cover test Plot TP3: northeast ridgeline

Photo 12: 2015 Cell Cover test Plot TP3: northeast ridgeline

Photo 13: 2003 Cell Cover test Plot TP4: located on upper west side

Photo 14: 2014 Cell Cover test Plot TP4: located on upper west side

Photo 15: 2015 Cell Cover test Plot TP4: located on upper west side

Photo 16: 2003 Cell Cover test Plot TP5: located on lower west side

Photo 17: 2014 Cell Cover test Plot TP5: located on lower west side

Photo 18: 2015 Cell Cover test Plot TP5: located on lower west side

Photo 19: 2011 Cell Cover test Plot TP6: located on lower west side

Photo 20: 2014 Cell Cover test Plot TP6: located on lower west side

Photo 21: 2015 Cell Cover test Plot TP6: located on lower west side

Photo 22: Erosion area north of the disposal cell

Photo 23: Historical Marker No. 2

Photo 24: Monitoring Well MW-3039

Appendix E

Inspection of Discharge Pipeline Report

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Inspection of Discharge Pipeline Manholes and Final Outfall Structure from the Weldon Spring, Missouri, Site to Missouri River Outlet: Conducted August 26, 2015

This inspection report summarizes the visual inspection of the four manhole access points, a crossing of the pipeline at a small creek, and the final discharge outfall structure on the Missouri River at the Weldon Spring, Missouri, Site. The inspection was performed on August 26, 2015 and participants included the Department of Energy-Legacy Management Site Manager for the Weldon Spring, Missouri, Site, three Legacy Management Services employees and a representative of the Missouri Department of Natural Resources. The manholes and outfall structure are part of the pipeline that begins at the facility for the Weldon Spring Leachate Collection and Removal System and terminates at a discharge outfall structure located on the Missouri River. The pipeline is regulated under a National Pollutant Discharge Elimination System (NPDES) permit with the State of Missouri. The permit number is MO-0107701 and expires June 30, 2016. The location of the pipeline and manholes is shown in Figure 1.

