GWOU ADMINISTRATIVE RECORD
SECTION TITLE:
GW-300-303-1.11

MAR 1 3 2003

Mr. Dan Wall
Project Manager
Superfund Division
U.S. EPA
Region VII
901 N. 5th Street
Kansas City, KS 66101

Dear Mr. Wall:

DRAFT PROPOSED PLAN FOR FINAL REMEDIAL ACTION FOR THE GROUNDWATER OPERABLE UNIT AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE

Enclosed are three copies of the above-referenced document, which presents the Department of Energy's plan for addressing groundwater contamination at the area of the former Chemical Plant. This plan has been developed in consultation with the EPA and the Missouri Department of Natural Resources (MDNR). The plan proposes a remedy of Monitored Natural Attenuation (MNA) for the contaminants in the groundwater, institutional controls to assure unacceptable risks do not occur during the attenuation period, and contingency activities in the event MNA does not progress as expected.

This document is a primary document under the Federal Facility Agreement and is subject to a 60-day agency review. Due to extensive advance coordination among the agencies, DOE is hopeful that formal comments will be developed and submitted by both EPA and MDNR in a relatively short period of time. We appreciate the commitment of the time and resources of both EPA and MDNR to this matter.

We want to emphasize the areas of agreement we have reached to date, but also acknowledge the areas that require additional discussions. DOE, EPA and MDNR have agreed that MNA is an appropriate solution for the Chemical Plant Area groundwater. This is a significant achievement. Establishing the performance monitoring and contingency activities have been extensively discussed, with agreement reached in some but not all, areas. This Proposed Plan is conceptually consistent with our discussions; however, it introduces some changes in previously discussed trigger values, some changes in the area of further plume delineation, and some additional performance monitoring which our technical teams have not yet discussed.

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One area in which we have had only preliminary discussions is in regards to nitroaromatic contamination. The Proposed Plan outlines an MNA approach, but also contains some "placeholder" language pending resolution of nitroaromatic contamination in the surrounding areas, which will be the subject of the US Army Corps of Engineers (USACE) groundwater decision. We are hopeful that discussions with EPA, MDNR and the USACE will result in a comprehensive approach to addressing nitroaromatic compounds. If that can be accomplished, DOE will make appropriate changes to this proposed remedy.

Given our mutual agreement on an MNA course of action, we remain confident that we will be able to agree upon the details during the 60-day review process. If you have any questions regarding the document, contact Tom Pauling at (636)926-7051.

Sincerely,

ORIGINAL SIGNED BY
PAMELA THOMPSON

Pamela Thomson
Project Manager
Weldon Spring Site
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As stated

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DOE/GJ/79491-932

Proposed Plan for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site, Weldon Spring, Missouri

March 2003
DRAFT

prepared by
Environmental Assessment Division, Argonne National Laboratory

prepared for
U.S. Department of Energy, Weldon Spring Site Remedial Action Project,
Weldon Spring, Missouri, under Contract W-31-109-ENG-38

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

General

ARAR	applicable or relevant and appropriate requirement
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DA	U.S. Department of the Army
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GAC	granular activated carbon
GWOU	groundwater operable unit
ICO	in-situ chemical oxidation
IROD	interim record of decision
MCL	maximum contaminant level
MDC	Missouri Department of Conservation
MNA	monitored natural attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
RA	remedial action
RAO	remedial action objective
RBC	risk-based concentration
RD	remedial design
RI	remedial investigation
ROD	Record of Decision
WSSRAP	Weldon Spring Site Remedial Action Project
WSTA	Weldon Spring Training Area

Chemicals

1,3-DNB	1,3-dinitrobenzene
DNT	dinitrotoluene
2,4-DNT	2,4-dinitrotoluene
2,6-DNT	2,6-dinitrotoluene
NB	nitrobenzene
TCE	trichloroethylene
1,3,5-TNB	1,3,5-trinitrobenzene
TNT	trinitrotoluene

2,4,6-TNT	2,4,6-trinitrotoluene

Units of Measure

ft	foot (feet)
gpm	gallon(s) per minute
ha	hectare(s)
km	kilometer(s)
L	liter(s)
μg	microgram(s)
m	meter(s)
mg	milligram(s)
mi	mile(s)
min	minute(s)
pCi	picocurie(s)

PROPOSED PLAN FOR FINAL REMEDIAL ACTION FOR THE GROUNDWATER OPERABLE UNIT AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE, WELDON SPRING, MISSOURI

1 INTRODUCTION

This Proposed Plan (PP) presents the final remediation strategy for addressing contaminated groundwater at the Chemical Plant area of the Weldon Spring site, in Weldon Spring, Missouri. The site is located about 48 km (30 mi) west of St. Louis in St. Charles County (Figure 1.1). The proposed action discussed in this plan is intended as a follow-on remedial action to the source removal (soils and structures) that has been completed. It also reflects the findings of the remedial action stipulated in the interim Record of Decision (IROD) of 2000 for the Groundwater Operable Unit at the Chemical Plant area (DOE 2000).

The U.S. Department of Energy (DOE) complies with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in conducting remedial activities at the site. National Environmental Policy Act (NEPA) values have been incorporated into the CERCLA process. That is, the analysis conducted and presented in the reports comprising the remedial investigation/feasibility study (RI/FS) included an evaluation of environmental impacts that is comparable to that performed under NEPA.

As was conducted in developing the IROD, alternatives presented in the FS (DOE and DA 1998) and the Supplemental FS (DOE 1999a) were considered in the identification of the proposed action presented in this plan. The alternatives were developed after careful analysis of available geological, environmental, and human health and ecological risk data, and an evaluation of the effectiveness, implementability, and cost of the various technologies available for groundwater remediation at the Chemical Plant area.

This PP is required under CERCLA to:

- Present to the public a notice and brief analysis of the remedial action alternatives developed in the FS and Supplemental FS;
- Identify and present the rationale for the proposed remedial action alternative identified in the PP;
- Summarize key information from the RI, Baseline Risk Assessment (BRA), FS, and Supplemental FS; and
- Inform the public of its role in the remedial selection process and give the public the opportunity to participate in that process.

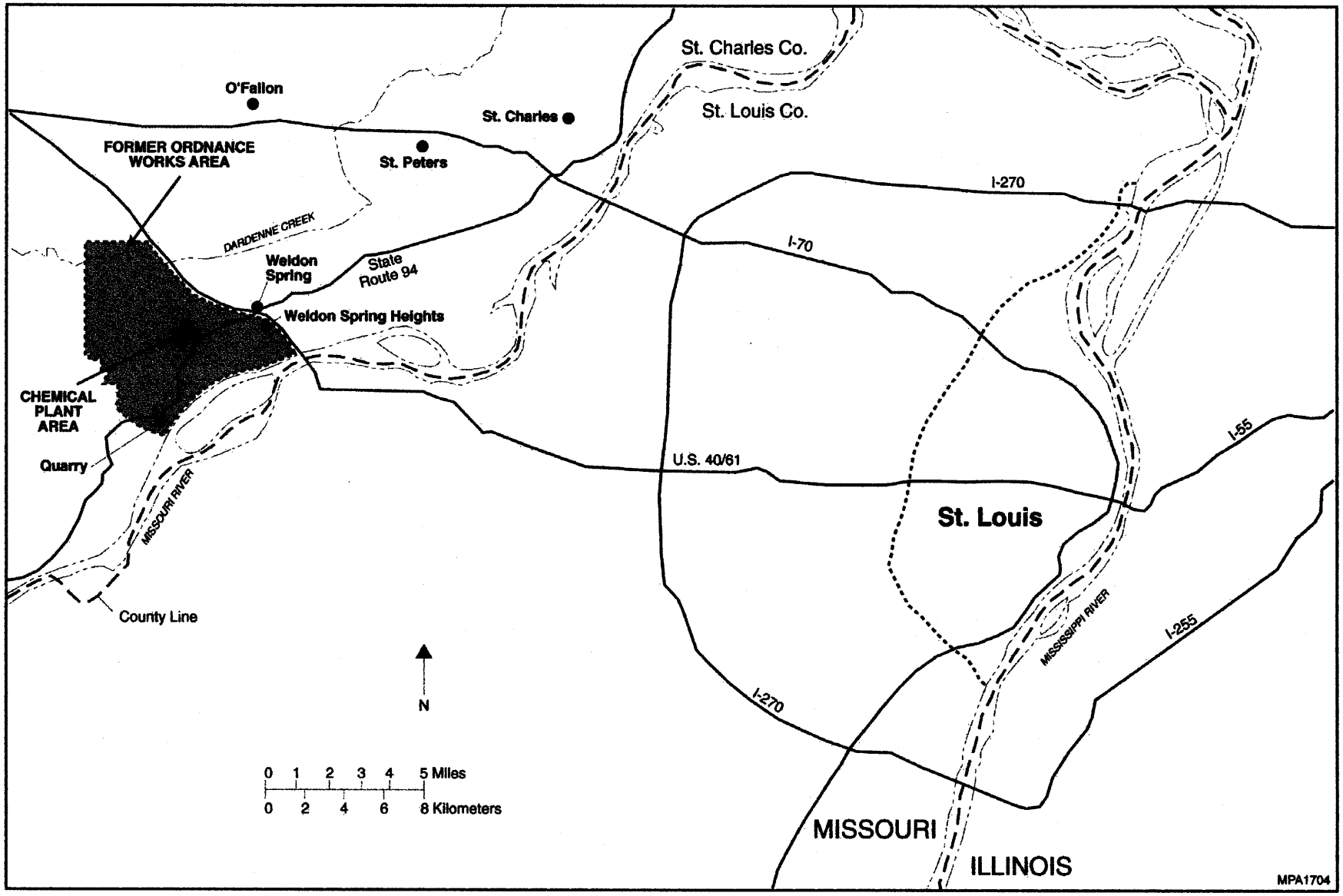


FIGURE 1.1 Location of the Weldon Spring Chemical Plant Area

DOE encourages public review and comment on this proposed remedial action plan for groundwater and springs at the Chemical Plant area. Additional details about the site and the remedial action alternatives may be found in the RI, BRA, FS, Supplemental FS, and in other supporting technical reports that are included in the Administrative Record.

The remainder of this PP is organized as follows:

- Chapter 2 presents the history and environmental setting of the Chemical Plant area and a summary of the nature and extent of contamination,
- Chapter 3 describes the scope and role of the proposed action,
- Chapter 4 summarizes the human health and ecological risks from groundwater and springs,
- Chapter 5 presents the preliminary remedial action objectives for groundwater,
- Chapter 6 summarizes the evaluation process and provides a brief description of the remedial action alternatives considered,
- Chapter 7 presents the proposed remedial action, and
- Chapter 8 describes the community's role in this action.

2 SITE BACKGROUND

The Weldon Spring Chemical Plant area is about 88-ha (217-acres) and lies within the boundaries of the Weldon Spring Ordnance Works. The Chemical Plant was used for trinitrotoluene (TNT) and dinitrotoluene (DNT) production from 1941 to 1945 and later as a uranium processing facility from 1957 to 1966. Sources of contamination have been remediated. These consisted of some 40 buildings, four Raffinate Pits (radioactive waste retention ponds), two ponds (Ash Pond and Frog Pond), and two former dumps (north and south) (see Figure 2.1). Background information related to the environmental setting of the site and the nature and extent of contamination is provided below.

2.1 ENVIRONMENTAL SETTING

Brief descriptions of the site geology, hydrogeology, surface water, land use, and groundwater use are presented in Sections 2.1.1 to 2.1.5.

2.1.1 Geology

Locally, the subsurface consists of porous, unconsolidated deposits that unconformably overlie bedrock. This unconsolidated overburden material consists primarily of modified loess, glacial drift, preglacial deposits, and residuum (DOE and DA 1997b). The thickness of these glacial and preglacial deposits, known as the "overburden," generally ranges from 4 to 18 m (13 to 59 ft) across the Chemical Plant area.

The Burlington-Keokuk Limestone, the uppermost bedrock unit at the Chemical Plant area, has been separated into two subunits, the weathered and unweathered. The weathered unit ranges in thickness from 3 to 17 m (10 to 55 ft). At the Chemical Plant area, fracturing in the bedrock is predominantly horizontal. Solution features are common in the weathered portion of the Burlington-Keokuk Limestone and range from pinpoint vugs to small zones of core loss, typically less than 1.5 m (5 ft). The larger zones in many cases appear to be at least partially filled with clay or clay mixture (DOE 1992). Significantly fewer horizontal and vertical fractures exist in the unweathered unit than in the weathered unit. Field data indicate a decrease in hydraulic conductivity with depth, which is attributed to decreased weathering. The size, abundance, geometry, and connection of the open fractures within the bedrock affect the transport of groundwater and contaminants through the bedrock.

2.1.2 Hydrogeology

There are three bedrock aquifers in the vicinity of the Chemical Plant area: a shallow unconfined aquifer (although it may be locally confined); a middle confined aquifer; and a deep confined aquifer. An additional shallow, alluvial aquifer is present near the Weldon Spring Quarry adjacent to the Missouri River.

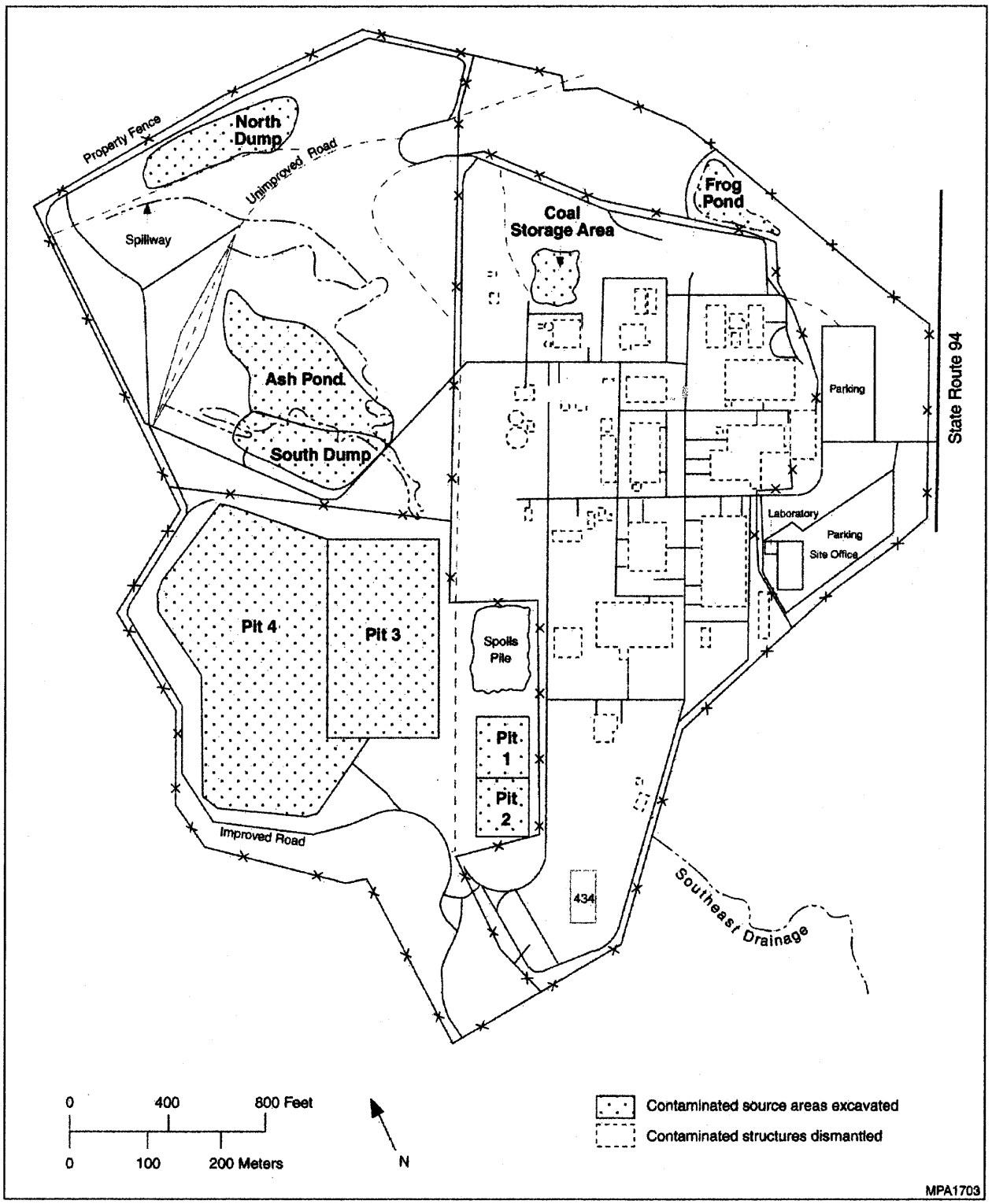


FIGURE 2.1 Original Layout of the Chemical Plant Area

As indicated by characterization data, the shallow unconfined aquifer has been affected by former activities at the Chemical Plant area. Thus, it is the groundwater system of primary interest for this PP. This aquifer consists of the Burlington-Keokuk Limestone and the Fern Glen Formation, both limestone units, and, to the north of the Chemical Plant, the overburden. The principal recharge to this shallow groundwater system is through infiltration of precipitation from the overburden or from losing streams. The water table elevation fluctuates seasonally and with precipitation, but remains within the upper bedrock or overburden. An east-west trending groundwater divide, which coincides with the topographic high point of the area, results in two distinct drainage systems. This divide presently is located south of the Chemical Plant property. Historically, the divide was situated beneath the raffinate pit area because of extensive recharge from the pits.

At the Chemical Plant area, shallow groundwater north of the divide flows to the north and into a karst conduit system that discharges at Burgermeister Spring (Figure 2.2). Transport through this conduit is very rapid. Water discharged at Burgermeister Spring then mixes with other surface water and with ponded water in Lake 34. Any dissolved contaminants in the discharged groundwater are then subject to extensive dilution and physical and chemical degradation. Because most of the shallow groundwater beneath the Chemical Plant area discharges to the surface in the vicinity of Burgermeister Spring, the spring defines the northern-most extent of direct groundwater transport from the site and provides an ideal location for monitoring endpoint contaminant concentrations.

Historically, groundwater south of the divide at the Chemical Plant area flowed south to southeast toward the Missouri River, primarily through the Southeast Drainage. Because this drainage has losing stream segments in its upper reaches, mixing between groundwater and surface water occurred. As with Burgermeister Spring, springs in the Southeast Drainage act as end points of direct groundwater transport from the Chemical Plant area and provide ideal locations for monitoring groundwater contamination. Data from groundwater downgradient of the springs indicate no impact.

The shallow groundwater system beneath the Chemical Plant area is hydrogeologically complex and is characterized by fractures, conduits, paleochannels, and dissolution/weathering features. Because of these features, the aquifer exhibits highly heterogeneous and anisotropic values in conductivity and transmissivity (i.e., the ease with which a porous material allows water to flow) from place to place. Pump tests performed in July 1998 to determine the effects of groundwater withdrawal on the aquifer further demonstrated the variability of the aquifer (MK-Ferguson 1998). In one location, pumping at a rate of less than 3.8 L/min (1 gallon per minute [gpm]) could not be sustained. In a second location approximately 30 m (100 ft) away, water could be pumped but at a rate of less than 37.9 L/min (10 gpm), which is a low value from a pump-and-treat perspective. Even with this low rate of pumping, the shallow groundwater system could not recharge to sustain this rate, which resulted in the water level in the well falling below the depth of the pump. Once pumping stopped, recovery of the groundwater level was very slow, and full recovery to water levels prior to testing was achieved about 1 year later. These findings were further supported by a subsequent field study performed in 2001 (see Section 6.2).

