DRAFT FINAL

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR SITE-WIDE GROUNDWATER AT THE FORMER BADGER ARMY AMMUNITION PLANT, BARABOO, WISCONSIN

Prepared for:
U.S. Army Environmental Command
2950 Connell Road
JBSA – Fort Sam Houston, TX 78232

NOVEMBER 2019

Prepared by:
SpecPro Professional Services, LLC
S7560 U.S. Highway 12
North Freedom, WI 53951

EXECUTIVE SUMMARY

This Remedial Investigation/Feasibility Study (RI/FS) presents updated groundwater investigation results, human health risk assessment findings, and the analysis of remedial alternatives for contaminated groundwater at the former Badger Army Ammunition Plant (BAAP). The RI/FS is prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and the Defense Environmental Restoration Program (DERP) requirements.

BAAP was constructed in 1942 to produce smokeless gunpowder and solid rocket propellant as munitions components for World War II. The former BAAP is located on the Sauk Prairie, between the Baraboo Range and the Wisconsin River. Because of production and waste disposal practices that were common at the time, soil and groundwater at the former BAAP were impacted. The Department of the Army (Army) has transferred a majority of the total 7,275 acres of BAAP to other Federal agencies.

The Army began assessing potential waste management areas that may be sources of soil and groundwater contamination in 1980. When the Army applied for a Resource Conservation and Recovery Act (RCRA) permit in 1988, the State of Wisconsin did not have authorization to implement certain elements of RCRA, also known as the Hazardous and Solid Waste Amendments of 1984, so the Army operated under a dual federal-state permit, where the Wisconsin Department of Natural Resources (WDNR) regulated the RCRA operating and/or closure requirements and the United States Environmental Protection Agency (USEPA) addressed RCRA corrective action requirements.

RCRA closure and post-closure requirements were managed through an *In-Field Conditions Report* (IFCR), which WDNR issued in 1987. As required by the IFCR, the Army has been conducting groundwater monitoring of both monitoring wells and residential wells since 1987. The current site-wide groundwater monitoring program follows the IFCR dated September 4, 2013 and subsequent revisions up through July 24, 2018. Currently, the Army is sampling 166 monitoring wells and 54 residential wells at varying frequencies.

In 2011, the Army submitted a Revised Alternative Feasibility Study, Groundwater Remedial Strategy report to the WDNR. The selected groundwater remedy was Monitored Natural Attenuation (MNA). Due to the relatively long remedial timeframe for the MNA remedy to achieve the proposed cleanup levels, the proposed remedy included construction and operation of a municipal drinking water system that would provide residents in the communities surrounding the former BAAP with drinking water while groundwater contamination continued to diminish over time. During an evaluation by the Army's Office of General Counsel it was determined the Army did not have the legal or funding authority to procure and operate a municipal water system as identified in the 2011 Revised Alternative Feasibility Study.

While a draft Decision Document (DD) for Site-Wide Groundwater was being prepared in 2012, the Army identified several areas where the draft DD did not meet both legal and policy requirements. Specifically, a human health risk assessment was not prepared, incorrect legal standards were identified for the selected groundwater remedy and key components of the proposed response action were outside the Army's authority. In 2017, the Army coordinated with the WDNR and informed the public regarding the need to align the Badger Site-Wide Groundwater remedy selection to comply with legal, policy, and funding authorities. The Army communicated the need to reevaluate the groundwater remedy at BAAP in a letter dated July 25, 2017.

Remedial Investigation

The Army has conducted numerous site investigations and remedial actions at the former BAAP property. Groundwater investigation activities at BAAP began in 1980. Site-wide groundwater investigations identified four groundwater plumes: Propellant Burning Ground (PBG) Plume, Central Plume, Deterrent Burning Ground (DBG) Plume, and Nitrocellulose Production Area (NC Area) Plume.

The regional groundwater flow direction in the BAAP area is south-southeast towards the Wisconsin River. The Wisconsin River acts as a discharge point for groundwater east and south of BAAP. Based on historical groundwater sampling data, groundwater is contaminated by chlorinated solvents and explosives. While other contaminants of concern were detected, it is unlikely these contaminants are site related.