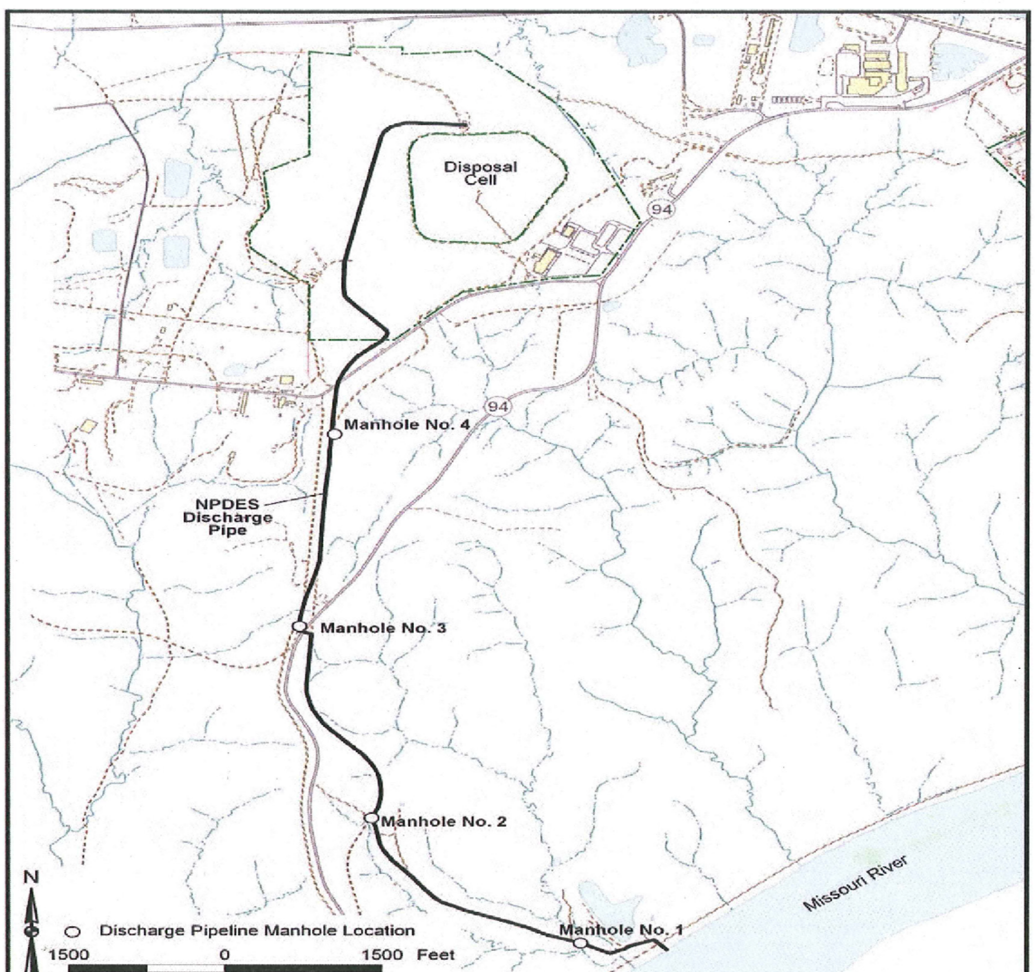

Figure 1. Location of Manholes and Outfall Structure at the Weldon Spring Site

Inspection of Manholes 1 Through 4

On August 26, 2015, the four manhole access points were located and inspected. The inspection began at Manhole 3 and 4 near the Hamburg trail and then continued to Manholes 1 and 2 located on Missouri Department of Conservation property. The inspection did not include opening of the manholes. Several cleanout structures were also observed during the inspection. The areas around each manhole were cleared of any vegetation and debris and photographs were taken at each location. The photographs of each manhole are presented below.

Each of the manhole locations were found to be in good condition with only minor vegetation or debris located at each manhole. The access trail and easement for the pipeline east of Highway 94 was mowed in July 2015 and cleared of the heavy vegetation along the trail to Manholes 1 and 2. Based on the clearing of the trail there was minimal vegetation maintenance required during the inspection. Manholes 3 and 4 are both located along the Hamburg Trail and vegetation is maintained on a frequent basis along this trail.

Approximately 100 yards east of Manhole 1 (downstream), a very large cottonwood tree had fallen in 2014 and continues to block the trail near the small bridge. However, the inspection team was able to navigate around the tree and continued with the pipeline outfall inspection without having to access the Katy Trail.

Manhole 1: Closest to Missouri River

Manhole 2: Near Old Railroad Line

Manhole 3: Near Highway 94

Manhole 4: Mound Near Hamburg Trail

Inspection of Discharge Outfall at the Missouri River and Creek Crossing

Approximately 100 yards east of Manhole 1 is a small abandoned bridge where the buried, concrete encased pipeline passes under the creek directly southeast of the bridge. The bridge has been inaccessible to vehicles for many years and is in poor condition. The pipeline is encased in concrete along the portion of the pipeline that crosses a small creek near the bridge to prevent damage from debris flowing in the creek. Though there was water flowing over the top of the pipeline encasement, no damage was observed anywhere along the encasement.

Pipeline crossing under small creek

The inspection of the pipeline discharge outfall and structure was performed on August 26, 2015. The structure was observed to be in good condition, as shown in the photo below. Some mud, debris, and rocks were observed inside and outside of the structure, but overall there was no damage or clogging of the pipeline observed at the outfall.

Discharge Outfall Structure at Missouri River

The sign placed near the discharge outfall structure has bullet penetrations. This damage occurred many years ago. The sign is in a direction where it can be viewed from the Missouri River and was not easily seen from the Katy Trail due to heavy growth of vegetation around the sign. It could not be determined if any additional damage occurred in the past year.