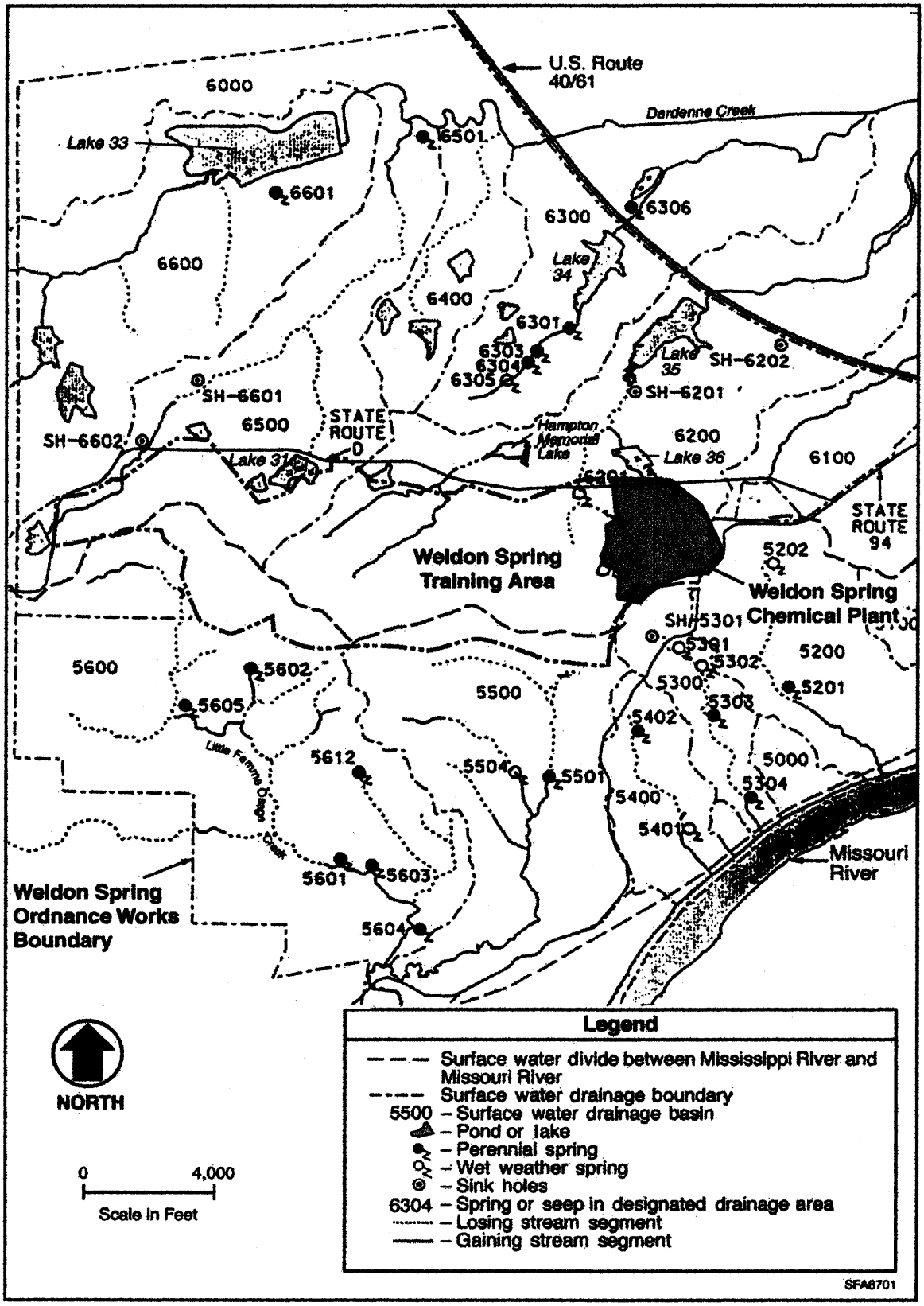


FIGURE 2.2 Springs and Drainage Areas in the Chemical Plant Area

2.1.3 Surface Water

The Chemical Plant area is located on an east-west drainage divide between the Missouri and Mississippi watersheds. At the Chemical Plant area, surface drainage to the south of the divide generally flows through the Southeast Drainage and discharges to the Missouri River. Surface drainage to the north of the divide flows toward Dardeene Creek and its tributaries. Schote Creek, the largest of the tributaries, drains a major portion of the Chemical Plant area. Dardenne Creek flows east to the Mississippi River (see Figure 2.2).

2.1.4 Land Use and Demography

The population of St. Charles County is about 300,000. The population in St. Charles County has increased by about 30% over the past 10 years. Approximately 20% of the population lives in the city of St. Charles, which is located about 22 km (14 mi) northeast of the Weldon Spring site. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 mi) to the northeast. The combined population of these two communities is about 5,000. No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses (MK-Ferguson 2001).

Francis Howell High School (FHHS) is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs approximately 150 faculty and staff and has about 1,500 students in attendance. In addition, approximately 50 full-time employees work at the high school annex, and about 50 bus drivers park their school buses in the adjacent parking lot.

The Missouri Highway and Transportation Department (MHTD) Weldon Spring Maintenance facility, located adjacent to the north side of the Chemical Plant, employs about 10 workers. The Army Reserve Training Area is to the west of the site and is visited periodically by the U.S. Department of the Army (DA) trainees and law enforcement personnel (MK-Ferguson 2001). About 300 ha (741 acres) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land is being developed into a high-technology research park. The conservation areas adjacent to the site are operated by the Missouri Department of Conservation and employ about 50 people.

2.1.5 Groundwater Use

As a whole, the shallow aquifer beneath the boundaries of the Chemical Plant area and the adjacent former Ordnance Works area is currently not used for drinking water or for irrigation. However, on the basis of U.S. Environmental Protection Agency (EPA) guidance (EPA 1986) for groundwater classification, site groundwater could be classified as potentially usable from a water quality standpoint.

A total of 23 active private wells were identified within a 4 mile radius of the site based on a review of archival records from state files. Several of these wells are not located along the groundwater flow path from the site. Although some of these private wells are open to the shallow aquifer, in order to obtain sufficient yield most of these wells were open throughout the entire shallow aquifer (including all or part of the Fern Glen) and some deeper units rather than only the Burlington-Keokuk. Three of the private wells identified are open to the deeper bedrock aquifers (i.e., Kimmswick and St. Peter) in order to obtain sufficient well yields and are greater than 1,000 ft. deep.

No domestic wells are known to be active within the Chemical Plant area or the adjacent Ordnance Works area or in the Busch Conservation area. The closest private wells downgradient from the site are located 2.1 miles to the north. These wells are estimated to be 70 to 91 m (325 to 350 ft) below the ground surface.

The current source of water for residents in the area is municipal water provided by several companies. County zoning for future housing developments in the area around the Chemical Plant and adjacent Ordnance Works indicate that when available, municipal water would continue to be the source of drinking water even for potential future residents in the area.

2.2 NATURE AND EXTENT OF CONTAMINATION

Data collected for the Chemical Plant area groundwater and springs from 1987 through 1995 were evaluated as part of the RI (DOE and DA 1997b). Data collected since the RI (up to those collected in 2002) have also been evaluated to support this PP. The current monitoring program consists of 75 wells (including 5 wells that monitor cell performance) and 5 springs. Approximately 60 additional monitoring wells have also been constructed and sampled since 1987 but have since been abandoned. The current network of wells monitored at the Chemical Plant area is shown in Figure 2.3.

2.2.1 Groundwater

The contaminants of concern (COCs) in groundwater are trichloroethylene (TCE), nitrate, uranium, and nitroaromatic compounds. The nitroaromatic compounds of concern include 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 2,4,6-trinitrotoluene (2,4,6-TNT), 1,3,5-trinitrobenzene (1,3,5-TNB), 1,3-dinitrobenzene (1,3-DNB), and nitrobenzene (NB).This list has remained unchanged from when the RI/FS reports were issued in 1999.

TCE contamination is localized at the Chemical Plant area, primarily in the vicinity of the former Raffinate Pits. The horizontal extent of contamination extends from east of the former Raffinate Pit 3 to the south and southwest of the former Raffinate Pit 4, just beyond the boundary of the adjacent Army site. Contamination is limited to the weathered portion of the shallow aquifer. The historical maximum concentration was reported in 1996 to be 9,000 μg/L. However, this concentration is a suspect value because concentrations obtained from subsequent sampling

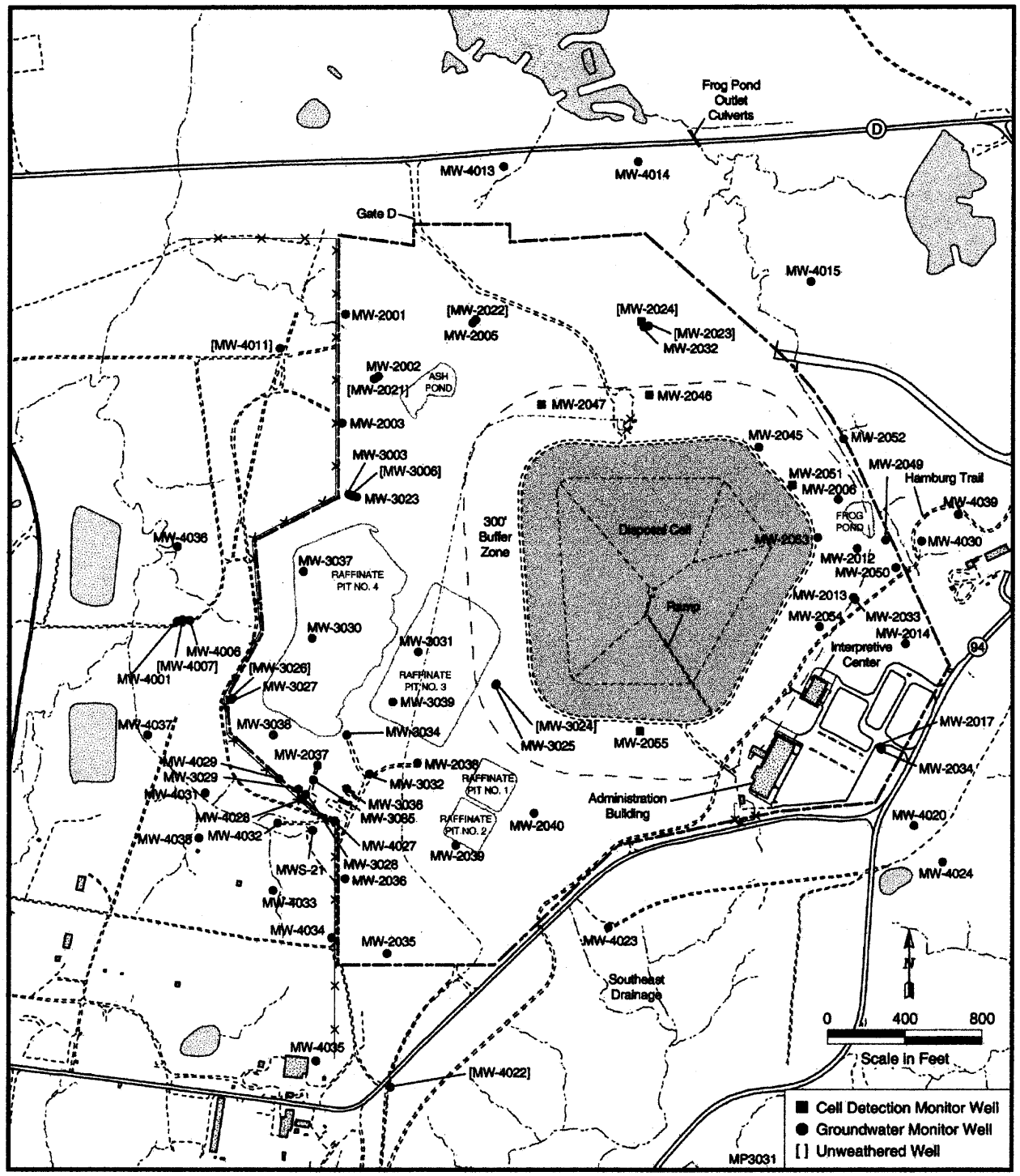


FIGURE 2.3 Locations of Monitoring Wells at the Chemical Plant Area

of the same well indicate much lower concentrations (about 1,100 μg/L). Decreasing trends since 1996 have been observed; data collected in 2002 ranged from 1.6 to 580 μg/L.

Figure 2.4 depicts the contamination contour at the Chemical Plant area based on data reported for 2002 that exceed the maximum contaminant level (MCL) of 5 μg/L for TCE. In 2002, TCE concentrations in 16 monitoring wells exceeded 5 μg/L with the higher TCE concentrations reported for MW-3028, MW-3029, MW-3030, MW-3034, MW-4028, MW-4029, and MW-4031.

Nitrate contamination is primarily limited to the Chemical Plant area and nearby vicinity. The highest concentrations of nitrate have typically been measured in the vicinity of the Raffinate Pits and Ash Pond. Historical concentrations as high as 12,000 mg/L have been reported before 1995. Recent data (2002) show a range of 0.4 to 826 mg/L, with the maximum reported for MW-4029. Remediation activities in the Raffinate Pit area and Ash Pond in 1998 have resulted in slight increases in contaminant concentrations in several of the vicinity wells at that time but has since stabilized. Wells downgradient from Raffinate Pits 1 and 2 have shown decreases in nitrate levels since 1998.

Figure 2.5 depicts the contamination contour at the Chemical Plant area based on nitrate data reported for 2002 that exceeded the MCL of 10 mg/L. Nitrate concentrations in 32 monitoring wells exceeded 10 mg/L in 2002; some of the higher nitrate concentrations were reported for MW-2003, MW-2038, MW-3003, MW-3025, MW-3030, MW-3034, MW-3039, MW-4029, and MW-4031.

The extent of uranium contamination in groundwater is primarily limited to the Chemical Plant area and nearby vicinity. Contamination occurs predominantly in the weathered unit of the aquifer. Recent data collected for uranium in 2002 ranged from 0.1 to 55 pCi/L; and concentrations in only two wells exceeded the recently promulgated MCL of 30 μg/L (or 20 pCi/L based on the isotopic ratio determined for the Weldon Spring site). These wells are MW-3024 (at 45 pCi/L) and MW-3030 (at 55 pCi/L). Analysis of uranium data from 1998 to 2002 indicates that uranium concentrations are generally static if not showing slight decreases at some of the monitored locations. Figure 2.6 depicts the uranium contamination contour at the Chemical Plant area based on data reported for 2002.

Nitroaromatic compounds occur in the northeastern and southwestern portions of the site where production lines were located. Contamination occurs predominantly in the weathered unit of the aquifer. The primary nitroaromatic compounds of concern in groundwater are 2,4-DNT, 2,6-DNT, 1,3,5-TNB, 2,4,6-TNT, 1,3-DNB, and NB.

In 2002, maximum concentrations of 1,600 μg/L for 2,4-DNT, 1,300 μg/L for 2,6-DNT, 280 μg/L for 1,3,5-TNB, 290 μg/L for 2,4,6-TNT, 1.7 μg/L for 1,3-DNB, and 69 μg/L for NB were detected. These maximums have been reported for one well in particular, MW-2012. Upward trends starting in 1999 were observed for nitroaromatic concentrations from this monitoring well near the Frog Pond area, most likely due to soil excavation activities in this area or the nearby area excavated by the Army.