The Army has replaced seven residential drinking water wells due to groundwater impacts associated with the BAAP groundwater plumes. Three residential wells were impacted by the PBG Plume where volatile organic compounds (VOCs) were detected above WDNR NR 140 Enforcement Standards (ES). Three residential wells were impacted by the Central Plume where total DNT concentrations exceeded the NR 140 ES. The final residential well that was replaced was impacted by the DBG Plume where total DNT concentrations exceeded the NR 140 ES. All seven residential wells withdrew water from the shallow sand and gravel aquifer.

Remedial activities addressing source areas for the four groundwater contaminant plumes have been implemented. Soil remedial actions addressed the source areas to the maximum extent possible and minimized the potential exposure to human health based on anticipated future land use at the former BAAP. The Army has received site closure from the WDNR on all soil related investigations and remedial actions at BAAP.

Risk Assessment

A groundwater human health risk assessment (HHRA) was conducted in 2018. The HHRA evaluated whether groundwater contamination originating from the BAAP poses a current or hypothetical future risk to human health. The HHRA evaluated two potential ways people could be exposed to chemicals in groundwater, through vapor intrusion and domestic use of groundwater. The HHRA is based on conservative screening level risk calculations using maximum groundwater chemical concentrations detected in each groundwater plume. These conservative calculations overestimate the actual risk.

Based on previous vapor intrusion investigations, groundwater contamination at the BAAP does not pose a current or potential future risk to area residents due to vapor intrusion from any of the four groundwater plumes.

The groundwater risk evaluation was conducted to estimate the potential risk associated with the domestic use of groundwater. Groundwater quality data (residential wells and monitoring wells) from 2015, 2016, 2017 and 2018 were used for the initial screening level risk evaluation to represent current and hypothetical future groundwater quality. The default risk-based screening values provided in the United States Environmental Protection Agency's (USEPA) Regional Screening Levels (RSLs) Resident Tapwater Generic Table (November 2018) were used to calculate both the cancer and non-cancer risks. The Tapwater RSLs incorporate exposure to chemicals in groundwater associated with ingestion (drinking water and food preparation), as well as dermal contact (hand washing and bathing) and inhalation (bathing, food preparation, and dishwashing) during use of the groundwater. When making risk management decisions, the Army considered a cumulative cancer risk above $1x10^{-6}$ (one in a million) for off-site residential wells and groundwater monitoring wells (current risk) and $1x10^{-4}$ (one in ten thousand) for on-site groundwater monitoring wells (hypothetical future) where existing property transfer documents are restricting access to groundwater. For both the off-site and on-site risk evaluations, the RI/FS identifies potential remedies when the cumulative non-cancer risk hazard index exceeds 1.0.

The risk-based COCs identified in the PBG Plume were chloroform, CTET, ethyl ether, TCE, and 2,6-DNT. For the PBG Plume, the risk evaluation identified unacceptable cancer risks and non-cancer hazards associated with current (off-site) groundwater access, as well as hypothetical future (on-site) cancer and non-cancer risk above the risk management criteria.

The risk-based COCs identified in the DBG Plume were chloroform, 1,1,2-TCA, TCE, and total DNT. For the DBG Plume, the risk evaluation identified unacceptable cancer risks and non-cancer hazards associated with current (off-site) groundwater access, as well as hypothetical future (on-site) non-cancer risk above the risk management criteria.

The risk-based COCs identified in the Central Plume were 1,2-dichloroethane, benzene, chloroform, and 2,6-DNT. The risk evaluation indicated that the Central Plume has current (off-site) cancer risk above the risk management criteria.

There were no risk-based COCs identified in the NC Area Plume. The current and future hypothetical cancer risks and non-cancer hazards associated with the NC Area Plume are below the risk management criteria.

The COCs that are identified in the RI have an associated current or hypothetical future risk. The Feasibility Study evaluates potential response actions for the identified risks.