Appendix F

Trend Calculations

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Testing for temporal trends is required in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004c) using data from the previous 5 years (2011 through 2015 for the Five-Year Review and the 2015 Annual Report). The trend analysis is conducted using the Mann-Kendall test described in Helsel and Hirsch (2002). The Mann-Kendall test for trends was implemented in a Microsoft Excel subroutine. This simplifies the comparison of trend results with the data used for trending. The Mann-Kendall results were checked using the Mann-Kendall test that is implemented in the Visual Sampling Plan (VSP) software (VSP 2013; Gilbert 1987; Hirsch et al. 1982). The data included in the trending calculations is indicated by a linear regression line fit to that data. The method used to calculate the line was derived from equations in Isaaks and Srivastava, 1989.

The chart below (Figure F-1) shows nitrate concentrations at spring SP-6301. Trends were calculated for two time periods, 2009 through 2013 and 2011 through 2015 (indicated by a linear regression fit for each on the chart) to illustrate the variability of trending results. The uptrend calculated from the 2009-2013 data barely passes the $p<0.05$ test for statistical significance. The 2011-2015 data is too variable (low plus/minus score, Table F-1, S(+-)) to have a statistically significant trend even using the less rigorous (more likely to conclude there is a trend) “1 – tail” test. Table F-1 provides additional data and calculations used in the Mann-Kendall test. On visual inspection of the data, it seems obvious that the long-term trend is down.