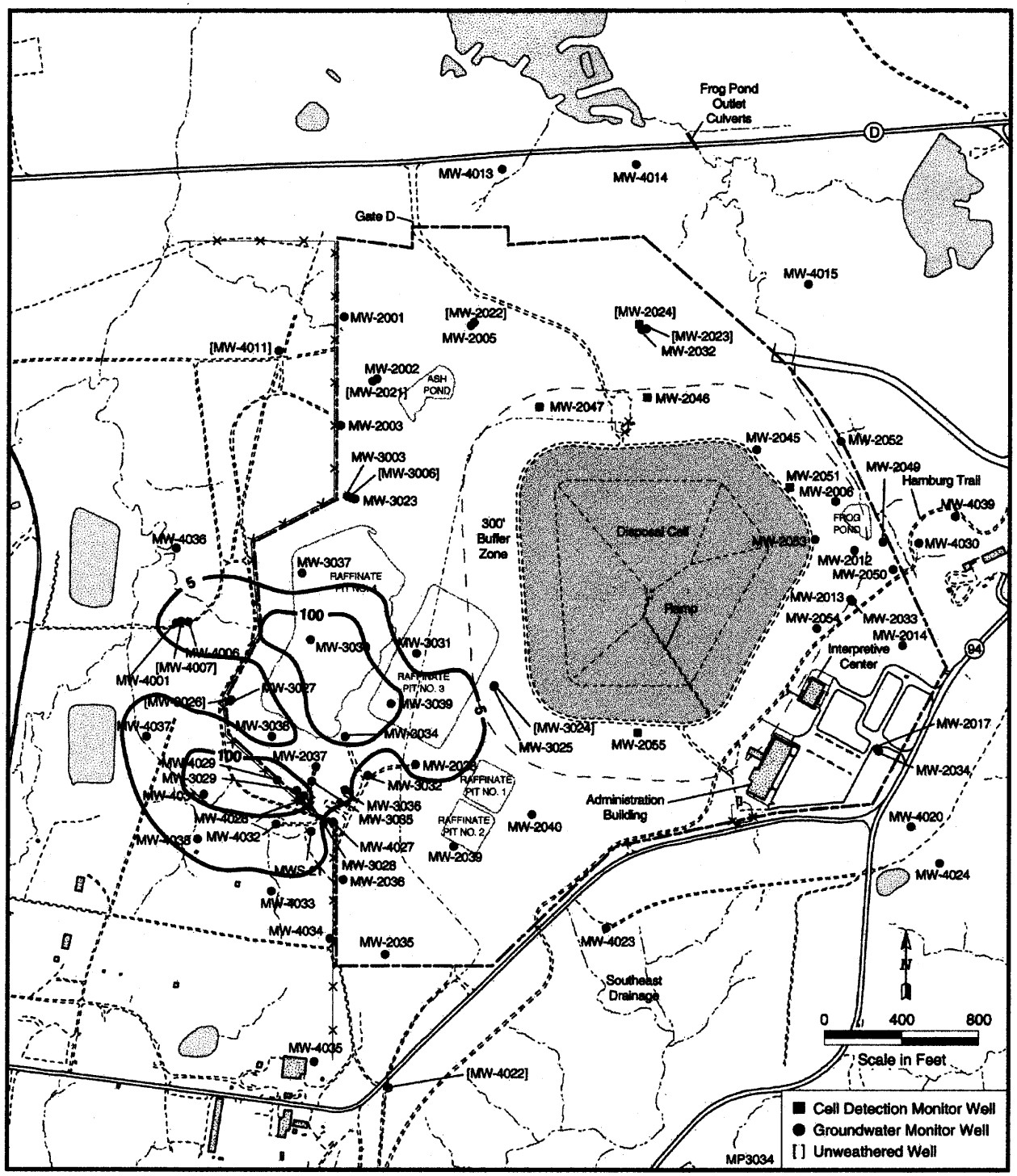


FIGURE 2.4 TCE Contamination Contour for 2002 at the Chemical Plant Area

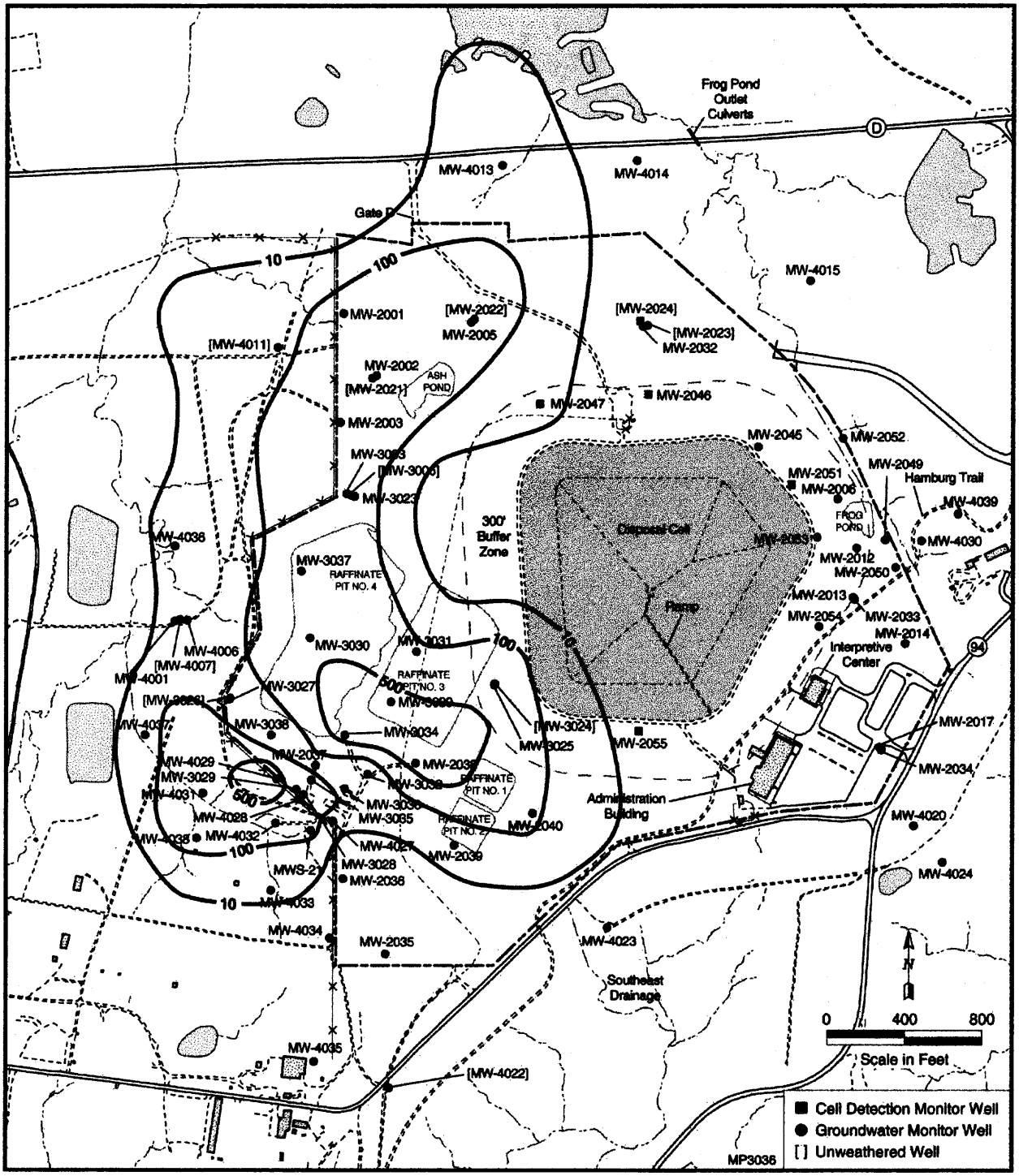


FIGURE 2.5 Nitrate Contamination Contour for 2002 at the Chemical Plant Area

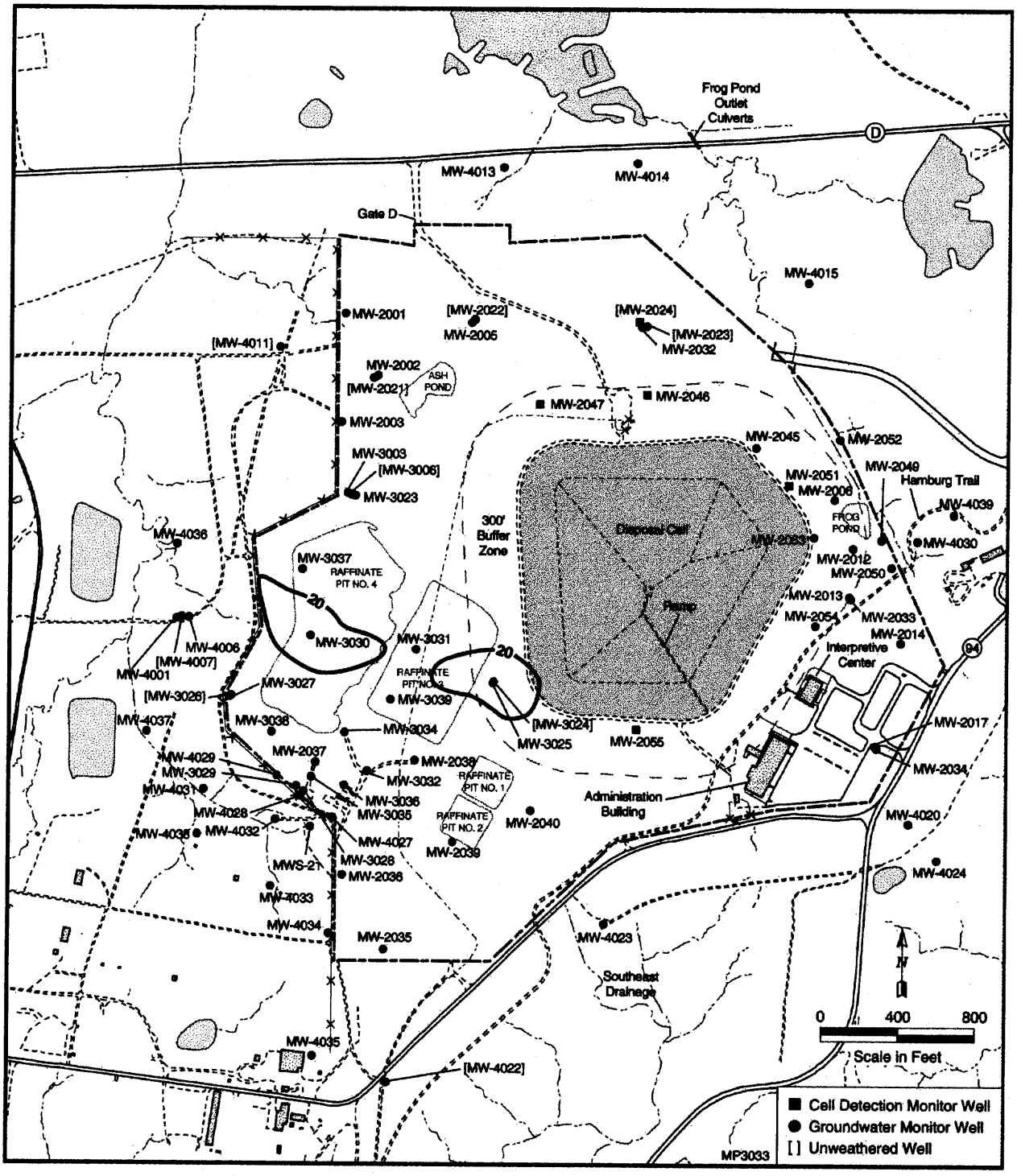


FIGURE 2.6 Uranium Contamination Contour for 2002 at the Chemical Plant Area

Figures 2.7 through 2.10 depict the contamination contours for 2.4-DNT, 2,6-DNT, 1,3,5-TNB, and 2,4,6-TNT. The depictions are based on concentrations for 2002 that exceed the State of Missouri Water Quality Standard or risk-based concentrations (RBCs) for these compounds. These concentrations are 0.11 μg/L, 0.13 μg/L, 1.8 μg/L, and 2.8 μg/L, respectively. In 2002, exceedances for 2,4-DNT, 2,6-DNT, 1,3,5-TNB, and 2,4,6-TNT were reported in 23, 32, 15, and 3 wells, respectively.

Contamination contour figures for 1,3-DNB and NB are not presented; the State of Missouri Water Quality Standards for these compounds (1.0 μg/L and 17 μg/L, respectively) were exceeded only for data reported for MW-2012. In addition, no exceedances have been observed previous to 2002 for these compounds.

2.2.2 Springwater

The primary contaminants in the springwater at surface springs around the Chemical Plant area are uranium, nitrate, and nitroaromatic compounds. Low levels of TCE have only been detected in one spring, SP 6303. Concentrations have been less than 2 μg/L. Elevated levels of uranium and nitrate have been routinely detected at Burgermeister Spring (6300 drainage). This spring is a primary discharge point for groundwater originating north of the groundwater divide at the Chemical Plant area.

Nitrate concentrations at Burgermeister Spring vary with changes in flow rate, but are generally lower than concentrations measured in groundwater. Lower concentrations occur during high flow rates because of dilution. Data from 1998 to 2002 for nitrate indicate a range of 1.1 to 49 mg/L; the maximum concentration reported for 2002 is 11 mg/L.

Uranium concentrations at Burgermeister Spring sampled during higher flow rates have been reported at slightly higher levels than in groundwater because of residuals in the fractured zones. Data from 1998 to 2002 for total uranium range from 1.0 to 154 pCi/L. The historical maximum uranium concentration measured at Burgermeister Spring is 240 pCi/L. The range reported for 2002 is 9 to 100 pCi/L.

Elevated uranium concentrations have also been measured in the Southeast Drainage perennial springs (SP-5303, SP-5304). The historical maximum uranium concentration at these springs is 370 pCi/L; data for 2002 ranged from 0.3 to 145 pCi/L. The most recent data reported (as of 2002) for nitroaromatic compounds in these springs are as follows: 2,6-DNT at 0.41 μg/L, 1,3,5-TNB at 0.5 μg/L, and NB at 0.11 μg/L; 2,4-DNT was not detected.