Feasibility Study

The FS identifies and provides a detailed evaluation of potential remedial alternatives that could reduce, control or mitigate exposure to groundwater COCs. Remedial alternatives considered in the FS must be protective of human health and the environment for the PBG Plume, DBG Plume, and Central Plume and meet Applicable, or Relevant and Appropriate Requirements (ARARs), which are CERCLA threshold criteria for remedy selection. The HHRA did not identify COCs for the NC Area Plume. Therefore, remedial alternatives are not being considered for the NC Area Plume.

The FS includes remedial action objectives (RAOs), which provide a general description of what the cleanup will accomplish, serves as the basis for evaluating each remedial alternative, and provides an understanding of how the unacceptable risks will be addressed by each remedial alternative.

Groundwater RAOs require the remedy to protect human health by preventing exposure to contaminated groundwater, to restore groundwater to the extent practicable, and minimize the impact of the contaminant plumes on the environment. Specifically, the RAOs for any individual plume are achieved when the risk-based groundwater COCs are below cleanup levels. The FS includes the identification and evaluation of general response actions (GRAs), remedial technologies, and process options with respect to effectiveness, implementability, and cost. Appropriate remedial technologies and process options were carried forward and combined to develop remedial alternatives for each individual plume. The remedial alternatives and a brief description are listed below.

Remedial Alternatives – PBG Plume

Based on site conditions and the screening of process options, six remedial alternatives were developed for the PBG Plume to address the presence of contaminants in groundwater at the BAAP.

Alternative 1: No Action

The No Action Alternative is a mandatory evaluation that provides a baseline to evaluate the other alternatives. It would have no impact on the contaminant plume, require no groundwater monitoring but would include on-site groundwater access restrictions.

Alternative 2: Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation (MNA) and Alternate Water Supply Alternative would include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 3: Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would target areas remediating the impacted groundwater with elevated 2,6-DNT concentrations. It would include groundwater removal through four extraction wells and treatment units located both on-site and off-site. It would also include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 4: Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would target remediating the impacted groundwater with elevated 2,6-DNT concentrations. It would include in-situ biochemical treatment utilizing permanent injection wells and temporary injection points to administer the biochemical product into the contaminant plume. The injection locations would be located both on-site and off-site. It would also include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 5: Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer residential wells, meeting replacement criteria, near the PBG Plume with deeper bedrock aquifer wells. It would also include continued groundwater monitoring and on-site groundwater access restrictions.

Alternative 6: Source Area Treatment

The Source Area Treatment Alternative would target remediating the impacted groundwater with elevated 2,6-DNT concentrations directly downgradient of the source areas. It would include in-situ biochemical treatment utilizing permanent injection wells to administer the biochemical product into the contaminant plume. In addition, the alternative would include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Remedial Alternatives – DBG Plume

Based on site conditions and the screening of process options, six remedial alternatives were developed for the DBG Plume to address the presence of contaminants in groundwater at the BAAP.

Alternative 1: No Action

The No Action Alternative is a mandatory evaluation that provides a baseline to evaluate the other alternatives. It would have no impact on the contaminant plume, require no groundwater monitoring but would include on-site groundwater access restrictions.

Alternative 2: Monitored Natural Attenuation and Alternate Water Supply

The MNA and Alternate Water Supply Alternative would include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 3: Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would target remediating the impacted groundwater with elevated total DNT concentrations. It would include groundwater removal through three extraction wells and treatment units located both on-site and off-site. The alternative would also include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 4: Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would target remediating the impacted groundwater with elevated total DNT concentrations. It would include in-situ biochemical treatment utilizing temporary injection points to administer the biochemical product into the contaminant plume. The temporary injection points would be located both on-site and off-site. It would also include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 5: Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer residential wells, meeting replacement criteria, near the DBG Plume with deeper bedrock aquifer wells. It would also include continued groundwater monitoring and on-site groundwater access restrictions.