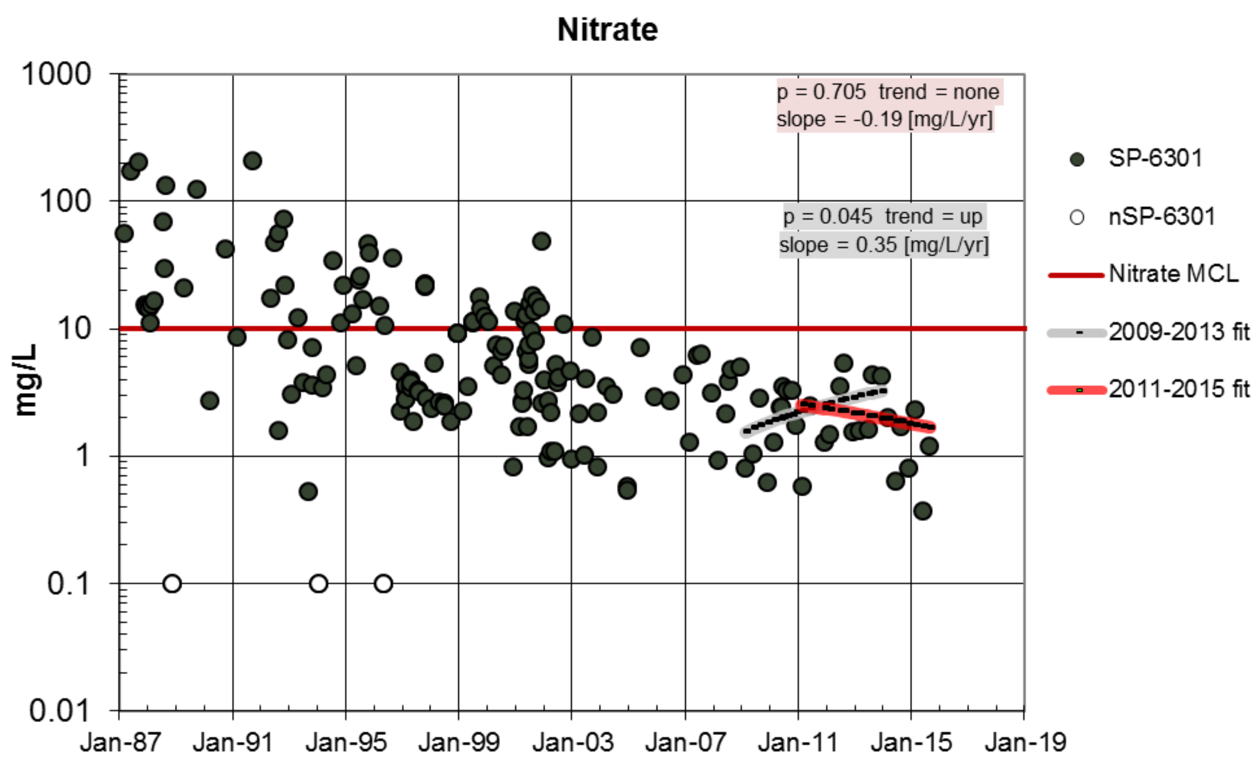


Figure F-1. Nitrate Concentrations with Trending Results for SP-6301

Table F-1. Nitrate Concentrations with Trending Results for SP-6301

well	analyte	units	begin	end	nSamples	avg (mg/L)	stdev	nPairs	S (+−)
SP-6301	Nitrate	mg/L	1/1/2009	1/1/2014	22	2.34	1.33	231	72
SP-6301	Nitrate	mg/L	1/1/2011	1/1/2016	18	2.07	1.44	153	−11

well	Kendalls τ	Z	p (2 tail)	Trend	slope (mg L^{-1} yr^{-1})	p (1 tail)	Trend	ties
SP-6301	0.312	2.00	**0.045**	**up**	0.35	0.023	up	1