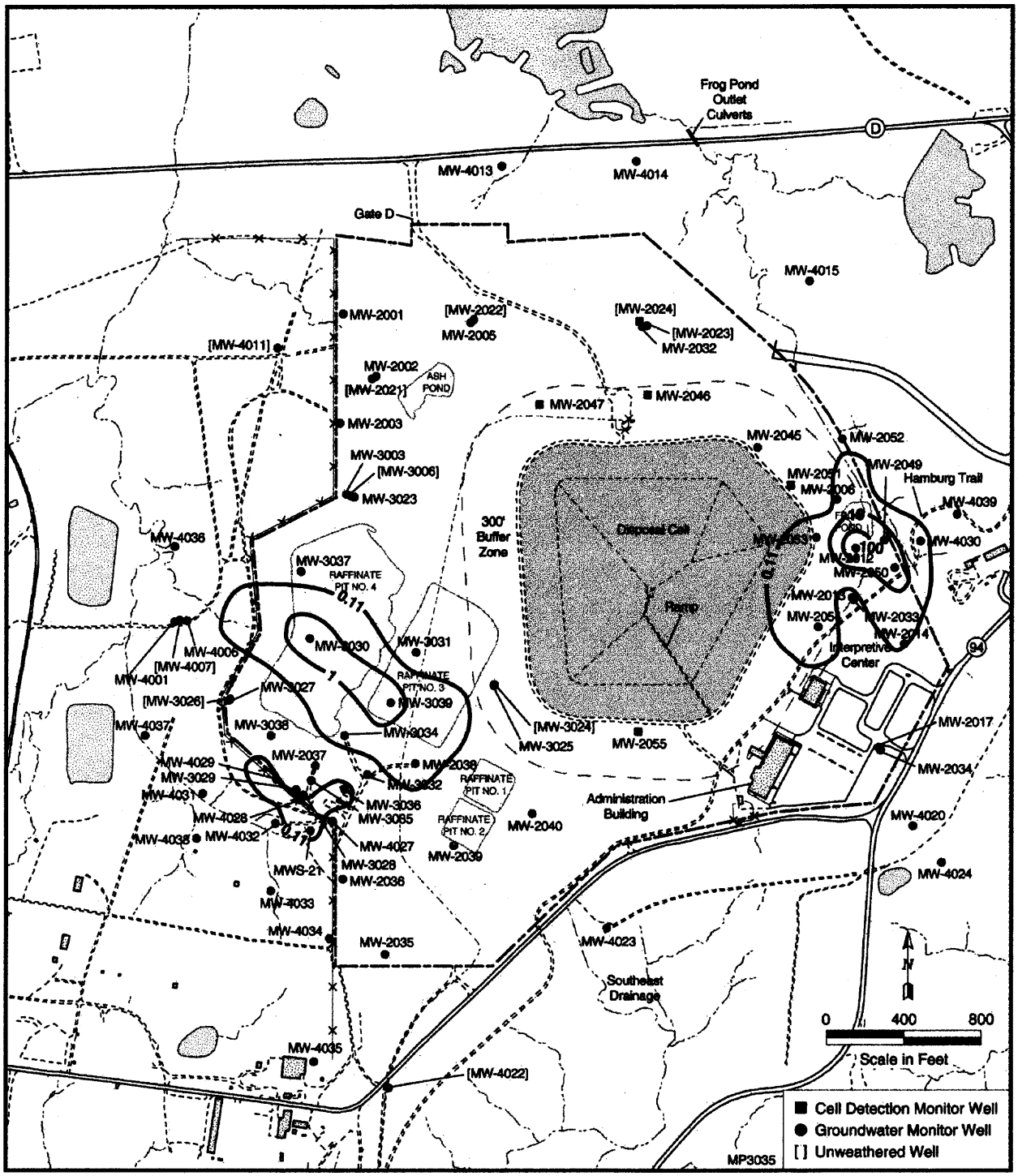


FIGURE 2.7 2,4-DNT Contamination Contour for 2002 at the Chemical Plant Area

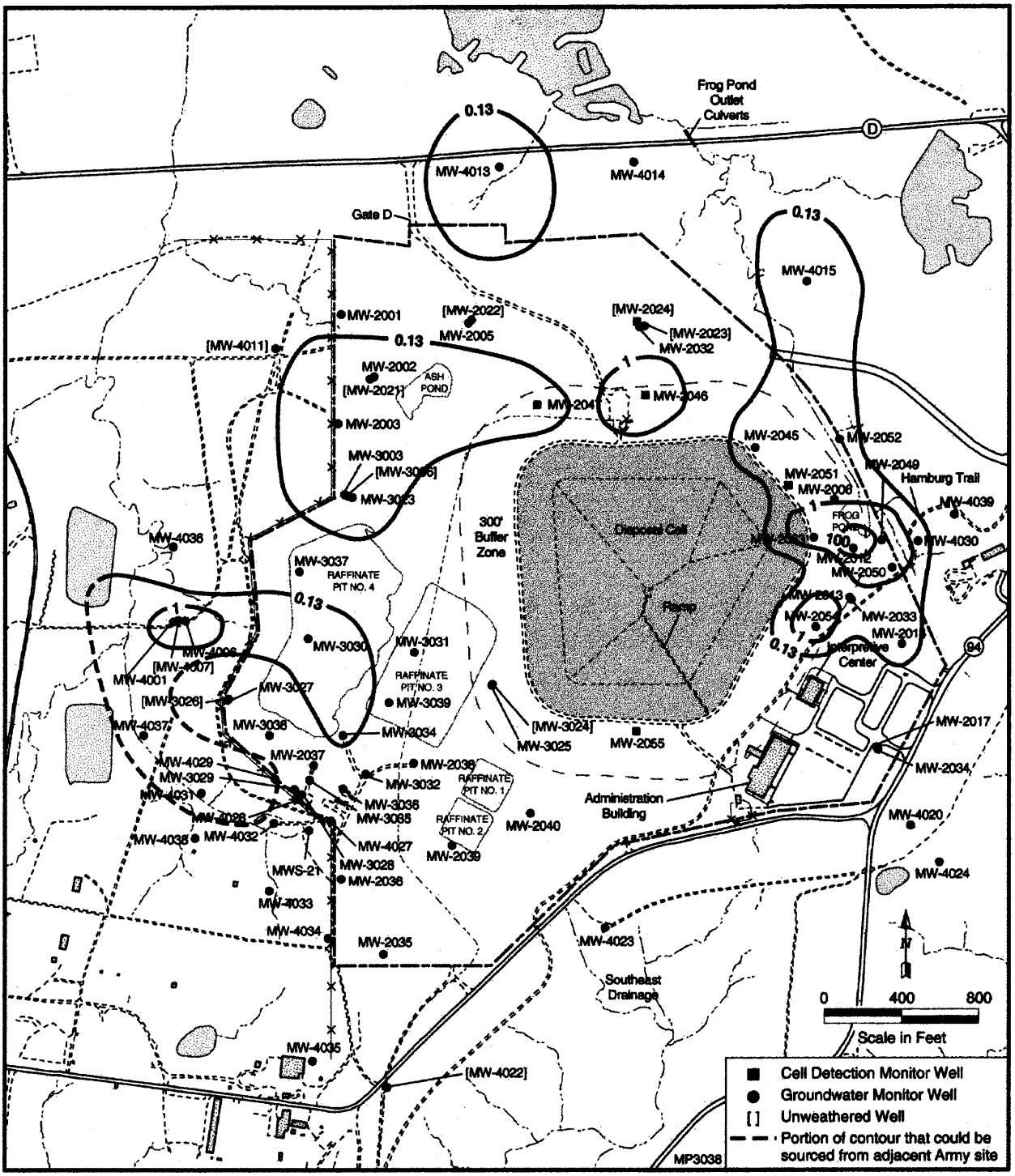


FIGURE 2.8 2,6-DNT Contamination Contour for 2002 at the Chemical Plant Area

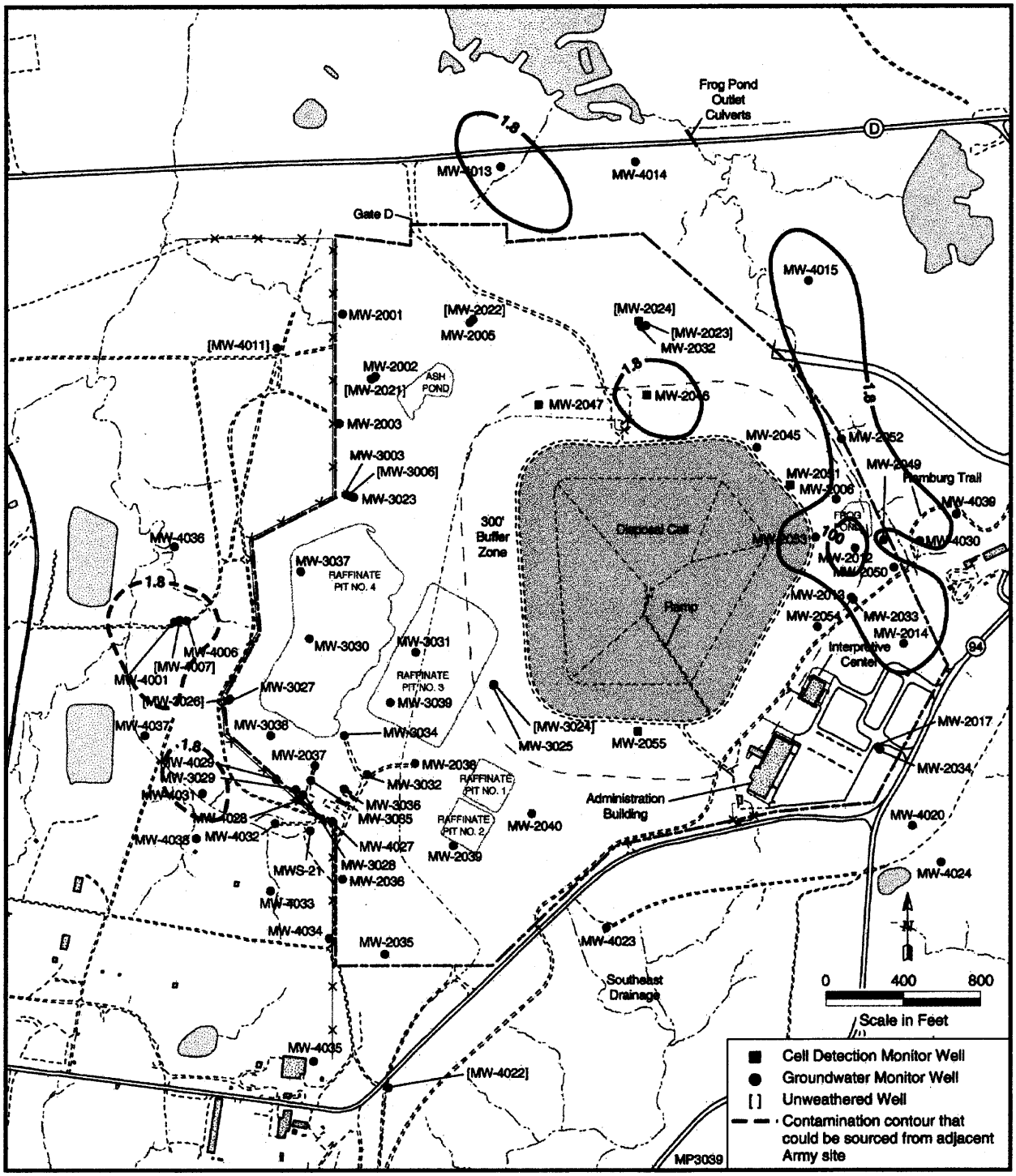


FIGURE 2.9 1,3,5-TNB Contamination Contour for 2002 at the Chemical Plant Area

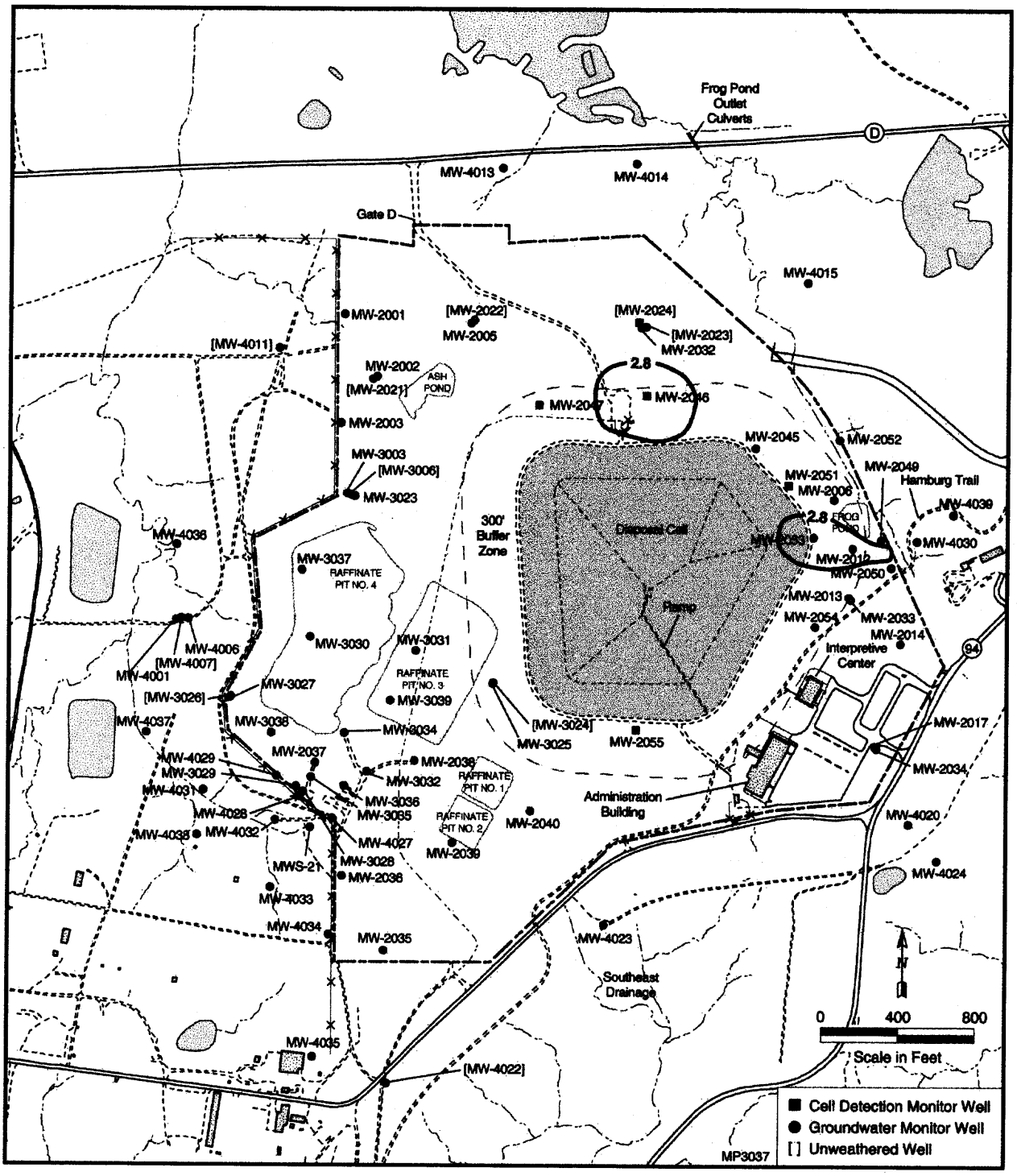


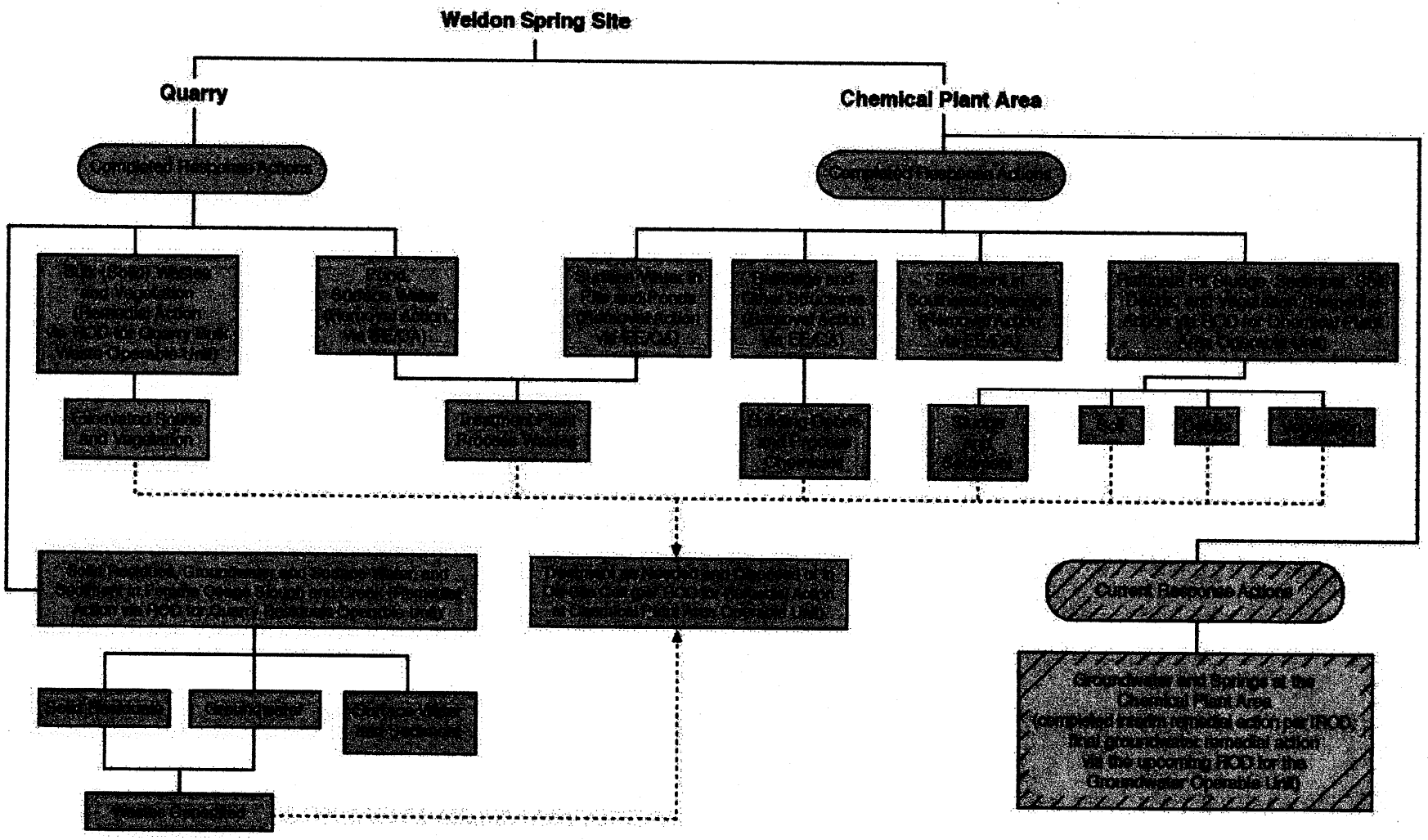
FIGURE 2.10 2,4,6-TNT Contamination Contour for 2002 at the Chemical Plant Area

3 SCOPE AND ROLE OF THE PROPOSED ACTION

This proposed remedial action constitutes the final component of the phased cleanup process implemented at the Weldon Spring site (Figure 3.1). The groundwater operable unit (GWOU) that is the subject of this PP constitutes the fourth operable unit in the overall cleanup scheme established for the Weldon Spring site. The first three operable units addressed contaminated bulk waste at the quarry; contaminated soil and structures located at the Chemical Plant; and remaining or residual contamination at the quarry area, including contaminated groundwater, respectively.

The proposed action contained in this plan is intended to address all of the COCs (TCE, nitrate, uranium, and nitroaromatic compounds) for groundwater and springwater at the Chemical Plant area. The remedial action stipulated in the ROD for the Chemical Plant approved in 1993 (DOE 1993) provided for the removal of the sources of contamination to groundwater. That is, contaminated soil has been excavated, buildings and structures have been dismantled, and Raffinate Pits surface water and sludge have been removed, dredged, and treated. All wastes have been disposed in the on-site disposal cell.

The RI/FS documents that included a PP developed for the GWOU were released to the public in 1999. That PP identified a proposed action of active remediation of the TCE and long-term monitoring for the other COCs. On the basis of comments received from the Missouri Department of Natural Resources (MDNR) and members of the public expressing concern that the proposal included active treatment for TCE only and not for all COCs, DOE decided to postpone the final groundwater decision until further field studies could be conducted to re-examine the effectiveness and practicality of further active remediation of the other COCs, but to move forward with the treatment of TCE. Consequently, an interim Record of Decision (IROD) was signed in September of 2000. The IROD stipulated in-situ chemical oxidation (ICO) of the TCE in groundwater at the Chemical Plant area. The scope of work identified in the IROD was conducted in 2002. The additional field studies were conducted in 2001. The results from these two activities have been incorporated into the proposed action presented in this plan (see Sections 6.3 and 7).



Note: The boxes represent contaminated media addressed by the project's cleanup actions for the chemical plant area and the quarry; they are connected by solid lines to the appropriate phase of site cleanup. Dashed lines identify wastes generated as a result of the completed response actions and that were treated and disposed of in the on-site cell at the chemical plant area. Boxes with cross-hatching constitute contaminated media that are being addressed as part of the GWOU and this PP. The GWOU is the final of four operable units for the Weldon Spring site.

MPA5801

FIGURE 3.1 Remediation Components for the Weldon Spring Site

4 SUMMARY OF RISKS

As part of the RI/FS, potential risks to human health and the environment from groundwater and springwater contamination were evaluated for the Chemical Plant area on the basis of current and likely future land uses. Foreseeable future land use at the Chemical Plant and surrounding area is likely to be recreational, which is the same as current land use. Portions of the adjacent Army site are currently used for field training and outdoor drilling by the U.S. Army Reserve, the Missouri Army National Guard, and other military and police units. The Army intends to continue using the training area for similar training activities in the future.

4.1 HUMAN HEALTH RISK ASSESSMENT

Consistent with CERCLA, potential human health risks were estimated with reference to current and likely foreseeable future recreational users. The Army reservists scenario was not evaluated because no active springs are located in the Army training area and municipal water is available at the tap. The potential risk to a reservist who might venture outside the training area and potentially drink springwater is covered by the calculations performed for the recreational visitor scenario. That is, the exposure assumptions (e.g., frequency and duration) for the Army reservist scenario would be equivalent to those assumed for the recreational visitor scenario. The assessment presented in the BRA (DOE and DA 1997a) also included risk estimates for a hypothetical future resident exposed to groundwater contaminants. Similar calculations have been performed to evaluate more recent (post-BRA) data to support this PP. Potential cancer and non-cancer risks for the recreational visitor and hypothetical resident scenarios posed by exposure to radiation and chemicals were assessed by using standard methods developed by the EPA and other agencies.

For cancer risks, the EPA has established an acceptable risk range of 1 in 1 million to 1 in 10,000 (EPA 1990); this means that contaminant concentrations at a site that result in increased likelihood of an individual developing cancer at 1 chance in 1 million to 1 chance in 10,000 would be considered acceptable. In addition, to put this risk range in context, it is estimated that about one in three Americans will develop cancer during their lifetime from all sources (American Cancer Society 2003), and that the risk of developing cancer from exposure to radiation naturally present in the environment (primarily from radon) is about 1 in 100 (EPA 1989). Thus, the acceptable range is a very small percentage of the cancer risk expected in the general U.S. population from everyday exposures.

Potential health effects other than cancer could also result from exposure to contaminants and were also assessed. The quantitative measure of noncarcinogenic health effects is the hazard index. The EPA has defined a hazard index of greater than 1 as indicating possible adverse noncarcinogenic health effects.

EPA guidance (EPA 1991) further provides that where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 1 chance in 10,000 and the noncarcinogenic hazard index is less than 1, action generally is not warranted unless there are adverse environmental impacts or if MCLs are exceeded.

Risk evaluations for the Chemical Plant area assumed that the most likely receptor for site-related groundwater and springwater contamination is a recreational visitor having access to springwater only. However, calculations for a hypothetical resident scenario were performed to assume access to contaminants in groundwater. An exposure point concentration for each COC was determined using the 95% upper confidence limit of the arithmetic mean from each monitoring well or spring. For the recreational visitor scenario, the assessment assumed conservatively that for 30 years the recreational visitor would visit the area 20 times a year for 4 hours each visit and each time ingest a cupful of springwater. For the hypothetical resident scenario, the assessment assumed ingestion of groundwater from each well for 350 days a year for 30 years, drinking 2 liters per day.

The human health risk assessment results presented in the BRA indicated that a recreational visitor ingesting springwater from any of the springs evaluated was not at increased risk for cancer or systemic toxicity due to site contaminants. The risk of developing radiation-induced cancer from uranium was estimated to range from 4 in 1 billion to 2 in 1 million. The estimated risk for developing chemical-induced cancer was similarly low and ranged from 2 in 10 billion to 3 in 10 million. These values are well within the acceptable risk range of 1 in 1 million to 1 in 10,000 recommended by the EPA (EPA 1990). The hazard indices estimated for a recreational visitor at the springs ranged from less than 0.001 to 0.2. Risk calculations based on more recent data (1998–2002) indicate slightly lower maximum risk levels and hazard indices for the recreational visitor scenario due to decreases in contaminant concentrations in the springs, particularly Burgermeister Spring (SP-6301).

The risk estimates presented in the BRA and those of more recent data for the hypothetical resident scenario indicate that groundwater contaminant concentrations in some of the monitoring wells could potentially result in human health risks greater than the acceptable risk range and a hazard index greater than 1.

On the basis of these risk assessment results, and the exceedances of MCLs in site groundwater that are discussed in Section 2, institutional controls to restrict use of groundwater and springwater in the Chemical Plant area have been incorporated into the proposed action described in Section 7. These restrictions would be applied to prevent use of groundwater and springwater (other than for purposes specified) throughout the remediation (natural attenuation) period (see Section 7).

4.2 ECOLOGICAL ASSESSMENT

The results of the ecological assessment indicate that contaminant concentrations in springwater and sediment pose little or no risk to ecological resources of the area, and that remediation from an ecological perspective is not needed.

Biotic surveys of macroinvertebrates, fish, and amphibians that inhabit the Burgermeister Spring drainage indicated no evidence of adverse effects. The spring was determined to contain generally good aquatic habitat, and the species present are typical of those found in similar habitats throughout the Midwest. Although the fish community was limited in diversity and the macroinvertebrate community was categorized as slightly impaired, the communities are likely affected by the physical nature of the spring and its drainage rather than by contaminant levels. Flow in the uppermost portion of Burgermeister Spring is maintained by groundwater discharge at the spring. Under low-flow conditions, as commonly occur in the summer, the stream drainage below the spring becomes intermittent, and portions of the habitat become dry. Surveys of amphibians found a community typical of similar habitats in the Midwest.

The results of toxicity testing of surface water and sediment indicate the potential for some toxicity to fish and macroinvertebrates from within Burgermeister Spring proper, but not downstream of the spring. However, the presence of apparently unaffected macroinvertebrate, fish, and amphibian communities in these locations suggests that local populations are tolerant of (or have adapted to) the contaminant levels present in surface water and sediment in the Burgermeister Spring drainage. Tissue analyses revealed relatively low levels of contaminant bioconcentration, all below levels of concern.

Modeling of contaminant uptake by the white-tailed deer and American robin drinking from Burgermeister Spring predicted very low levels of contaminant uptake by these species. No risk of harm was found to be caused by the modeled contaminant doses to land-based plants and animals drinking from Burgermeister Spring or other springs in the area.

An evaluation of the aquatic community in Burgermeister Spring indicate that this community is typical of similar habitats elsewhere in the Midwest and does not appear to be adversely affected by contaminant concentrations.

5 REMEDIAL ACTION OBJECTIVES FOR THE CHEMICAL PLANT GROUNDWATER

The evaluations presented in the RI (DOE and DA 1997b) and the BRA (DOE and DA 1997a), and review of more recent data indicate that contaminant concentrations in Chemical Plant area groundwater do not pose an unacceptable risk to the recreational visitor because there is no access to the groundwater under this scenario. In addition, contaminant concentrations at the surface springs are low and likewise do not pose unacceptable risk to the recreational visitor. However, concentrations of TCE, nitrate, uranium, 2,4-DNT, 1,3-DNB, and NB, exceed their respective drinking water or water quality standards and are at levels that could pose unacceptable risk for a hypothetical resident scenario.

Although groundwater at the Chemical Plant area is currently not used for residential purposes, this groundwater is considered potentially usable (EPA 1986; MK-Ferguson 1990). Therefore, restoration of this groundwater to beneficial use to include potential residential use was considered. To this end, alternatives that could reduce or remove contaminants were evaluated in the FS (DOE and DA 1998) and the Supplemental FS (DOE 1999a), in addition to those that provide verification of decreasing groundwater contaminant concentrations due to source removals stipulated in the Chemical Plant ROD (DOE 1993).

Preliminary remedial action objectives (RAOs) for the groundwater COCs have been identified as follows: (1) 5 μg/L for TCE based on the federal MCL for drinking water; (2) 10 mg/L for nitrate based on the federal MCL for drinking water; and (3) 20 pCi/L for uranium based on the recently promulgated federal MCL of 30 μg/L (the conversion to 20 pCi/L takes into account the isotopic ratios of uranium established for the Weldon Spring site); (4) 0.11 μg/L /L for 2,4-DNT, 1.0 μg/L for 1,3-DNB, and 17 μg/L for NB based on State of Missouri Water Quality Standards; and (5) risk-based concentrations (RBCs) for 2,6-DNT, 1,3,5-TNB, and 2,4,6-TNT at 0.13, 1.8, and 2.8 μg/L, respectively. The RBCs are concentrations estimated to be equivalent to either a hazard index of 1 or a risk of 1 in 1,000,000 for a hypothetical resident scenario. RAOs for TCE, nitrate, uranium, 2,4-DNT, 1,3-DNB, and NB would be chemical-specific ARARs in the upcoming ROD.

6 ANALYSIS OF ALTERNATIVES

Appropriate remedial action alternatives that eliminate, reduce, or control risks to human health and the environment were identified in the development of preliminary alternatives for the FS (DOE and DA 1998). A broad range of remediation technologies, both in-situ and ex-situ, was considered (see Figure 6.1). Seven of nine alternatives were analyzed in detail in the FS. These alternatives were considered in the context of follow-on activities after source removal and other control response actions have been implemented at the Chemical Plant area. An additional evaluation was performed for two of these alternatives as detailed in the Supplemental FS (DOE 1999a) prepared subsequent to the FS (DOE and DA 1998). The latter evaluation focused on monitored natural attenuation (MNA) and groundwater removal with treatment (pump-and-treat).

The alternatives that were evaluated in the FS and Supplemental FS are described and compared in Appendix A. These alternatives were (1) Alternative 1: No Action; (2) Alternative 2: Long-Term Monitoring; (3) Alternative 3: Monitored Natural Attenuation; (4) Alternative 4: Groundwater Removal and On-Site Treatment Using Granular Activated Carbon (GAC) and Ion Exchange; (5) Alternative 7: Removal and On-Site Treatment of Groundwater in the Vicinity of the Raffinate Pits; (6) Alternative 8: In-situ Treatment of TCE Using In-Well Vapor Stripping; and (7) Alternative 9: In-situ Chemical Oxidation (ICO) of TCE Using Fenton-Like Reagents. Alternatives 5 and 6 provided for groundwater removal with on-site treatment using ultra-violet oxidation and phytoremediation, respectively. These two alternatives were not evaluated further in the FS because Alternative 4 provides a similar action using a more established technology (i.e., GAC). The seven final alternatives were evaluated using the nine criteria stipulated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA 1990) as follows: (1) overall protection of human health and the environment; (2) compliance with applicable or relevant and appropriate requirements (ARARs), unless a waiver condition applies; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance.

These alternatives were considered in developing the PP (DOE 1999b) that supported the IROD of September 2000 and provided the basis for identifying the final proposed action presented in Section 7. The remedial action stipulated in the IROD was based on Alternative 9 above. However, a permanganate reagent was applied to achieve oxidation rather than Fenton-like reagents (see Section 6.1). The in-situ chemical treatment performed is discussed in Section 6.1. Additional field studies were also planned and implemented so that information could be obtained to further determine the effectiveness of the pump-and-treat option using less conventional techniques thought to enhance performance. Details of these field studies are discussed in Section 6.2. The results of the ICO and the information obtained from the additional field studies have been incorporated into the approach taken to identify a final groundwater decision (see Section 6.3).

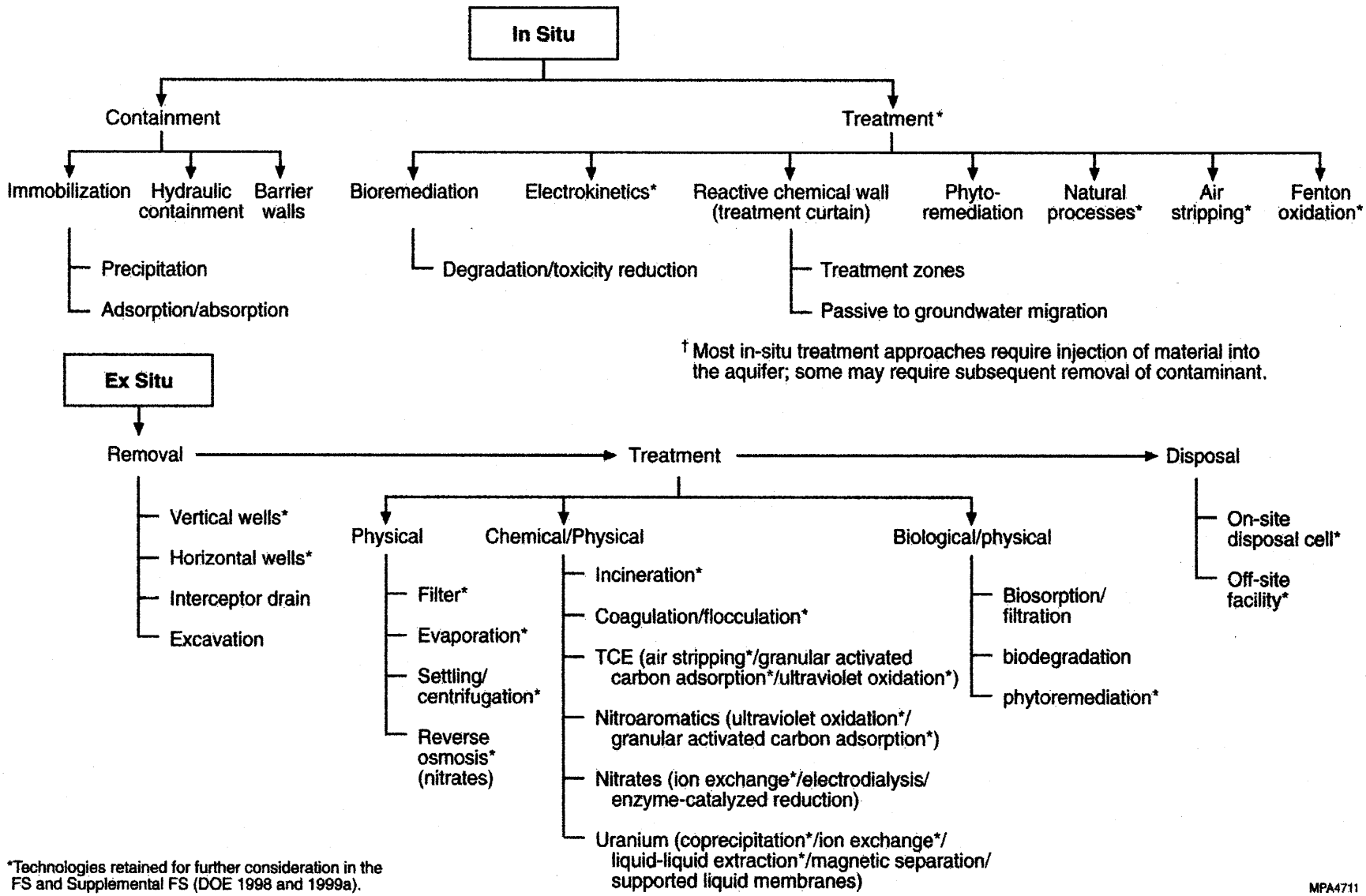


FIGURE 6.1 Technologies Considered for Groundwater Remediation at the Chemical Plant Area

6.1 IN-SITU CHEMICAL OXIDATION OF TCE IMPLEMENTED IN 2002

ICO was selected because it offered the greatest potential for rapid reduction of TCE, was cost effective, and had greater potential for success in comparison to pump-and-treat options. The IROD likewise recognized the uncertainties associated with the complex hydrogeology of the site that would likely affect the effectiveness and implementability of the ICO process.

To implement the remedial action, DOE procured bench-scale tests by several vendors to demonstrate the effectiveness of ICO in treating TCE at the site and to evaluate all of the ICO processes. On the basis of the results of these initial tests, proposals were solicited to conduct the remedial action stipulated in the IROD. However, the development of the design to achieve full treatment of TCE throughout the plume was not possible at the outset due to uncertainties associated with the hydrogeology of the site that influenced design elements such as actual spacing of the injection wells, the zone of influence of these wells, and the amount of oxidants needed to be injected to achieve the reduction of TCE. Consequently, a phased approach was taken to allow for a pilot-scale test to be performed before decisions could be made regarding full implementation.