SP-6301	−0.072	0.38	**0.705**	**none**	−0.19	0.352	none	0

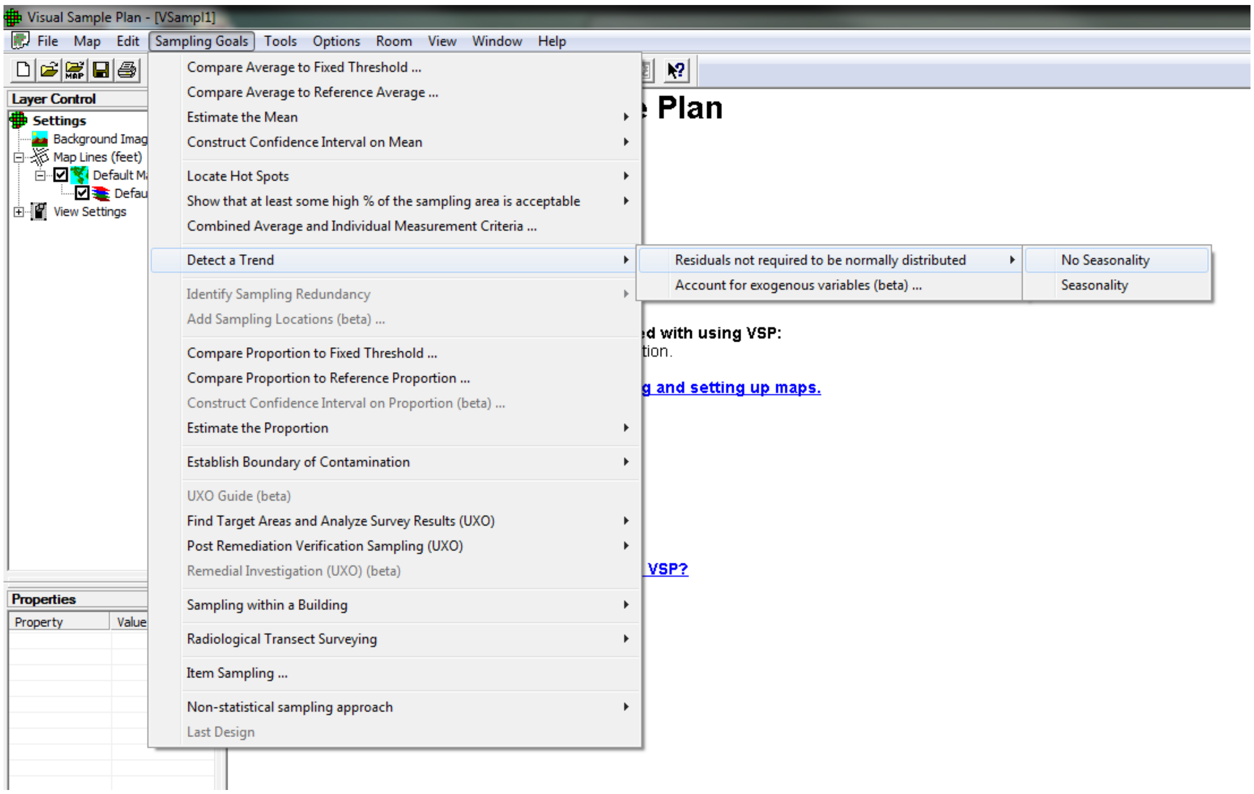
mg/L = milligrams per liter
mg L^{-1} yr^{-1} = milligrams per liter per year
nSamples = number of sample results used in the Mann-Kendall calculation
avg = average
stdev = standard deviation
nPairs = number of pairs of results compared for either plus (second result greater than first result), minus (second result less than first result) score, or ties (first and second result equal)
S (+−) = total of plus/minus scores

Kendalls τ = S divided by nPairs
Z = z score, a statistical measurement of a scores relationship to the mean in a group of scores
P value = a tool for deciding whether to reject the null hypothesis (no trend), a normalized z-score

Trend Calculation Example Using VSP:

1) Install and open VSP (VSP can be downloaded at http://vsp.pnnl.gov/)

Under **Sampling Goals**, select **Detect a Trend**, then select **No Seasonality**.

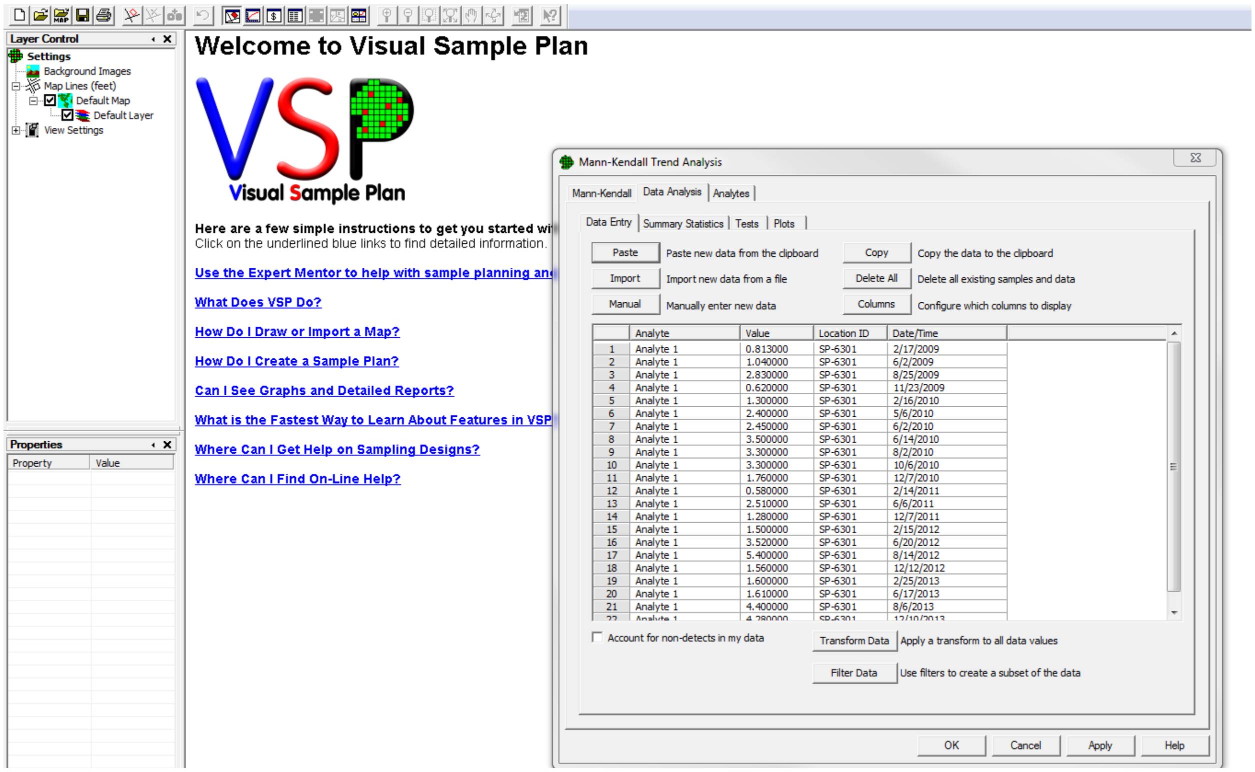


2) Enter data.

Data used for trend calculations is available on the GEMS (Geospatial Environmental Mapping System) system at [http://gems-int.lm.doe.gov] in the Groundwater Quality by Location report.

The example provided uses nitrate data for Burgermeister Spring (SP-6301).
Under the Data Analysis, Data Entry tab, the data was pasted from Excel.
Select the proper headings during this step.

Location	Sampling Date	Nitrate (mg/L)
SP-6301	2/17/2009	0.813
SP-6301	6/2/2009	1.04
SP-6301	8/25/2009	2.83
SP-6301	11/23/2009	0.62
SP-6301	2/16/2010	1.3
SP-6301	5/6/2010	2.4
SP-6301	6/2/2010	2.45
SP-6301	6/14/2010	3.5
SP-6301	8/2/2010	3.3
SP-6301	10/6/2010	3.3
SP-6301	12/7/2010	1.76
SP-6301	2/14/2011	0.58
SP-6301	6/6/2011	2.51
SP-6301	12/7/2011	1.28
SP-6301	2/15/2012	1.5
SP-6301	6/20/2012	3.52
SP-6301	8/14/2012	5.4
SP-6301	12/12/2012	1.56
SP-6301	2/25/2013	1.6
SP-6301	6/17/2013	1.61
SP-6301	8/6/2013	4.4
SP-6301	12/10/2013	4.28