The pilot-scale ICO appears to have achieved reduction of TCE in the area of influence. The sodium permanganate solution was distributed to a distance of about 30 m (100 ft) from the injection point with the dispersion of the sodium permanganate favoring a downgradient direction toward the paleochannel features of the site. Uniform distribution of the injected chemicals was not achieved. The pilot-scale ICO also indicated that the injection volume at each injection point that would be required to achieve a radius of influence greater than 30 m (100 ft) could average 20,000 gallons of the sodium permanganate solution. This volume is 20 times greater than that estimated based on the results of the bench-scale testing and 5 times greater than that used during the first injection of the pilot scale ICO.

In addition, increased chromium, mercury, silver, and manganese concentrations were observed in areas where sodium permanganate appeared. Although the metal concentrations are expected to decrease in proportion to the disappearance of the sodium permanganate solution injected, insufficient data are available to verify this expectation. Sodium permanganate is still present at some locations 1 year after the completion of the pilot-scale ICO. Sodium permanganate treatment did not affect uranium or nitrate concentrations at the site.

The results of the pilot-scale ICO could not be directly applied to the whole TCE area because of the nonuniform, heterogeneous nature of the site hydrogeology. The study was designed to perform the field tests at two locations within the impacted area; the first at the lowest conductivity area and high TCE concentrations, and the second at the highest conductivity area and high TCE concentrations. However, this may not have been achieved during implementation, as other areas with lower conductivities and TCE concentrations that exceed the MCL are known to be present. Consequently, uncertainties associated with defining the zone of influence of the injection points and the volume of oxidants needed to achieve the required reduction of TCE across the impacted area would still have to be addressed in designing a full-scale remediation effort. It was envisioned in the IROD that two sets of wells and two injections

would achieve the MCL (these specifications were based on the understanding of the site and the knowledge regarding the innovative nature of the ICO technology at the time). But preliminary remedial designs based on the results of the pilot-scale indicated that at least 20 times as many injection wells would be needed and therefore, 20 times as much volume of the oxidant would need to be injected for a full scale implementation. These estimates constitute the amounts needed at the initial phase of the implementation with possible additional injection wells and a greater volume of oxidants needed to attain the MCL. The limitations imposed by site hydrogeology on the design for full-scale implementation, the concern regarding potentially large increase in metals concentrations in groundwater associated with a large volume of injection, and the persistence of the chemical in the aquifer were primary factors in the overall decision not to go forward with full-scale implementation of ICO.

6.2 ADDITIONAL FIELD STUDIES CONDUCTED IN 2001

Groundwater field studies were conducted to obtain data to determine whether using artificial recharge in conjunction with groundwater extraction, or the use of an angled well for extraction could significantly improve contaminant removal rates as compared to a conventional system (extraction using a vertical well with no artificial recharge). Variations that were evaluated included the injection of water to provide additional recharge to the aquifer and the use of an angled extraction well to increase the likelihood of intersecting any vertical flow paths in the subsurface.

The results of the field studies conducted in 2001 indicate that the modifications to conventional pump-and-treat that were implemented did not increase the mass of contaminants removed as compared with a conventional vertical well system with no artificial recharge (MK-Ferguson 2002). Consequently, the amount of water extracted from the area due to artificial recharge would not reduce the remediation time frames for TCE, nitrate, uranium, or nitroaromatic compounds. Another modification, the use of an angled well, likewise failed to produce results comparable to the vertical extraction well. These results reflect the difficulty involved in siting productive wells in the complex geology of the site.

The hydrogeologic data obtained from these studies are consistent with the data collected during the previous study performed in 1998. The results from these two field studies support the conceptual model, which is that the sustainable yields are low and recharge of the aquifer is very slow as indicated by the recovery of the monitoring wells. Continuous pumping would result in localized dewatering in the vicinity of the extraction well. Cycles of pumping could be performed but due to the slow recharge of the aquifer, periods between active pumping would be long.

The distribution of the contaminants did not change as a result of the field studies, with the exception of significant dilution in the vicinity of the injection wells. The majority of the wells returned to baseline concentrations or were showing increasing trends at the end of the monitoring period, which could be attributed to several mechanisms. One mechanism may be the slow transport of upgradient contaminated groundwater into the study area because of the low hydraulic gradient across the Chemical Plant area. Another mechanism may be the diffusion of

contaminants from poorly connected or dead-end fractures and solution features into the more transmissive portions of the aquifer (i.e., paleochannels). Either scenario would indicate that the majority of the contaminated groundwater removed was from the interconnected secondary porosity features (likely paleochannels). This would indicate that extracting the water from the more transmissive portions of the shallow aquifer would effectively remediate the groundwater in this area, and that desorption and/or slower groundwater movement from the lower conductivity portions of the aquifer would control the remediation time frames.

6.3 APPROACH FOR IDENTIFYING A FINAL GROUNDWATER DECISION

The results discussed in Sections 6.1 and 6.2 were incorporated into the evaluation for identifying a final groundwater remediation strategy for the Chemical Plant area. Overall, the results indicate that while ICO resulted in reduction of TCE concentrations within the area of influence, it may not be effective in reducing TCE concentrations to 5 μg /L or below throughout the plume. That is, the complex hydrogeology of the site contributes to limiting the overall performance and effectiveness of the technology. On the basis of the field studies conducted in 2001 and previously conducted studies in 1998, the effectiveness of a conventional or enhanced pump-and-treat option is similarly limited by the complexities of the site hydrogeology.

A review of currently available technologies was also conducted to determine if any recently (post FS and Supplemental FS) developed technologies should be considered in addition to those evaluated in the FS and Supplemental FS. It was determined that the set of technologies (see Figure 6.1) and alternatives previously evaluated is still representative of what is currently available for addressing the groundwater COCs at the Chemical Plant area.

In light of the results obtained from the ICO process that was implemented and the results of the additional field studies, the DOE, in consultation with the EPA and the State of Missouri, decided to reevaluate MNA (previously evaluated as Alternative 3) as an alternative. The reevaluation of the effectiveness of MNA focused on revising calculations of the time frames that predict how long it takes to reduce COC concentrations to MCLs, and a determination of how suitable site conditions are for selecting MNA on the basis of recommended criteria presented in EPA guidance. The input parameters and the results of revised calculations for predicted time frames are presented in Appendix B, and the comparison of site conditions to EPA guidance (EPA 1999) is presented in Table 6.1.

The results of the revised calculations (see Appendix B) indicated time frames of about 100 years to achieve ARARs for TCE, uranium, nitrate, 2,4-DNT, 1,3,-DNB, and NB. These results indicate much shorter time frames than those previously presented in the Supplemental FS. The upper 95% limit of the arithmetic mean of the hydraulic conductivities within the plume contours was used in the revised calculations to account for high permeability regions associated with paleochannel features at the site. This approach resulted in higher hydraulic conductivities than those used for the calculations presented in the Supplemental FS, and is the primary reason for the shorter time frames obtained from the revised calculations. The shorter time frames predicted are also due to currently lower contaminant concentrations reflecting source removals and the on-going effects of natural attenuation processes that are occurring.

The comparison to EPA guidance for MNA indicates that site conditions are suitable for selecting MNA as a remedial option. Site conditions that include completed source removal (including reduction of TCE in parts of the plume via the ICO process that was implemented), generally decreasing trends in contaminant concentrations, currently protective conditions to human health and the environment, and relatively stable contaminant plumes indicate that MNA is an appropriate response option.

In summary, the MNA alternative is being considered for the following reasons: (1) it allows for monitoring to verify the decreases in contaminant concentrations that are expected due to source removals and from continued effects of the natural attenuation processes; predicted time frames are deemed reasonable; (2) it allows for data to be obtained so that continued protection to human health and the environment can be maintained; (3) institutional controls can be readily implemented to assure that protection of human health is maintained over the natural attenuation time period; (4) it allows for the development and implementation of contingency measures, as appropriate; and (5) ARARs can be met within a reasonable time frame thus avoiding the need to invoke ARAR waivers.

TABLE 6.1 Site Characteristics Suitable for Selecting MNA

Desirable Site Characteristics for MNA (as identified in EPA guidance)	Chemical Plant area Groundwater Characteristics
Source removal completed. Some TCE reduction achieved by ICO process implemented.	Contaminated soil and structures have been remediated. Selecting MNA as the action for the GWOU can be considered as the follow-on action to the active remedial action completed for the Chemical Plant soil and structures.
Physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants.	Dispersion/dilution processes are occurring to reduce contaminant concentrations with time. The contaminated shallow aquifer is recharged by infiltrating rainwater and runoff.
Relatively low exceedances of contaminant concentrations as compared with chemical-specific ARARs (MCLs) and risk-based concentrations.	With some exceptions, current contaminant concentrations are relatively low as indicated by plume contours.
Chemical-specific ARARs can be met within a reasonable time frame.	Estimates of cleanup times for MNA indicate chemical-specific ARARs for uranium, nitrate, TCE, and 2,4-DNT can be met in about 100 years.
Groundwater is not currently used and future use is not likely.	The area includes state-owned and federally – owned land and is currently used for recreational purposes. Portions of the adjacent Army site are also used for training by Army reservists, however, municipal water is available at the tap at this training area. Nearby residential areas, including subdivisions, currently utilize county water. Future use would be prevented via the implementation of real estate agreements with property owners (e.g., Missouri Department of Conservation [MDC], etc.) until ARARs are met.
Implementation of performance monitoring to gauge effectiveness and protect human health and the environment.	Triggers (e.g., when, where, and how) would be established that signal unacceptable performance of MNA at the site.
Need to incorporate contingency planning to support proposed action of MNA.	Contingency activities would be identified as part of the proposed action because cleanup times for meeting ARARs under MNA were based on predictive analysis. These activities include active hot spot remediation of TCE, reevaluation and modification of institutional controls, modification of monitoring under the Long Term Stewardship Plan, and Five-Year Reviews to optimize the MNA approach.

7 PROPOSED ACTION

The DOE is proposing the following action to address groundwater contamination at the Weldon Spring Site Chemical Plant area: MNA supported by performance monitoring, with implementation of institutional controls (ICs) and identification of appropriate contingency activities.

7.1 DESCRIPTION OF THE PROPOSED ACTION

The proposed action relies on the natural attenuation processes of dilution and dispersion that are occurring at the site (there is little evidence of biodegradation occurring based on data evaluated for the site). Performance monitoring would be conducted to evaluate attainment of established performance goals and remedial action objectives, including ARARs. The goals for monitoring include the following: (1) that natural attenuation of COCs is occurring as expected (not to exceed concentrations would be established as part of this goal); (2) that COC plumes are not migrating unexpectedly; (3) that TCE is not present at locations where human exposure could occur and that the other COCs are not present at concentrations that are not protective per land use (e.g., recreational scenario at Burgermeister Spring); (4) performance of upgradient monitoring; and (5) demonstration of hydrologic stability. Additional goals for monitoring TCE are to delineate the vertical extent of contamination and to monitor for rebound in TCE concentrations in the area where in-situ chemical oxidation was implemented in 2002 as stipulated in the IROD.

Institutional controls addressing the area from the former Chemical Plant to the Burgermeister Spring and the Southeast Drainage would be implemented to ensure that groundwater use is restricted. Figure 7.1 depicts the proposed area where institutional controls would be implemented. Current plans include drafting a real estate restriction preventing access to groundwater for use except for investigation purposes. Routine inspections would be performed to look for indications of groundwater withdrawal or use.

Contingency measures triggered by established events and observed contaminant concentrations would also be developed as part of this proposed action. These activities include (1) reevaluation of contaminant data; (2) resampling; (3) increasing the sampling frequency; (4) revising MNA predictions; (5) revising institutional controls; and (6) conducting an active contingency response action for TCE (expected to be similar in scope to the ICO process implemented for the IROD, as appropriate).

Five-year reviews would be conducted as groundwater contaminant concentrations would remain at levels that do not allow for unlimited use and unrestricted exposure. Table 6.1 identifies characteristics of a site where selecting MNA as a remedial action may be suitable as given in EPA's guidance for MNA. Chemical Plant area groundwater conditions or characteristics that are suitable for MNA are also presented for comparison.

Appendix C presents specific monitoring activities for the COCs consistent with this proposed action. These monitoring strategies are being developed with the EPA and the State of Missouri and are based on the concept of providing trigger locations, trigger events and trigger concentrations that invoke increase in sampling frequency, reevaluation of predicted MNA time frames, and reevaluation of ICs as described above. The contingencies for the COCs other than TCE would not include active remediation.

7.2 COMPARISON TO NCP CRITERIA

The evaluation of the proposed action against the nine criteria indicate that the proposed action provides overall protection of human health and the environment, would meet ARARs within a reasonable time frame, and is cost effective. The EPA and the MDNR have indicated a favorable response to the proposed action described in this report. Table 7.1 provides an analysis of the evaluation of the proposed action and the nine criteria given in the NCP.

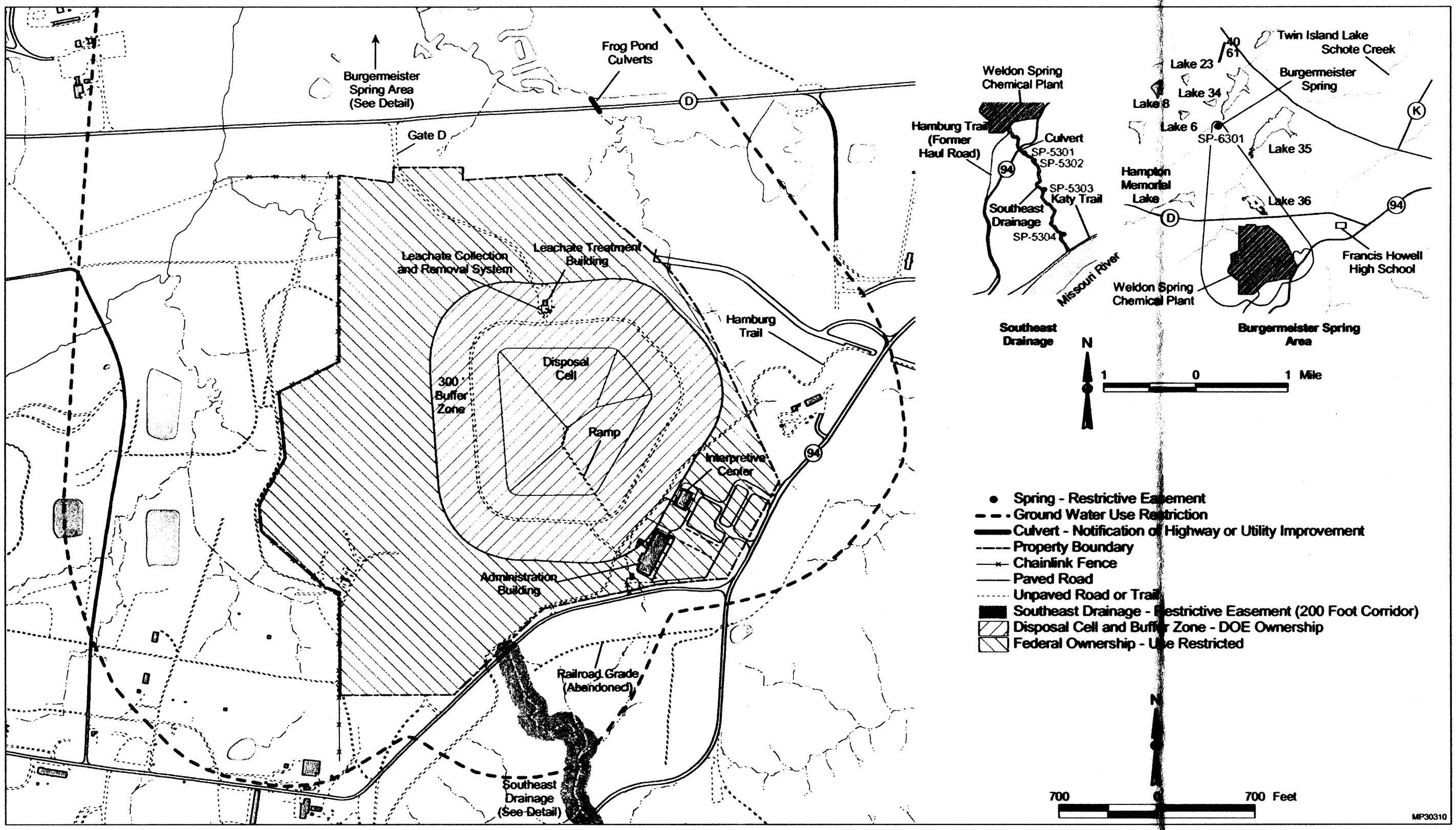


FIGURE 7.1 Institutional Controls Location Map for the Chemical Plant Area (Figure excerpted from Draft LTSP dated August 2002)

TABLE 7.1 Analysis of DOE's Proposed Action Using the Nine Criteria

Criteria	Proposed Action
Overall protection of human health and environment [Addresses whether the alternative provides adequate protection of human health and the environment. Evaluation focuses on a specific alternative's ability to achieve adequate protection and describes how site risks posed by each pathway are eliminated, reduced, or controlled through natural processes, treatment, engineering, or institutional controls. This evaluation also allows for consideration of any unacceptable short-term impacts associated with each alternative. Because of its broad scope, this criterion also reflects the focus of criteria 2 through 5.]	Provides adequate protection of human health and the environment. Current land use does not include groundwater use. Future land use is likely to remain the same as current; however, institutional controls would be implemented to ensure conditions remain protective until chemical-specific ARARs are met. Monitoring data would be collected to verify that plumes have not expanded to areas previously not contaminated or to areas with potential receptors. These data would determine if concentrations are decreasing as predicted. Contingencies have been incorporated into the remedy to assure that occurrences different from those expected can be mitigated to prevent any potential unacceptable exposure.
Compliance with ARARs [Addresses whether all applicable or relevant and appropriate state federal laws and regulations are met. Evaluation focuses on whether each alternative will meet federal and state ARARs or whether there is justification for an ARAR waiver.]	Chemical-specific ARARs for uranium, nitrate, TCE, 2,4-DNT, 1,3-DNB, and NB are expected to be met in about 100 years. This time frame is considered reasonable based on the following factors: recreational land use projected for the long-term; complex site hydrogeology that reduces the effectiveness of other remediation technologies and increases the cleanup times; and low well yields.
Long-term effectiveness and permanence [Addresses the risk remaining at the operable units after remediation goals have been met. Evaluation focuses on the ability of the alternative to maintain reliable protection of human health and the environment over time, once these goals have been met.]	The proposed action provides long-term effectiveness and permanence after ARARs are met because contaminant concentrations would be at levels equal to or lower than the chemical-specific ARARs for uranium, nitrate, TCE, 2,4-DNT, 1,3-DNB, and NB. In addition, since source removal has been completed, concentrations are expected to remain protective after ARARs are met.
Reduction of toxicity, mobility, or volume [Addresses the statutory preference for selecting an alternative that permanently and significantly reduces the toxicity, mobility, or volume of hazardous substances at a site. Evaluation focuses on the extent to which this is achieved by the alternative.]	While there is no active process implemented to reduce the toxicity, mobility, or volume, the predicted decrease in contaminant concentrations by natural processes would result in the reduction of the hazard associated with contaminated groundwater at the site.
Short-term effectiveness [Addresses the potential impacts to workers, the general public, and the environment during implementation of the alternative.]	Potential impacts are expected to be low, with less than one case of occupational injury and no occupational fatalities during construction of new wells or abandonment of old wells, as necessary.

TABLE 7.1 (Cont.)

Criteria	Proposed Action
Implementability [Addresses technical and administrative feasibility, including the availability and reliability of resources or materials required during implementation, and the need to coordinate with other agencies.]	Performance monitoring can be implemented using conventional and readily available methods. Institutional controls in the form of real estate agreements can be obtained. Approaches or methods or tools for the identified contingency activities should be available and can be readily implemented.
Cost [Addresses both capital costs and annual operation and maintenance (O&M) costs, as well as the combined net present worth of the alternative.]	Capital costs are estimated to be about $120,000. Annual O&M costs are estimated to be about $200,000.
Community acceptance [Assesses the community's apparent preference for, or concerns about, the alternative being considered. This criterion will be addressed in the responsiveness summary and the ROD that will be prepared following the pubic comment period.]	A public comment period that includes a public meeting will be held in order to provide the public the opportunity to review the proposed action and voice any concerns or preferences.

8 COMMUNITY PARTICIPATION

Comments on all the alternatives evaluated and the proposed remedial action will be received during the public review period from June xx through July xx, 2003. Oral comments will be received at a public meeting to be held (during the week of June xxx) for this action. Written comments may either be submitted at the public meeting or mailed before the close of the comment period to:

Pamela Thompson, Site Manager
U.S. Department of Energy
Weldon Spring Site Remedial Action Project
7295 Highway 94 South
St. Charles, MO 63304
pthompson@wssrap.com

Information relevant to the proposed remedial action is included in the Administrative Record that is located at the site and can be accessed via the web at www.gjo.doe.gov/programs/ltsm. The following RI/FS documents prepared to support the GWOU and this PP are included in the Administrative Record:

1. U.S. Department of Energy and U.S. Department of the Army, 1997, *Baseline Risk Assessment for the Groundwater Operable Units at the Chemical Plant area and the Ordnance Works Area, Weldon Spring, Missouri*, DOE/OR/21548-568, prepared by Argonne National Laboratory, Argonne, IL, for U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, and U.S. Department of the Army, Corps of Engineers, Kansas City District, Kansas City, MO, July.