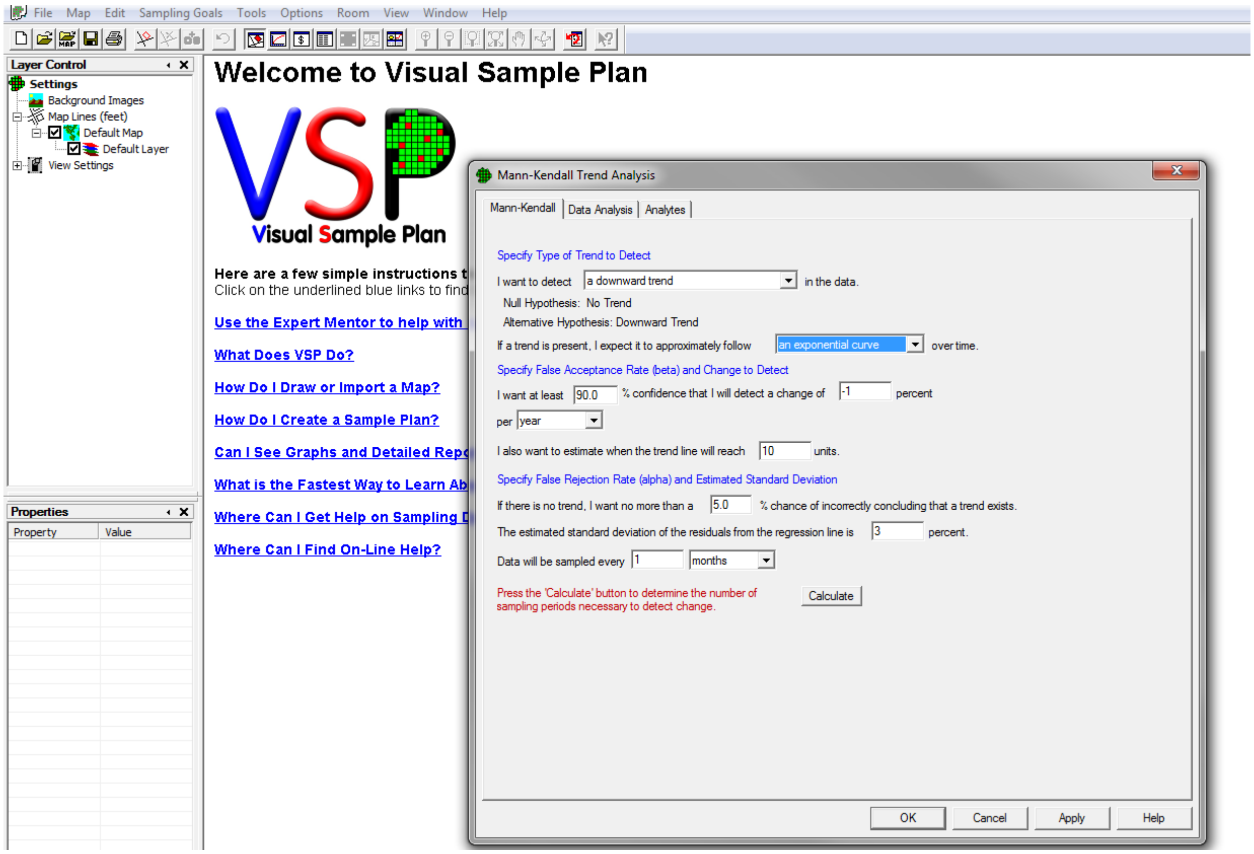
3) Set the parameters under the **Mann-Kendall** tab.

a) The “I want to detect” box allows selecting a downward or upward trend (1-tail test), or either trend (2-tail test).