2. U.S. Department of Energy and U.S. Department of the Army, 1997, *Remedial Investigation for the Groundwater Operable Units at the Chemical Plant area and the Ordnance Works Area, Weldon Spring Site, Weldon Spring, Missouri*, DOE/OR/21548-571, prepared by MK-Ferguson Company and Jacobs Engineering Group, Inc., Weldon Spring, MO, and Argonne National Laboratory, Argonne, IL, for U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, and U.S. Department of the Army, Corps of Engineers, Kansas City District, Kansas City, MO, July. (see p. 5-10 for TCE and p. D-9 for 2,6-DNT)

3. U.S. Department of Energy and U.S. Department of the Army, 1998, *Feasibility Study for Remedial Action for the Groundwater Operable Units at the Chemical Plant area and the Ordnance Works Area, Weldon Spring, Missouri,* DOE/OR/21548-569, prepared by Argonne National Laboratory, Argonne, IL, for U.S. Department Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, and U.S. Department of the Army, Corps of Engineers, Kansas City District, Kansas City, MO, Dec.

4. U.S. Department of Energy, 1999, *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/OR/21548-783, prepared by Argonne National Laboratory, Argonne, IL, for U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, June.

5. U.S. Department of Energy, 1999, *Proposed Plan for Remedial Action at the Groundwater Operable Unit at the Chemical Plant area of the Weldon Spring Site, Weldon Spring, Missouri,* DOE/OR/21548-733, prepared by Argonne National Laboratory, Argonne, IL, for U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, July.

6. U.S. Department of Energy, 2000, *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant area of the Weldon Spring Site,* DOE/OR/21548-798, prepared by U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN, Sept.

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U.S. Department of Energy, 1999a, *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/OR/21548-783, prepared by Argonne National Laboratory, Argonne, IL, for U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, June.

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APPENDIX A:

DESCRIPTION AND COMPARATIVE ANALYSIS OF ALTERNATIVES (AS PRESENTED IN THE FS AND SUPPLEMENTAL FS)

APPENDIX A:

DESCRIPTION AND COMPARATIVE ANALYSIS OF ALTERNATIVES (AS PRESENTED IN THE FS AND SUPPLEMENTAL FS)

The alternatives evaluated in the feasibility study (FS) (DOE 1998) and the Supplemental FS (DOE 1999a) provided the basis for identifying the proposed action presented in this plan. The information presented in the FS and Supplemental FS have been reproduced in this Appendix to facilitate review of the proposed action.

A.1 DESCRIPTION OF FINAL ALTERNATIVES

Seven of nine alternatives were evaluated. Alternatives 5 and 6 were not evaluated further in the FS because Alternative 4 provides a similar action with a more established technology (i.e., GAC).

Alternative 1: No Action

This alternative is used as a baseline against which to compare the other alternatives being considered. Under the no action alternative, groundwater at the Chemical Plant area would remain "as is." No further containment, removal, treatment, or other mitigating actions would be implemented. The no action alternative does not include groundwater monitoring or any other active or passive institutional controls that may reduce any potential for human exposure (e.g., land use restrictions). Under Alternative 1, it is assumed that all current activities, including groundwater monitoring by the U.S. Department of Energy (DOE), would be discontinued. However, contaminant concentrations are expected to decrease as a result of natural processes that will continue to occur and from current source removals being conducted per the Chemical Plant Record of Decision (ROD) (DOE 1993).

Alternative 2: Long-Term Monitoring

Under Alternative 2, no active remediation would take place; however, long-term monitoring of the groundwater would be performed. The concentrations of contaminants in groundwater at the Chemical Plant area are expected to decrease with time. This decrease is expected to result from source removals and dilution from infiltration of rainwater and runoff. Further evaluation through long-term monitoring and associated activities would verify whether these processes decreased contaminant levels.

Groundwater monitoring would be conducted via an optimized network developed from the existing monitoring well network. The existing network would be expanded or reduced as appropriate to optimize. Monitoring would be performed for an appropriate period of time as defined in the remedial design/remedial action (RD/RA) phase. As required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a review

would be conducted every five years because contaminants would remain in site groundwater at levels above those that allow for unlimited use and unrestricted exposure.

Alternative 3: Monitored Natural Attenuation

This alternative involves the collection of monitoring data to verify the effectiveness of naturally occurring processes to reduce contaminant concentrations. Dilution and dispersion are the primary natural processes identified that are acting to reduce all contaminant concentrations in groundwater at the Chemical Plant area (DOE 1999). However, because of the wide range in hydraulic conductivities and the karst nature of the aquifer across the contaminated areas, uncertainties are associated with the remedial time frames predicted. The evaluation presented in the Supplemental FS (DOE 1999) indicates time periods in the order of hundreds of years to approach ARARs. (For this Proposed Plan [PP], the calculations were revised to incorporate more recent field information and concentrations [see Appendix B]).

The source removals that were performed per the Chemical Plant ROD (DOE 1993) are expected to ultimately result in decreasing groundwater contaminant levels, since no further contribution to the contamination will occur. Conditions do not appear to be favorable for biological processes degrading the trichloroethylene (TCE), nitroaromatic compounds, or nitrate; however, sorption of uranium is expected to be occurring to some extent. In addition, discharged groundwater (to the surface springs, primarily Burgermeister Spring and the Southeast Drainage) is subject to further extensive dilution and physical and chemical degradation. Performance monitoring to determine continued occurrence of dilution and dispersion would be similar to that performed under Alternative 2. The monitoring activities would essentially be to verify contaminant concentration decreases at the various monitoring wells and discharge points (e.g., Burgermeister Spring). Monitoring strategies for the COCs are presented in Appendix C.

As required by CERCLA, a review would be conducted every five years because contaminants would remain in site groundwater at levels above those that allow for unlimited use and unrestricted exposure.

Alternative 4: Groundwater Removal and On-Site Treatment Using Granular Activated Carbon (GAC) and Ion Exchange

This alternative involves using conventional vertical extraction wells to remove groundwater with contaminant levels exceeding the MCLs. In the evaluation presented in the Supplemental FS (DOE 1999), an estimated 24 vertical extraction wells would be required to address the contaminants at the Chemical Plant area to achieve a reasonable extraction rate and to provide wide enough coverage to prevent any bypass of contaminated groundwater. The evaluation presented in the Supplemental FS indicates time periods in the order of hundreds of years for contaminant concentrations to approach ARARs. In addition, the evaluations simulate ideal groundwater conditions and are not reflective of actual complex site conditions. The results, therefore, provide the most optimistic performance under this alternative for ideal groundwater conditions; much poorer performance is expected under actual site conditions.

The extracted groundwater would be pumped and treated at an aboveground treatment system. Organic compounds, such as TCE and 2,4-dinitroluene (2,4-DNT), would be removed by using the well-established GAC adsorption technology. Inorganic contaminants, such as nitrate and uranium, would be treated using ion exchange.

As required by CERCLA, a review would be conducted every five years because contaminants would remain in site groundwater at levels above those that allow for unlimited use and unrestricted exposure.

Alternative 7: Removal and On-Site Treatment of Groundwater in the Vicinity of the Raffinate Pits

This alternative involves the extraction of TCE-contaminated groundwater primarily in the vicinity of the Raffinate Pits of the Chemical Plant area. In the evaluation presented in the Supplemental FS (DOE 1999), approximately 15 vertical extraction wells were estimated to be required to achieve a reasonable extraction rate and to provide wide enough coverage to prevent any bypass of the contaminants.

As required by CERCLA, a review would be conducted every five years because contaminants would remain in site groundwater at levels above those that allow for unlimited use and unrestricted exposure.

Alternative 8: In-Situ Treatment of TCE Using In-Well Vapor Stripping

In-well vapor stripping technology involves the creation of a groundwater circulation pattern and simultaneous aeration within the vapor stripping well to volatilize the TCE from the circulating groundwater. This alternative is focused on remediating the TCE-contaminated groundwater that has been identified near the Raffinate Pits area of the Chemical Plant area. Because of the nature of the technology involved, this alternative would not remediate the nitrate, nitroaromatic compounds, and uranium that may also be present.

The in-well vapor stripping technology consists primarily of a screened well submerged beneath the water table and an air line within the well extending to below the water table. A compressor delivers air or an inert gas such a nitrogen to the water column, thereby aerating the water within the well. The gas bubbles cause the water within the well to be less dense than the nonaerated water outside. As a result, the dense water flows in through the well screen and forces the aerated water upward within the well. The result is a rising column of aerated water within the well, which forms an air-lift pumping system.

As required by CERCLA, a review would be conducted every five years because contaminants would remain in site groundwater at levels above those that allow for unlimited use and unrestricted exposure.

Alternative 9: In-situ Chemical Oxidation of TCE Using Fenton-Like Reagents

This alternative involves in-situ chemical oxidation (ICO) of the TCE-contaminated groundwater that has been identified at the Chemical Plant area. Because this technology has been proven to address organic compounds only, this alternative would primarily address TCE.

The application of this technology would consist of injecting aqueous solutions of hydrogen peroxide, ferrous sulfate, and other chemicals (e.g., acetic acid) into the shallow bedrock aquifer through a series of injection wells. (A variation of this alternative, the injection of permanganate solution rather than Fenton-like reagents was implemented in 2002 at the Chemical Plant area as stipulated in the interim Record of Decision (IROD) [DOE 2000]).

As required by CERCLA, a review would be conducted every five years because contaminants would remain in site groundwater at levels above those that allow for unlimited use and unrestricted exposure.

A.2 COMPARATIVE ANALYSIS OF FINAL ALTERNATIVES

The seven final remedial action alternatives are compared with the nine CERCLA evaluation criteria (Table A.1). The nine evaluation criteria are categorized into the following three groups, as stipulated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA 1990): threshold criteria, primary balancing criteria, and modifying criteria.

The threshold category contains the two criteria that an alternative must meet in order to be eligible for selection:

- Overall protection of human health and the environment, and
- Compliance with applicable or relevant and appropriate requirements (ARARs), unless a waiver condition applies.

These threshold criteria ensure that the remedial action selected will be protective of human health and the environment and that the action will attain the ARARs identified at the time of the ROD or provide grounds for invoking a waiver.

The primary balancing category contains the five criteria that are used to assess the relative advantages and disadvantages of each alternative:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

TABLE A.1 Comparative Analysis of Alternatives

	Alternative 1: No Action	Alternative 2: Long-Term Monitoring	Alternative 3: Monitored Natural Attenuation	Alternative 4: Groundwater Removal and On-Site Treatment Using GAC and Ion Exchange	Alternative 7: Removal and On-Site Treatment of Groundwater near the former Raffinate Pits Area	Alternative 8: In-situ Treatment of TCE Using In-Well Vapor Stripping	Alternative 9: In-situ Chemical Oxidation of TCE Using Fenton-Like Reagents
Overall protection of human health and the environment	Like all of the alternatives, would be adequately protective of human health and the environment, although monitoring data would not be available to verify this occurrence.	Like all of the alternatives, would be adequately protective of human health and the environment. Monitoring data would be collected to verify that conditions continued to be protective of human health and the environment.	Like all of the alternatives, would be adequately protective of human health and the environment. Monitoring data would be collected to verify that conditions continued to be protective of human health and the environment.	Like all of the alternatives, would be adequately protective of human health and the environment.	Like all of the alternatives, would be adequately protective of human health and the environment.	Like all of the alternatives, would be adequately protective of human health and the environment.	Like all of the alternatives, would be adequately protective of human health and the environment.
Compliance with ARARs	Calculations for Alternative 3 would be applicable for this alternative since the same processes (dilution and dispersion) would be occurring to reduce contaminant concentrations. The revised calculations for Alternative 3 (presented in Appendix B) indicate a time period of about 100 years to approach chemical specific ARARs.	Calculations for Alternative 3 would be applicable for this alternative since the same processes (dilution and dispersion) would be occurring to reduce contaminant concentrations. The revised calculations for Alternative 3 (presented in Appendix B) indicate a time period of about 100 years to approach chemical specific ARARs.	Calculations presented in the Supplemental FS indicated time periods on the order of hundreds of years to approach ARARs. These calculations were revised to incorporate a re-evaluation of site data. Revised calculations (see Appendix B) indicate a time period of about 100 years to approach ARARs.	Like MNA, calculations presented in the Supplemental FS indicated time periods on the order of hundreds of years to approach ARARs. A revision of these calculations for this alternative similar to that performed for Alternative 3 would also indicate shorter time periods. However, the complex hydrogeologic characteristics of the site would limit the success of any efforts for groundwater removal as was indicated by the field tests performed in 1998 and 2001.	The ARAR for TCE could be approached in a similar amount of time as Alternative 4, but longer than Alternatives 8 and 9. ARARs for the other COCs would be approached in this area in a time period similar to that in Alternative 4.	Complies with the ARAR for TCE in a shorter period of time than Alternative 7 and in a slightly longer period of time than Alternative 9. The ability to approach the ARAR is also limited by the complex hydrogeologic characteristics of the site and the state of current technology.	Requires the least time to comply with chemical specific ARAR for TCE as compared with all other alternatives, including Alternatives 7 and 8. The ability to approach the ARAR is also limited by the complex hydrogeologic characteristics of the site and the state of current technology. The in-situ chemical oxidation (ICO) implemented for the IROD (DOE 2000) was limited by the complexities imposed by site hydrogeology.
Long-term effectiveness and permanence	Is expected to afford long-term effectiveness and permanence, although investigative and monitoring activities would not be performed.	Provides for long-term effectiveness and permanence; unlike Alternative 1, would provide verification monitoring of the groundwater within the operable unit.	Provides for long-term effectiveness and permanence. Performance monitoring data would be collected.	Affords long-term effectiveness and permanence because contaminant concentrations would be removed or reduced through extraction and treatment.	Would reduce concentrations of TCE, nitrate, nitroaromatic compounds, and uranium in groundwater near the former Raffinate Pits area. Natural processes and source removals per the Chemical Plant ROD (DOE 1993) are expected to result in decreases of contaminant levels in the other areas of the site.	TCE would be reduced or removed by treatment of groundwater. Natural processes and source removals per the Chemical Plant ROD (DOE 1993) are expected to result in decreases of the other contaminants of concern (COCs).	TCE would be reduced or removed. Natural processes and source removals per the Chemical Plant ROD (DOE 1993) are expected to result in decreases of the other COCs.
Reduction of toxicity, mobility, or volume through treatment	No reduction of toxicity, mobility, or volume through treatment would be accomplished because the contaminated groundwater would not be treated. However, with the effects of dilution and dispersion with time, the hazards posed by the contaminants of concern would be reduced as concentrations decrease.	No reduction of toxicity, mobility, or volume through treatment would be accomplished because the contaminated groundwater would not be treated. However, with the effects of dilution and dispersion with time, the hazards posed by the contaminants of concern would be reduced as concentrations decrease.	No reduction of toxicity, mobility, or volume through treatment would be accomplished because the contaminated groundwater would not be treated. However, with the effects of dilution and dispersion with time, the hazards posed by the contaminants of concern would be reduced as concentrations decrease.	Reduction of the toxicity, mobility, or volume associated with all groundwater contamination within the shallow bedrock aquifer would be accomplished upon successful implementation of this alternative.	Reduction of the toxicity, mobility, or volume associated with TCE, nitrate, nitroaromatic compounds, and uranium would be accomplished upon successful implementation of this alternative.	Reduction of the toxicity, mobility, or volume associated with TCE contamination at the Chemical Plant area would be accomplished upon successful implementation of this alternative.	Reduction of the toxicity, mobility, or volume associated with TCE contamination at the Chemical Plant area would be accomplished upon successful implementation of this alternative.

TABLE A.1 (Cont.)

	Alternative 1: No Action	Alternative 2: Long-Term Monitoring	Alternative 3: Monitored Natural Attenuation	Alternative 4: Groundwater Removal and On-Site Treatment Using GAC and Ion Exchange	Alternative 7: Removal and On-Site Treatment of Groundwater near the former Raffinate Pits Area	Alternative 8: In-situ Treatment of TCE Using In-Well Vapor Stripping	Alternative 9: In-situ Chemical Oxidation of TCE Using Fenton-Like Reagents
Short-term effectiveness	No potential impacts on workers or the environment because no activities would be undertaken.	Potential impacts are expected to be low, with less than one case of occupational injury and no occupational fatalities during proposed monitoring well construction. Any potential short-term environmental impacts would be limited to the immediate vicinity of the operable unit, and mitigative measures would be implemented to ensure minimal impacts to off-site areas.	The same as Alternative 2.	Potential impacts associated with construction of the extraction wells. Construction activities are estimated to result in up to seven cases of occupational injury and less than one occupational fatality. Any potential short-term environmental impacts would be limited to the immediate vicinity of the operable unit, and mitigative measures would be applied to ensure minimal impacts to off-site areas.	Expected to be low, with less than five cases of occupational injury and no occupational fatalities during operations and well construction activities. Any potential short-term environmental impacts would be limited to the immediate vicinity of the operable unit, and mitigative measures would be applied to ensure minimal impacts to off-site areas.	The same as Alternative 7.	The same as Alternative 7.
Implementability	No implementability concerns because no action would be taken nor would any future activities be considered.	Few implementability concerns because of the limited actions taken. Current monitoring operations would continue with the use of readily available resources.	The same as Alternative 2.	Groundwater treatment technologies in this alternative have been demonstrated at full-scale implementation for similar contaminants. However, uncertainties with implementation of this alternative are associated with the need for location (or area)-specific hydrogeologic data to verify the appropriateness of assumptions applied in the evaluations.	Specific hydrogeologic data indicated difficulty in establishing a sustainable yield; in addition, localized dewatering and very slow recovery of the aquifer were observed from the pump test performed in 1998 and in 2001. Uncertainties with implementation of this alternative are associated with the need for location (or area)-specific hydrogeologic data to verify the appropriateness of assumptions applied in the evaluations.	Uncertainties with implementation of this alternative are associated with the complex hydrogeologic characteristics of the site and the state of current technology. The generation of a vertical circulation pattern is expected to be difficult.	The potential to introduce materials was indicated by the pump test performed in 1998. The implementation of the technology for this alternative requires introducing a chemical reagent into the aquifer.
Cost	Lowest future cost.	Annual costs expected to be similar to those of Alternative 3.	Capital costs of approximately $120,000, primarily for construction of additional wells, with an annual cost of approximately $200,000.	On the basis of the estimates presented in the FS and supplemental FS, capital costs were estimated to be approximately $7 million, with the present-worth cost estimated to range between $15 million and $24 million. The actual cost would likely be higher based on cost incurred in implementing the field study performed in 2001. A cost of approximately $3 million was incurred for a much smaller scale effort than that involved in full-scale site-wide groundwater removal as described in this alternative.	On the basis of estimates presented in the FS, capital costs are estimated to be approximately $5 million, with the present-worth cost estimated to range between $14 million and $20 million. The actual cost would likely be higher based on cost incurred in implementing the field study performed in 2001. A cost of approximately $3 million was incurred for a much smaller scale effort than that involved in groundwater removal required under this alternative.	On the basis of estimates presented in the FS, capital costs are estimated to range between $1 million and $3 million. Annual costs are estimated to be $0.4 million for monitoring.	Lowest cost as compared with other TCE treatment alternatives (Alternatives 7 and 8). The ICO implemented in 2002 costs approximately $1M with the cost of full implementation expected to be >$9M. Uncertainties in attaining the ARAR would still be imposed by the site hydrogeology.

Cost-effectiveness is determined by evaluating three of the five balancing criteria: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness. Overall effectiveness is then compared with cost to ensure that the costs are proportional to the overall effectiveness of a remedial action.

The modifying category consists of:

- State acceptance, and
- Community acceptance.

These two modifying criteria will be addressed in the responsiveness summary and ROD that will be prepared following the public comment period for this PP; therefore, they are not addressed in this analysis. The results of the comparative analysis performed for the final alternatives on the basis of the first seven criteria are summarized in Table A.1.

The information presented in Table A.1 served as the basis for DOE's proposal in 1999 (DOE 1999b) to treat TCE via Alternative 9. This alternative showed promise in reducing TCE concentrations which were the primary contributors to risk from ingestion of groundwater from the Chemical Plant area at the time. An IROD was signed in September 2000 to implement this remedial action. In addition, independent of the IROD, DOE also planned for additional field studies to explore the effectiveness of enhanced pump-and-treat. The outcome of these activities were to be considered in developing the final groundwater decision and response action described in Sections 6 and 7 of this PP.

APPENDIX A REFERENCES

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APPENDIX B:

MONITORED NATURAL ATTENUATION (MNA) PREDICTED TIME FRAMES FOR GROUNDWATER CONTAMINANTS OF CONCERN AT THE CHEMICAL PLANT AREA (REVISED CALCULATIONS)

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MONITORED NATURAL ATTENUATION (MNA) PREDICTED TIME FRAMES FOR GROUNDWATER CONTAMINANTS OF CONCERN AT THE CHEMICAL PLANT AREA (REVISED CALCULATIONS)

Calculations were performed to estimate predictive times (the number of years) when natural attenuation processes would likely reduce concentrations of the contaminants of concern (COCs) to levels equal to or below the chemical-specific applicable or relevant and appropriate requirements (ARARs) and risk-based concentrations (RBC). These calculations were presented in the Supplemental Feasibility Study (FS) (DOE 1999) and have been revised to incorporate observations from the field study completed in 2001 (MK-Ferguson 2002) and to incorporate more representative values for several of the input parameters. The following input parameters were revised from those used in the Supplemental FS: (1) hydraulic conductivity – used the upper 95% limit of the arithmetic mean of the hydraulic conductivities within a given plume contour. This approach was taken to account for high-permeability regions associated with paleochannel features at the site; (2) hydraulic gradient – used a revised value to account for the variability along the groundwater flow path; (3) effective porosity – used a lower value than that used in the Supplemental FS to be more representative of site conditions; (4) contaminant concentrations – used current concentrations averaged over the plume area; and (5) distribution coefficients (K_ds) - more representative K_ds were incorporated. The K_ds used in the Supplemental FS calculations were those identified for soil matrices and may not be as representative for the aquifer matrix being evaluated as those used in the revised calculations presented in this Appendix.

Table B.1 presents a summary of the input parameters and the results obtained from the revised calculations. The time frames presented in Table B.1 are shorter than those presented previously in the Supplemental FS. The decrease in number of years is primarily due to the higher hydraulic conductivities, lower distribution coefficients, and generally lower current contaminant concentrations that were used for the revised calculations.

TABLE B.1 Revised MNA Predictive Cleanup Times Using the Flushing Model[a]

Contaminant	Contour	Wells Included	K_d[b] (mL/g)	R	K[c] (UL 95) (cm/s)	Actual GW Velocity (ft/yr)	L (ft)	∇h	Initial Conc. (avg.)	Regulatory Standard or RBC[d]	Time (yr)
Uranium	Contour 1	3030	0.4	5.5	0.0012	103.3	1,050	.0125	54	20 pCi/L	56
	Contour 2	3025	0.4	5.5	0.003	258.7	460	0.0125	29	20 pCi/L	4
TCE	Contour 1	4006, 4001, 3030, 3025, 4037, 3039, 3034, 2037, 2038, 4029, 3035, 4031, 3036, 3029, 3028, 4028, 3033, 4027, 4032, MWS 21, 4038, 3032	0.3	4.4	.00411	141.7	1,300	.005	61	5 µg/L	101
Nitrate	Contour 1										
	Area 1	4036, 3037, 4006, 4001, 3030, 3031, 3027, 3026, 3039, 3025, 4027, 3038, 3034, 2037, 2038, 4029, 3035, 3032, 3028, 3029, 3036, 4031, 4028, 3033, 4038, 4032	0	1	.00315	130.4		.006	198	10 mg/L	63
	Area 2	4013, 2001, 2005, 4011, 2021, 2002, 2047, 2003, 3003, 3023	0	1	.00173	238.7	2,350	.02	173	10 mg/L	28
2,4-DNT	Contour 1	3038, 2037, 4029, 3035, 3029, 3028, 4028, 3033, 4032, MWS 21, 4033, 4006, 4001, 3030, 3039, 3034, 2038	0.09	2.0	.001	55.2	1,600	.008	.43	0.11 µg/L	79
	Contour 2	2047, 2046	0.09	2.0	.00104	43.0	400	.006	.18	0.11 µg/L	9
	Contour 3	2052, 2006, 2053, 2054, 2013, 2012, 2049, 2050, 2033, 4030, 2014	0.09	2.0	.00352	267.1	1,400	0.011	114	0.11 µg/L	73
1,3-DNB	Contour 1	2012	0	1.0	.001	76	500	0.011	1.7	1.0	4
NB	Contour 1	2012	0	1.0	.001	76	500	0.11	69	17	9

TABLE B.1 (Cont.)

Contaminant	Contour	Wells Included	K_d[b] (mL/g)	R	K[c] (UL 95) (cm/s)	Actual GW Velocity (ft/yr)	L (ft)	∇h	Initial Conc. (avg.)	Regulatory Standard or RBC[d]	Time (yr)
2,6-DNT	Contour 1	4036, 4006, MWS-4, 4001, 3030, 3039, 3034, 4037, 3038, 4031, 4029, 3029, 3028, 4028, 3033, 3036, 4027, 4032	0.2	3.3	.0012	98.2	1,700	.0119	.34	0.13 µg/L	55
	Contour 2	2002, 2003, 3003, 3023	0.2	3.3	.00019	21.9	1,050	.0167	.41	0.13 µg/L	182
	Contour 3	2005	0.2	3.3	.000021	1.8	400	.0125	.27	0.13 µg/L	536
	Contour 4	2047, 2046	0.2	3.3	.00104	89.7	500	.0125	.81	0.13 µg/L	34
	Contour 5	4015, 2045, 2052, 2051, 2006, 2053, 2049, 2012, 4030, 4039, 2050, 2013, 2033, 2054, 2014	0.2	3.3	.00341	555.1	2,300	.0236	66	0.13 µg/L	85
2,4,6-TNT	Contour 1	2046	0.04	1.5	.0014	482.8	400	.05	4.2	2.8 µg/L	0.6
	Contour 2	2053, 2049, 2012	0.04	1.5	.00396	341.4	350	.0125	75	2.8 µg/L	5
1,3,5-TNB	Contour 1	4031	0.16	2.7	.0007	24.1	500	.005	2.9	1.8 µg/L	27
	Contour 2	4007, 4006, 4001	0.16	2.7	.00005	5.9	500	.017	17	1.8 µg/L	514
	Contour 3	4013	0.16	2.7	.00006	10.4	200	0.025	24	1.8 µg/L	135
	Contour 4	2046	0.16	2.7	.0014	280	400	0.029	2.6	1.8 µg/L	1
	Contour 5	4015, 2052, 2006, 2053, 2013, 2033, 2014, 2050, 2012, 2049, 4030	0.16	2.7	.0026	179.3	2,400	.010	20	1.8 µg/L	87

[a] Calculations presented in this table performed using the same methodology (i.e. Flushing Model) as that presented in the Supplemental FS (DOE 1999). The following input parameters were also used in the calculations in addition to those shown in this table: bulk density at 1.7 g/cc and effective porosity at 0.15. See Figures 2.4 to 2.10 for contours for TCE, nitrate, uranium, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, and 2,4,6-TNT. R = retardation for the contaminant; L = length of the contaminated zone in a direction parallel to the direction of groundwater flow; ∇h = hydraulic gradiant present.

[b] Sources for distribution coefficients or K_ds presented in this table: uranium (EPA 2000); nitrate (Strenge and Peterson 1989); TCE and 2,6-DNT (DOE and DA 1997); for 2,4-DNT, 2,4,6-TNT, 1,3,5-TNB, 1,3-DNB, and NB (Brannon and Pennington 2002).

[c] Hydraulic conductivities or K's presented are upper 95% limits of the arithmetic means of the hydraulic conductivities for the monitoring wells included in the contours.

[d] Regulatory standards include the MCLs for TCE, uranium, nitrate; Missouri Water Quality Standards for 2,4-DNT, 1,3-DNB, and NB. Risk-based concentrations (RBCs) developed for 2,6-DNT, 2,4,6-TNT, and 1,3,5-TNB are based on concentrations that are equivalent to either a hazard index of 1 or 1 in 1,000,000 (10^{-6}) risk for a hypothetical resident scenario, as appropriate.

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APPENDIX C:

PROPOSED MNA PERFORMANCE MONITORING STRATEGY FOR GROUNDWATER CONTAMINANTS OF CONCERN AT THE CHEMICAL PLANT AREA

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PROPOSED MNA PERFORMANCE MONITORING STRATEGY FOR GROUNDWATER CONTAMINANTS OF CONCERN AT THE CHEMICAL PLANT AREA

The proposed monitoring strategy for groundwater Contaminants of Concern (COCs) at the Chemical Plant area addresses the following five objectives:

(1) Verify that natural attenuation of the COCs is occurring as expected; not to exceed concentrations are specified for each COC. (Identified as Objective B in Tables C.1 to C.4). For TCE (Table C.1), Objective B specifies that concentrations within the plume could not exceed 1,000 μg/L; for nitrate (Table C.2), Objective B specifies that concentrations within the plume could not exceed 1,500 mg/L; for uranium (Table C.3), Objective B specifies that concentrations within the plume could not exceed 300 pCi/L; and for nitroaromatic compounds (Table C.4), concentrations within the plume located in the northeastern portion of the site (designated as B-1) could not exceed 2,000 μg/L for 2,4-DNT at MW-2012 or an average of 400 μg/L for 2,4-DNT using data from all of the B-1 locations. Concentrations with the remainder of the plumes (designated as B-2) could not exceed an average of 100 μg/L for 2,4-DNT using data from all of the B-2 locations;

(2) Ensure that the COC plumes are not migrating unexpectedly (identified as Objective C in Tables C.1 to C.4);

(3) Demonstrate that TCE is not present at locations where human exposure could occur and that the other COCs are not present at concentrations that are not protective of the recreational visitor scenario (identified as Objective D in Tables C.1 to C.4);

(4) Perform upgradient monitoring(identified as Objective E in Tables C.1 to C.4); and

(5) Demonstrate hydrologic stability (identified as Objective G in Tables C.1 to C.4). The complete network of wells to be monitored for this objective would be the combined set of wells specified in the monitoring strategy for each of the COCs.

Aside from the objectives listed above, two additional objectives are included for monitoring TCE. Monitoring for TCE would be performed to delineate its vertical extent of contamination (Objective A in Table C.1) and to monitor for rebound in TCE concentrations in the area where in-situ chemical oxidation was implemented in 2002 (Objective F in Table C.1). Figure C.1 presents monitoring locations of the proposed TCE performance monitoring network.

The monitoring strategies consist of sampling for COCs at specified monitoring wells at specific frequencies to determine if the objectives listed above are being met. Trigger events, trigger locations, and trigger concentrations are stipulated to ensure that the protection of human health and the environment is maintained throughout the process. The monitoring strategies presented in Tables C.1 to C.4 reflect current working drafts of these strategies.

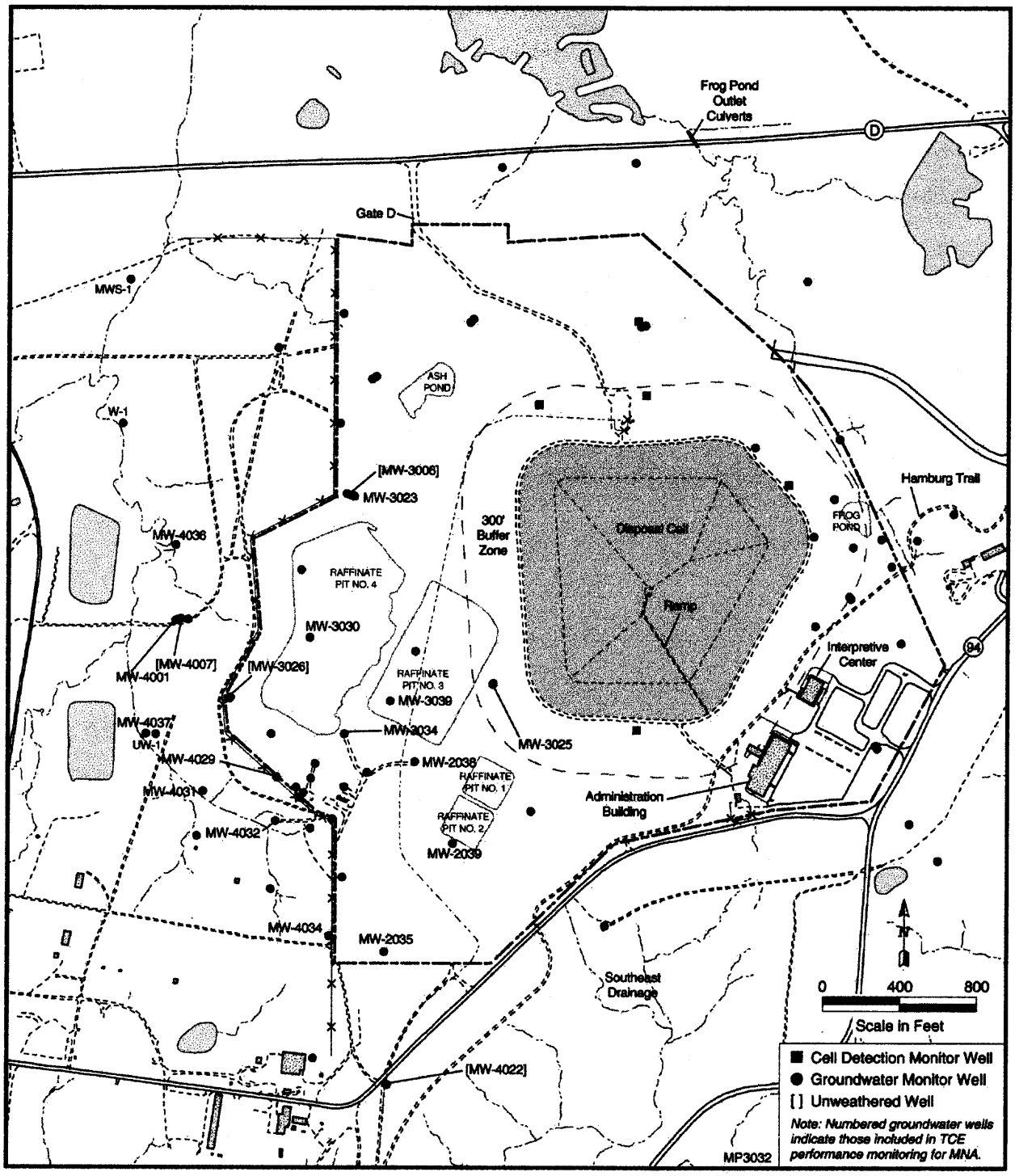

FIGURE C.1 TCE Performance Monitoring Network

TABLE C.1 Proposed MNA Performance Monitoring for TCE

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
Characterization	UW-1 (w/MW-4037)	A	- Vertical characterization of TCE extent downgradient of impacted area.. - Wells cased 10-ft within UW unit with 10-ft screen.	- Quarterly for first 2 years, then as outlined under this program.	Detection and confirmation of sample of 3 μg/L or greater at any of these locations.	Additional characterization to determine the extent of contamination.
	W-1	A	- New well to be installed along flow path from TCE impact area to SP-6301. - Install at predetermined location between MWS-2 and MW-4036. - Well cased within permeable portion of W unit as determined by packer tests with 10-ft screen. - Well will be located approximately 1000 ft northwest from MW-4001. - Location will be optimized by drilling up to 3 boreholes perpendicular to the estimated location of the paleofeature in attempt to intercept preferential flow pathway.			

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for TCE	MW-2038	B	- Dramatic decline in TCE concentrations from >1000 μg/L in 1996 to <50 μg/L at present. Demonstrates dissipation of the plume. - Not impacted by P&T or ICO	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002.	- Increase sampling frequency to quarterly at these "B" locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling and recalculate MNA timeframes.
	MW-3030	B	- Within 100 μg/L contour, stable at 200–300 μg/L. - Not impacted by P&T or ICO - Along preferential flow path			
	MW-3039	B	- Within 100 μg/L contour, but has shown some increase since installation. - Not impacted by P&T or ICO - Along preferential flow path		- Any location exceeding 1000 μg/L with confirmatory sampling.	- Increase sampling frequency to quarterly at these "B" locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 1000 μg/L, then invoke hotspot ICO or better remediation alternative.
	MW-4001	B	- Concentration stable at <10 μg/L. - Screened in W/UW but primarily W. - Good location downgradient from source to measure plume dissipation. - Better that newer MW-4006 in same well cluster.			
	MW-4029	B	- Within 500 μg/L contour. - Not impacted by P&T. - Slight impact from ICO, but rebounded to 500–600 μg/L.			

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for TCE	MW-4031	B	- Within 100 μg/L contour, stable from 120–220 μg/L. - Not impacted by P&T or ICO - Along flow path			
	MW-4037	B	- Concentrations have shown increase since installation – 1.6 to 30 μg/L. - Good location downgradient from source to measure plume dissipation. - Along flow path.			

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for TCE	W-1	C	- Weathered well located along flow path from TCE impact area to SP-6301. - New well installed in support of this monitoring program.	- Quarterly for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan to build dataset. - Annual thereafter. - Reevaluate/optimize as part of 5-Year Reviews.	- Detection and confirmation of sample of 3 μg/L or greater at any of these locations. - Detection and confirmation of sample of 75 μg/L or greater.	- Increase sampling frequency to quarterly at all TCE MNA locations. - After 4 quarters, (1) if concentrations return to <3 μg/L, then return to previous sampling frequency. (2) If concentration remains above 3 μg/L but <75 μg/L and all "B" locations are below baseline levels and the remainder of the "C" locations are less than 3 μg/L, then continue quarterly sampling at W-1. (3) If concentration remains above 3 μg/L but <75 μg/L and any other "B" location concentration is above baseline levels or any other "C" location is >3 μg/L, then continue quarterly sampling at all locations, add appropriate existing downgradient monitoring locations to quarterly sampling, recalculate MNA timeframes, and reevaluate ICs. - If 2 consecutive quarters with confirmation sampling show concentration of 75 μg/L or greater, then invoke ICO hotspot or better remedial alternative. This contingency remedy will not be invoked if TCE concentrations in the center of the plume have dissipated to <300 μg/L.

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for TCE	MWS-1	C	- Weathered well located along flow path from TCE impact area to SP-6301. - Recent sampling indicates ND (1 event).	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - MWS-1 & UW-1 will be sampled quarterly for 2 years to build dataset. - All wells sampled annually thereafter. - Reevaluate/optimize as part of 5-Year Reviews.	- Detection and confirmation of sample of 3 μg/L or greater at any of these locations.	- Increase sampling frequency to quarterly at all TCE MNA locations. - After 4 quarters, (1) if concentrations return to <3 μg/L, then return to previous sampling frequency. (2) If concentration remains above 3 μg/L but less than the trigger concentration and all "B" locations are below baseline levels and the remainder of the "C" locations are less than 3 μg/L, then continue quarterly sampling at location above 3 μg/L. (3) If concentration remains above 3 μg/L but less than the trigger concentration and any other "B" location concentration is above baseline levels or any other "C" location is >3 μg/L, then continue quarterly sampling at all locations, add appropriate existing downgradient monitoring locations to quarterly sampling, recalculate MNA timeframes, and reevaluate ICs. - If 2 consecutive quarters with confirmation sampling show concentration above the trigger concentration at any of these 5 locations, then invoke ICO hotspot or better remedial alternative. This contingency remedy will not be invoked if TCE concentrations in the center of the plume have dissipated to <300 μg/L.
	UW-1	C	Unweathered well to detect vertical migration of TCE from the weathered unit clustered with MW-4037.			
	MW-3006 (UW)	C	- Unweathered well under edge of TCE plume. - Clustered with MW-3003 and MW-3023, which have had estimated detects (<1 mg/L) of TCE. - All data ND.			
	MW-3026 (UW)	C	- Unweathered well located in low conductivity area within the TCE plume. - Clustered with MW-3027, which has had estimated detects (<1 μg/L) of TCE. - All data ND.			
	MW-4007 (UW)	C	- Unweathered well under the leading edge of the 5 μg/L contour in the weathered unit. - Well clustered with MW-4001. - Located along flow path. - All data ND.		- Detection and confirmation of sample of 20 μg/L at MWS-1 or 10 μg/L or greater at any of UW locations.	

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for TCE	SP-6301 Burger-meister Spring	C, D	- Primary discharge point for groundwater originating from the chemical plant. - All data ND. - Point of exposure.	Semiannual.	- Detection and confirmation of sample of 3 μg/L or greater at any of these locations.	- Increase sampling frequency to quarterly at all TCE MNA locations. Investigate possible external sources of TCE. - After 4 quarters, (1) if concentrations return to <3 μg/L, then return to previous sampling frequency. (2) If concentration remains above 3 μg/L but < 5 μg/L and all "B" locations are below baseline levels and the remainder of the "C" locations are less than 3 μg/L, then continue quarterly sampling at location above 3 μg/L. (3) If concentration remains above 3 μg/L but <5 μg/L and any other "B" location concentration is above baseline levels or any other "C" location is >3 μg/L, then continue quarterly sampling at all locations, add appropriate existing downgradient monitoring locations to quarterly sampling, recalculate MNA timeframes, and reevaluate ICs. - If 2 consecutive quarters with confirmation sampling show concentration at any location is greater than 5 μg/L, then invoke ICO hotspot or better remedial alternative. This contingency remedy will not be invoked if TCE concentrations in the center of the plume have dissipated to <300 μg/L.
	SP-6303	C, D	- Discharge point for groundwater originating from the chemical plant. - Estimated detects of TCE (<1 μg/L). - Point of exposure.		- Detection and confirmation of sample of 5 μg/L or greater at any of these locations.	

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
	MW-2035	E	- Upgradient weathered monitoring location. - All data ND. - Large dataset.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Review.	- Detection and confirmation of sample of 3 μg/L or greater at this location.	- Increase sampling frequency to quarterly at this and "B" locations. - After 4 quarters, (1) if concentrations return to < 3 μg/L, then return to previous sampling frequency. (2) If concentration remains above 3 μg/L but < 10 μg/L and all "B" locations are below baseline levels, then continue quarterly sampling at location above 3 μg/L. (3) If concentration remains above 3 μg/L but < 10 μg/L and any other "B" location concentration is above baseline levels, then continue quarterly sampling at all locations, add appropriate existing downgradient monitoring locations to quarterly sampling, investigate possible upgradient sources or changed conditions, recalculate MNA timeframes, and reevaluate ICs.
					- Detection and confirmation of sample of 10 μg/L or greater at this location.	- If 2 consecutive quarters with confirmation sampling show concentration at any location is greater than 10 μg/L, then invoke ICO hotspot or better remedial alternative. This contingency remedy will not be invoked if TCE concentrations in the center of the plume have dissipated to <300 μg/L.