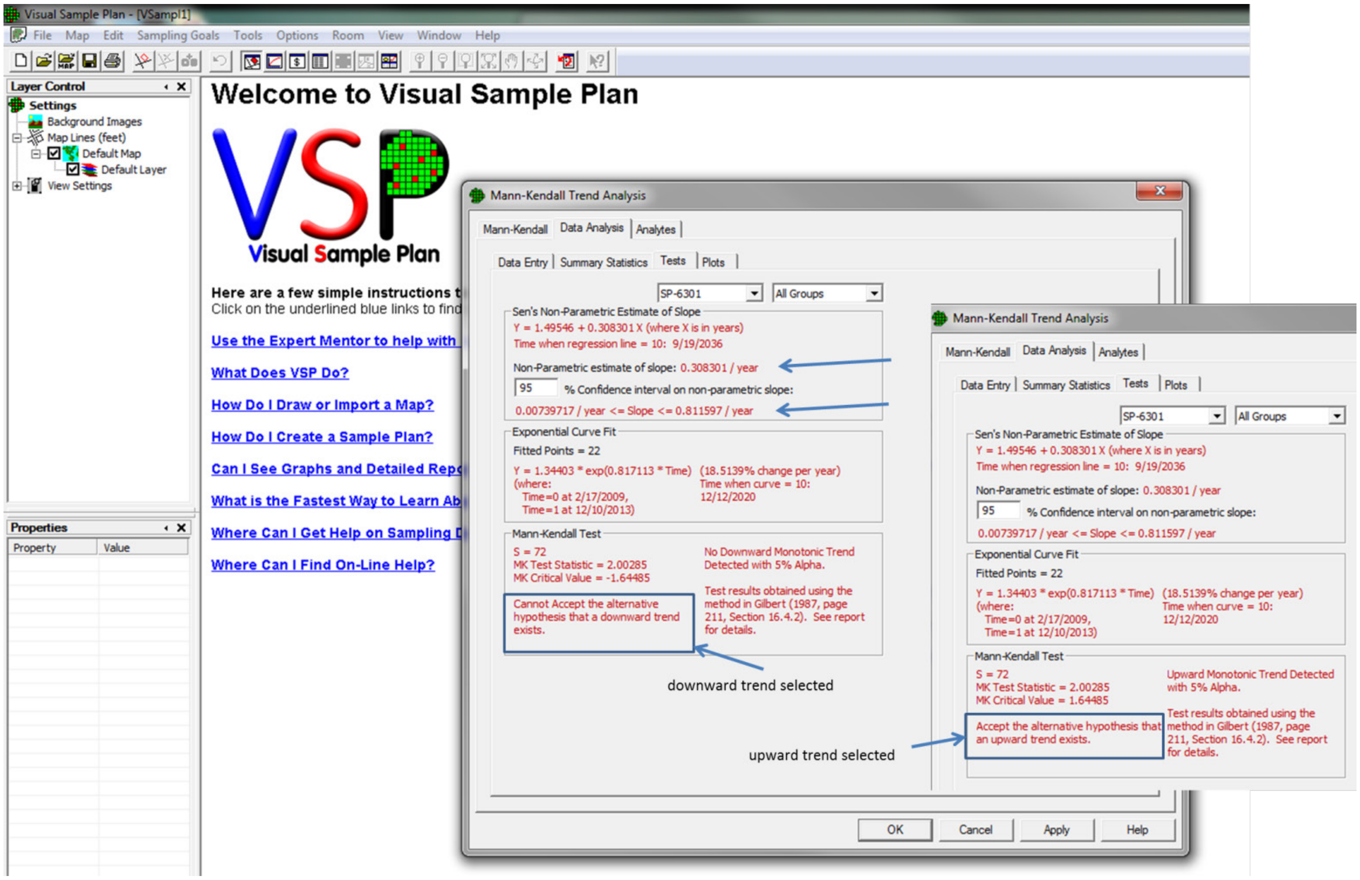
b) You can calculate an exponential or linear equation to fit the data.

c) Selecting less than 5% chance of an incorrect trend sets the p value at 0.05.

d) Click **Calculate**.


File Map Edit Sampling Goals Tools Options Room View Window Help
Layer Control
Settings
Background Images
Map Lines (feet)
Default Map
Default Layer
View Settings
Properties
Property
Value
Welcome to Visual Sample Plan
Visual Sample Plan
Use the Expert Mentor to help with
What Does VSP Do?
How Do I Draw or Import a Map?
How Do I Create a Sample Plan?
What is the Fastest Way to Learn Ab
Where Can I Find On-Line Help?
Mann-Kendall Trend Analysis
Mann-Kendall
Data Analysis
Analytes
Specify Type of Trend to Detect
I want to detect
a downward trend
in the data.
Null Hypothesis: No Trend
Alternative Hypothesis: Downward Trend
If a trend is present, I expect it to approximately follow
an exponential curve
over time.
Specify False Acceptance Rate (beta) and Change to Detect
I want at least
90.0
% confidence that I will detect a change of
-1
percent
per
year
I also want to estimate when the trend line will reach
10
units.
Specify False Rejection Rate (alpha) and Estimated Standard Deviation
If there is no trend, I want no more than a
5.0
% chance of incorrectly concluding that a trend exists.
The estimated standard deviation of the residuals from the regression line is
3
percent.
Data will be sampled every
1
months
Press the 'Calculate' button to determine the number of sampling periods necessary to detect change.
Calculate
OK
Cancel
Apply
Help

4) Results are under the **Data Analysis**, **Tests** tab.
Results are shown on the figure.



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Appendix G

CD of Report

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