TABLE C.1 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
ICO Rebound Monitoring	MW-3034	F	- Location with highest TCE contamination that was impacted by ICO pilot scale project. TCE previously 1000 μg/L, presently ND. - Evaluate rebound from study (time and amount). - Quantify changes in plume due to rebound.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Review.	NONE	NONE
Hydrologic Stability	MW-2039	G	- Upgradient from TCE area. - Weathered location.	- Semiannual water level measurements throughout monitoring program. - Water table map will be constructed for each semi-annual measurement event.	- Change in the groundwater table that indicates insufficient monitoring coverage. May be due to changes in flow directions or increase/decrease in gradient. - Groundwater elevation has decreased to a level that results in "dry" monitoring wells.	- Reevaluate MNA predicted timeframes. - Reevaluate ICs. - Reevaluate if additional wells should be included in monitoring program due to changes in groundwater flow. - Reevaluate adequacy of monitoring network for long-term program.
	MW-3023	G	- Cross-gradient from TCE area. - Weathered location.			
	MW-3025	G	- Cross-gradient from TCE area. - Weathered location.			
	MW-4022(UW)	G	- Upgradient from TCE area. - Unweathered location.			
	MW-4032	G	- Within TCE area. - Along flow path. Weathered location.			
	MW-4034	G	- Upgradient from TCE area. - Weathered location.			
	MW-4036	G	- Down-gradient from TCE area. - Along flow path. - Weathered location.			

TABLE C.2 Proposed MNA Performance Monitoring for Nitrate

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitrate	MW-2038	B	- Decline in nitrate concentrations from >1600 mg/l (1993) to an avg of 600 mg/l at present. - Demonstrates dissipation of the plume. - Not impacted by P&T	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002. For those locations with limited data, quarterly sampling will be performed for the first two years to establish baseline. - Any location exceeding 1,500 mg/l with confirmatory sampling. - The average of the high three concentrations exceeds 1,000 mg/l	- Increase sampling frequency to quarterly at these "B" locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling. - Increase sampling frequency to quarterly at these "B" locations. - If 2 consecutive quarters with confirmatory sampling show a single location with concentrations greater than 1,500 mg/l or the average of the high three locations greater than 1,000 mg/l, then recalculate MNA timeframes.
	MW-2040	B	- Within 100 mg/l contour and has shown decreases since removal of raffinate pits. - Along historical flow path to Southeast Drainage. - Not impacted by P&T. - Demonstrates dissipation of the plume.			
	MW-3030	B	- Within 100 mg/l contour, but has shown increases from 150 to >350 mg/l. - Demonstrates dispersion of nitrate in groundwater. - Not impacted by P&T. - Along preferential flow path.			
	MW-4001	B	- Concentration has been <100 mg/l but has shown slight increases over time. - Demonstrate dispersion of nitrate in groundwater. - Screened in W/UW but primarily W. - Good location downgradient from GW impact area to monitor plume dispersion.			

TABLE C.2 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitrate	MW-4029	B	- Nitrate ranges between 400-600 mg/l. - Measures centroid of GW impact area. - Not impacted by P&T.			
	MW-2002	B	- Historically >1000 mg/l. - Decreasing trend overall, now within 100 mg/l contour, but has shown increase from <50 to >100 mg/l. - Measures Ash Pond source area. - Along flow path of Ash Pond GW impact area and Raffinate Pit GW impact area. - Demonstrates dissipation of plume.			
	MW-2005	B	- Within 100 mg/l contour, but has shown increase from <100 to >175 mg/l. - Monitors Ash Pond GW impact area.			
	MW-4011	B	- Increased from <100 mg/l (1993) to >200 mg/l (1998) back down to approximately 100 mg/l. Impacted in 1990's by Ash Pond and Raffinate Pit remediation. - Monitors Ash Pond and Raffinate Pit GW impact areas. - UW well. Screened in upper 20 ft.			

TABLE C.2 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitrate	MW-4013	B	- Concentrations <100 mg/l. - Screened in W/UW but primarily W. - Monitors northern flow path from Ash Pond GW impact area. - Along northern preferential flow path from site. - Likely location to demonstrate dispersion of nitrate in groundwater.			
	MW-3026	B	- Concentrations between 100 and 200 mg/l. - UW well. Screened 20 ft below W/UW contact. Screened interval of 20 ft. - Nested with MW-3027.			

TABLE C.2 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitrate	MWS-1	C	- W well located along flow path from Raffinate Pit and Ash Pond impact areas to SP-6301. - 1995 RI data approx. 2 mg/l. One data point in 2002 was 9 mg/l.	- Quarterly for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan to build baseline dataset. - Annual thereafter. - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002. For new wells or those locations with limited data, quarterly sampling will be performed for the first two years to establish baseline.	- Increase sampling frequency to quarterly at all Nitrate locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling. - Add appropriate monitoring locations.
	W-1	C	- W well located along flow path from Raffinate Pit impact area to SP-6301. - New well installed in support of this program.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - W-1 and UW-1 will be sampled quarterly for 2 years to build baseline dataset. - All wells sampled annually thereafter. - Reevaluate/optimize as part of 5-Year Reviews.		
	UW-1	C	UW well to determine if vertical migration of nitrate has occurred from the weathered unit. - Clustered with MW-4037.		- Any location exceeding 500 mg/l with confirmatory sampling.	- Increase sampling frequency to quarterly at all Nitrate locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 500 mg/l, then recalculate MNA timeframes.

TABLE C.2 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
	MW-3006 (UW)	C	- UW well. - Nitrate data <1 mg/l. - Clustered with MW-3003 and MW-3023, which have concentrations at 300 mg/l.			
MNA Performance Monitoring for Nitrate	SP-6301	C, D	- Primary discharge point for groundwater originating from the chemical plant. - Nitrate concentrations decreased substantially after Ash Pond Diversion was constructed. Levels have since stabilized to <20 mg/l. - Point of exposure.	Semiannual.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002.	- Increase sampling frequency to quarterly at all Nitrate MNA locations. - Investigate possible external sources of Nitrate. - After 4 quarters, continue quarterly monitoring at all locations which exceed baseline and return to semiannual for locations which are below baseline. - Add appropriate monitoring locations.
	SP-6303	C, D	- Discharge point for groundwater originating from the chemical plant. - Nitrate has declined from high of 66 mg/l to <20 mg/l. - Point of exposure.		- Any location exceeding 100 mg/l with confirmatory sampling.	- Increase sampling frequency to quarterly at all Nitrate locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 100 mg/l, then recalculate MNA timeframes and reevaluate ICs.

TABLE C.2 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitrate	MW-2035	E	- Upgradient weathered monitoring location. - All nitrate data <1 mg/l. - Large dataset. - Same upgradient location as TCE monitoring approach.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Review.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002. - Exceeds 100 mg/l with 2 quarters of confirmatory sampling.	- Increase sampling frequency to quarterly at all nitrate locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling. - Add appropriate monitoring locations. - Increase sampling frequency to quarterly at all nitrate locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 100 mg/l, then recalculate MNA timeframes.

TABLE C.2 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
Hydrologic Stability	MW-2032	G	- Cross-gradient from Ash Pond nitrate impact area. - Weathered location.	- Semiannual water level measurements throughout monitoring program. - Water table map will be constructed for each semi-annual measurement event.	- Change in the groundwater table that indicates insufficient monitoring coverage. May be due to changes in flow directions or increase/decrease in gradient.	- Reevaluate MNA predicted timeframes. - Reevaluate ICs. - Reevaluate if additional wells should be included in monitoring program due to changes in groundwater flow.
	MW-4023	G	- Upgradient from Raffinate Pit nitrate impact area. - Weathered location.			
	MW-4022(UW)	G	- Upgradient from nitrate area. - Unweathered location.		- Groundwater elevation has decreased to a level that results in "dry" monitoring wells.	- Reevaluate adequacy of monitoring network for long-term program.

TABLE C.3 Proposed MNA Performance Monitoring for Uranium

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Uranium	MW-3024	B	- One of two wells with uranium concentrations above the MCL. Stable conc.s ranging from 44 to 72 pCi/l over last 6 years. - Not impacted by P&T	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002	- Increase sampling frequency to quarterly at these "B" locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling.
	MW-3030	B	- Second of two wells with uranium concentrations above the MCL. Stable conc.s ranging from 47 to 73 pCi/l over last 2 years. - Along flow path from MW-3024. - Not impacted by P&T.		- Any location exceeding 300 pCi/l with confirmatory sampling.	- Increase sampling frequency to quarterly at these "B" locations. - If 2 consecutive quarters with confirmatory sampling show a single location with concentrations greater than 300 pCi/l, then recalculate MNA timeframes.

TABLE C.3 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Uranium	MWS-1	C	- W well located along flow path for nitrate and TCE contaminants. Should also be along uranium flow path. - 3 data points, highest is 1.3 pCi/l.	- Quarterly for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan to build baseline dataset. - Annually thereafter. - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during baseline period of 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. (For locations consistently <5 pCi/l, the threshold of mean plus 3 sigma will be replaced by 20 pCi/l)	- Increase sampling frequency to quarterly at all Uranium locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling. - Add appropriate monitoring locations.
	MW-4036	C	W well along flowpath from impacted wells. One 2001 data point is 15 pCi/l.			
	W-1	C	- W well located along flow path for nitrate and TCE contaminants. Should also be along uranium flow path.			
	MW-4007	C	UW well along flowpath from impacted weathered wells. Recent data all <3 pCi/l.		- Any location exceeding 100 pCi/l with confirmatory sampling.	- Increase sampling frequency to quarterly at all Uranium locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 100 pCi/l, then recalculate MNA timeframes.

TABLE C.3 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Uranium	SP-6301 (Burgermeister Spring)	C, D	- Primary discharge point for groundwater originating from the chemical plant. - Uranium concentrations have decreased gradually over time, now ranging from 10 to 100 pCi/l. - Point of recreational exposure.	Semiannual.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002. (Conc.s at SP-6303 are too low to apply mean plus 3 sigma).	- Increase sampling frequency to quarterly at all Uranium locations. - After 4 quarters, continue quarterly monitoring at all locations which exceed baseline and return to semiannual for locations which are below baseline. - Add appropriate monitoring locations.
	SP-6303	C, D	- Discharge point for groundwater originating from the chemical plant. - Uranium concentrations have decreased gradually over time, now stable at <1 pCi/l. - Point of recreational exposure.			
	SP-5303	C, D	- Discharge point in Southeast Drainage. - Uranium concentrations have decreased gradually over time, now ranging from 25 to 150 pCi/l. - Point of recreational exposure.		- Any location exceeding 300 pCi/l with confirmatory sampling.	- Increase sampling frequency to quarterly at all Uranium locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 300 pCi/l, then recalculate MNA timeframes and reevaluate ICs.
	SP-5304	C, D	- Discharge point in Southeast Drainage. - Uranium concentrations have decreased gradually over time, now ranging from 10 to 100 pCi/l. - Point of recreational exposure.			

TABLE C.3 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Uranium	MW-2035	E	- Upgradient weathered monitoring location. - Uranium data for last 5 years <1 pCi/l. - Large dataset. - Same upgradient location as other contaminants in MNA monitoring approach.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Review.	- A concentration >20 pCi/l	- Increase sampling frequency to quarterly at all uranium locations. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, then continue quarterly sampling. - Add appropriate monitoring locations.
					- Exceeds 100 pCi/l with 2 quarters of confirmatory sampling.	- Increase sampling frequency to quarterly at all uranium locations. - If 2 consecutive quarters with confirmatory sampling show concentrations greater than 100 pCi/l, then recalculate MNA timeframes.

TABLE C.3 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
Hydrologic Stability	Locations established as part of TCE and Nitrate evaluations are sufficient for uranium			- Semiannual water level measurements throughout monitoring program. - Water table map will be constructed for each semi-annual measurement event.	- Change in the groundwater table that indicates insufficient monitoring coverage. May be due to changes in flow directions or increase/decrease in gradient. - Groundwater elevation has decreased to a level that results in "dry" monitoring wells.	- Reevaluate MNA predicted timeframes. - Reevaluate ICs. - Reevaluate if additional wells should be included in monitoring program due to changes in groundwater flow. - Reevaluate adequacy of monitoring network for long-term program.

TABLE C.4 Proposed MNA Performance Monitoring for Nitroaromatic Compounds

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	MW-2012	B-1	- Weathered well that monitors highest impact from nitroaromatic compounds in the Frog Pond area. - Located in flow pathway in northeast portion of the site. - 2,4-DNT and 2,6-DNT highest at this location (2002 maximum of 1600 μg/l and 1300 μg/l, respectively). -1,3,5-TNB; 2,4,6-TNT; and nitrobenzene also present. - Increases observed after performing soil removal action in 1999. - Large data set.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002. - A confirmed concentration greater than 2,000 μg/l for 2,4-DNT.	- Increase sampling frequency to quarterly at MW-2012. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, and all other "B-1" locations are below baseline, then continue quarterly sampling at location above baseline. (3) If concentration remains above baseline and any other "B-1" location is above baseline levels, then continue quarterly sampling at all locations - If 2 consecutive quarters with confirmatory sampling show this well exceeds 2,000 μg/l,(2,4-DNT) add appropriate existing downgradient monitoring locations to quarterly sampling, investigate possible upgradient sources or changed conditions, recalculate MNA timeframes, and reevaluate ICs.

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	MW-2014	B-1	- Weathered well located upgradient of highest impact from nitroaromatic compounds in the Frog Pond area- - Can be used to demonstrate decrease of contaminants. - 2,4-DNT presently at 0.15 μg/l. - 1,3,5-TNB and 2,6-DNT also present. - Large dataset.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002. - The average concentration of the B-1 wells is greater than 400 μg/l for 2,4-DNT based on confirmatory sampling.	- Increase sampling frequency to quarterly the suspect location. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentrations remain above baseline levels, and all other "B-1" locations are below baseline, then continue quarterly sampling at location above baseline. (3) If concentration remains above baseline and any other "B-1" location is above baseline levels, then continue quarterly sampling at all locations - If confirmatory sampling shows the average concentration of the B-1 wells exceeds 400 μg/l (2,4-DNT), add appropriate existing downgradient monitoring locations to quarterly sampling, investigate possible upgradient sources or changed conditions, recalculate MNA timeframes, and reevaluate ICs.
	MW-2052	B-1	- Weathered well located downgradient of highest impact from nitroaromatic compounds in the Frog Pond area- - Can be used to monitor expected dispersion of contaminants along flow path. - 2,4-DNT presently at 0.13 μg/l. - 1,3,5-TNB and 2,4,6-TNT also present. -Recently installed (2001).			
	MW-2054	B-1	- Weathered well located upgradient of highest impact from nitroaromatic compounds in the Frog Pond area- - Can be used to demonstrate decrease of contaminants. 2,4-DNT at 7 μg/l. - 1,3,5-TNB and 2,6-DNT also present. - Recently installed (2001).			

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
	MW-4015	B-1	- Weathered well located downgradient of highest impact from nitroaromatic compounds in the Frog Pond Area- - Can be used to monitor expected dispersion of contaminants along flow path. - 2,4-DNT presently less than 0.11 μg/l. - 1,3,5-TNB and 2,6-DNT also present. - Large dataset.			
	MW-4030	B-1	- Weathered well located cross-gradient of highest impact from nitroaromatic compounds in the Frog Pond area- - Can be used to demonstrate decrease of contaminants. - 2,4-DNT presently at 0.18 μg/l. - 1,3,5-TNB; 2,4,6-TNT, and 2,6-DNT also present. - Recently installed (2000). - Also monitors Lagoon 1 (WSOW) source area.			

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	MW-3030	B-2	- Weathered well monitors highest impact from nitroaromatic compounds in the Raffinate Pits area. - Located in flow pathway in southwest portion of the site. - 2,4-DNT presently at 1.2 μg/l. - 2,6-DNT also present. - Recently installed (2001).	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Reviews.	- A concentration at any location greater than established baseline levels. Baseline is defined as the arithmetic mean plus 3 standard deviations as determined from data collected during 2001 and 2002.	- Increase sampling frequency to quarterly at suspect "B-2" location. - After 4 quarters, (1) if concentration falls below baseline levels, then return to previous sampling frequency. (2) If concentration at B-2 location remains above baseline levels and all other "B-2" locations are below baseline, then continue quarterly sampling at location above baseline. (3) If concentration remains above baseline and any other "B-2" location is above baseline levels, then continue quarterly sampling at all locations
	MW-4001	B-2	- Weathered well located downgradient of highest impact from nitroaromatic compounds in the Raffinate Pits area- - Can be used to monitor expected dispersion of contaminants along flow path. - 2,4-DNT presently at 0.22 μg/l. - 1,3,5-TNB; 2,4,6-TNT; and 2,6-DNT also present. - Large dataset. - May also show impact from source areas on the WSOW.			
	MW-4029	B-2	- Weathered well located downgradient of highest impact from nitroaromatic compounds in the Raffinate Pits area- - Can be used to monitor expected dispersion of contaminants along flow path. - 2,4-DNT presently at 0.13 μg/l. - 1,3,5-TNB and 2,6-DNT also present. - Recently installed (2001).		- The average concentration of the B-2 wells is greater than 100 μg/l for 2,4-DNT based on confirmatory sampling.	- If confirmatory sampling shows the average concentration of the B-1 wells exceeds 100 μg/l (2,4-DNT), add appropriate existing downgradient monitoring locations to quarterly sampling, investigate possible upgradient sources or changed conditions, recalculate MNA timeframes, and reevaluate ICs.

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	MW-2002	B-2	- Weathered well monitors impact from nitroaromatic compounds in the Ash Pond area. - Located in flow pathway in northwest portion of the site. - No 2,4-DNT, but 1,3,5-TNB and 2,6-DNT present. - Large dataset.			
	MW-3003	B-2	- Weathered well monitors impact from nitroaromatic compounds north of the Raffinate Pits area. - Located in flow pathway in northeastern portion of the site. - 2,4-DNT at 0.14 mg/l. - 2,6-DNT also present. - Large dataset.			
	MW-4013	B-2	- Weathered well monitors highest impact from nitroaromatic compounds north of the chemical plant proper. - Located in flow pathway in northern portion of the site. - No 2,4-DNT, but 1,3,5-TNB and 2,6-DNT present. - Historically as shown 2,4-DNT impact.			

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	MW-4014	C	-Weathered well located along flow path from Frog Pond area. - Historical 2,4-DNT data all ND's. - Historically has shown nitroaromatic compound impact.	- All "C" wells will be sampled quarterly for 2 years to build dataset. - Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - All wells sampled annually thereafter. - Reevaluate/optimize as part of 5-Year Reviews.	None, pending regional nitroaromatic groundwater decision to be documented by US Army Corps of Engineers in Record of Decision for the Weldon Spring Ordnance Works. DOE RD/RA Work Plan will be modified to reflect changes in this area after the Army ROD is signed and implemented.	None, pending regional nitroaromatic groundwater decision to be documented by US Army Corps of Engineers in Record of Decision for the Weldon Spring Ordnance Works. DOE RD/RA Work Plan will be modified to reflect changes in this area after the Army ROD is signed and implemented.
	MWS-1	C	Weathered well located along flow path from Ash Pond and Raffinate Pits area. - Recent data indicates no 2,4-DNT; however, 2,6-DNT has been observed. - Other areas of nitroaromatic compound impact on the WSOW could impact this location.			
	MW-2021	C	- Unweathered well located beneath Ash Pond area. - Clustered with MW-2002, which shows elevated levels of nitroaromatic compounds. - Historical data all ND's.			
	MW-3006	C	- Unweathered well located adjacent to Raffinate Pit area. - Clustered with MW-3003, which shows elevated levels of nitroaromatic compounds. - Data since 1991 all ND's.			
	MW-4007	C	- Unweathered well located downgradient of Raffinate Pit area. - Clustered with MW-4001, which shows elevated levels of nitroaromatic compounds. - Data since 1990 all ND's.			

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	SP-6301	C, D	- Primary discharge point for groundwater originating from the chemical plant. - Point of exposure. - 2,4-DNT presently at 0.07 μg/l. - 2,6-DNT also present.	Semiannual.	None, pending regional nitroaromatic groundwater decision to be documented by US Army Corps of Engineers in Record of Decision for the Weldon Spring Ordnance Works. DOE RD/RA Work Plan will be modified to reflect changes in this area after the Army ROD is signed and implemented.	None, pending regional nitroaromatic groundwater decision to be documented by US Army Corps of Engineers in Record of Decision for the Weldon Spring Ordnance Works. DOE RD/RA Work Plan will be modified to reflect changes in this area after the Army ROD is signed and implemented.
	SP-6303	C, D	- Discharge point for groundwater originating from the chemical plant. - Point of exposure. - 2,4-DNT presently at 0.1 μg/l. - 1,3,5-TNB; 2,4,6-TNT, and 2,6-DNT also present.			

TABLE C.4 (Cont.)

Goal	Monitoring Locations	Objective	Rationale for Selection	Sampling Frequency	Trigger Concentration or Event	Contingency Actions
MNA Performance Monitoring for Nitroaromatic Compounds	MW-2017	E	- Upgradient weathered monitoring location for the Frog Pond Area. - All data ND. - Large dataset.	- Semiannual for 2 years after initiation of the long-term monitoring as described in the RD/RA Work Plan. - Annual thereafter - Reevaluate/optimize as part of 5-Year Review.	- Detection and confirmation of sample equal to or greater than 0.11 μg/l at this location.	- Increase sampling frequency to quarterly at this and the appropriate "B" locations. - After 4 quarters, (1) if concentrations return to less than 0.11 μg/l, then return to previous sampling frequency. (2) If concentration remains greater than 0.11 μg/l and all other "B" locations are below baseline, then continue quarterly sampling at location above trigger level. (3) If concentration remains greater than 0.11 μg/l and any other "B" location is above baseline levels, then continue quarterly sampling at all locations, add appropriate existing downgradient monitoring locations to quarterly sampling, investigate possible upgradient sources or changed conditions, recalculate MNA timeframes, and reevaluate ICs.
	MW-2035	E	- Upgradient weathered monitoring location for the Raffinate Pit area. - All data ND. - Large dataset.			