Alternative 6: Source Area Treatment

The Source Area Treatment Alternative would target remediating the impacted groundwater with elevated total DNT concentrations directly downgradient of the source area. It would include in-situ biochemical treatment utilizing temporary injection points to administer the biochemical product into the contaminant plume. In addition, the alternative would include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Remedial Alternatives – Central Plume

Based on site conditions and the screening of process options, five remedial alternatives were developed for the Central Plume to address the presence of contaminants in groundwater at the BAAP.

Alternative 1: No Action

The No Action Alternative is a mandatory evaluation that provides a baseline to evaluate the other alternatives. It would have no impact on the contaminant plume, require no groundwater monitoring but would include on-site groundwater access restrictions.

Alternative 2: Monitored Natural Attenuation and Alternate Water Supply

The MNA and Alternate Water Supply Alternative would include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 3: Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would target remediating the impacted groundwater with elevated 2,6-DNT concentrations. It would include groundwater removal through eight extraction wells and treatment units. The alternative would also include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 4: Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would target remediating the impacted groundwater with elevated 2,6-DNT concentrations. It would include in-situ biochemical treatment utilizing temporary injection points to administer the biochemical product into the contaminant plume. The temporary injection points would be located both on-site and off-site. It would also include continued groundwater monitoring, on-site groundwater access restrictions, and a provision for an alternate water supply, where necessary.

Alternative 5: Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer residential wells, meeting replacement criteria, near the Central Plume with deeper bedrock aquifer wells. It would also include continued groundwater monitoring and on-site groundwater access restrictions.

Each alternative was evaluated based on criteria identified the USEPAs 1994 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and includes overall protection of human health and the environment, compliance with Applicable or Relevant and Appropriate Requirements (ARARs), long-term effectiveness and permanence, reduction in toxicity, mobility and volume, short-term effectiveness, implementability, and cost.

The Army's preferred alternative or remedy will be presented in the Proposed Plan; the remedy will be based on the results of this RI/FS. The Proposed Plan will briefly summarize the remedial investigation and the remedial alternatives evaluated in this RI/FS, highlighting the key factors that led to identifying the preferred alternative. The Army will submit the Proposed Plan to the regulatory agencies and then the public for review. After this review, the Army will release a Decision Document that documents the selected remedy, certifies that the remedy selection process was carried out in accordance with CERCLA, and addresses public comments on the Proposed Plan.

CERTIFICATION PAGE

Certification Statement
In accordance with NR 712.09, a registered professional engineer, a hydrogeologist, or a scientist from the State of Wisconsin shall certify this report. The required certification statements are presented, and signed and sealed as follows:

"I, **Joel L. Janssen**, hereby certify that I am a Professional Geologist as that term is defined in s. NR 712.03(1), Wis. Adm. Code, and that, to the best of my knowledge, all of the information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code."

Joel L. Janssen

11/05/19

Joel L. Janssen, P.G. License No. 1325
Geologist, SpecPro Professional Services, LLC

Date

JOEL
L.
JANSSEN
PG-1325
MADISON, WI

"I, **Brian S. Jacobs**, hereby certify that I am a professional engineer in the State of Wisconsin, registered in accordance with the requirements of ch. A-E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code."

11/05/19

Brian S. Jacobs, P.E. License No. 35309-006
Engineer, SpecPro Professional Services, LLC

Date

BRIAN
JACOBS
E-35309-006
MADISON
WI

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

1,1,1-TCA	1,1,1-Trichloroethane
1,1,2-TCA	1,1,2-Trichloroethane
2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
µg/l	Micrograms per liter
ARAR	Applicable or relevant and appropriate requirement
atm	Atmosphere-meters
Army	Department of the Army
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
BAAP	Badger Army Ammunition Plant
BEST	Biologically Enhanced Subsurface Treatment
BNA	Base Neutral Acid
BSD	Bluffview Sanitary District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund: Amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA).
cm/sec	Centimeters per second
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern

CSM	Conceptual Site Model
CTET	Carbon Tetrachloride
DBG	Deterrent Burning Ground
DD	Decision Document
DERP	Defense Environmental Restoration Program
DNT	Dinitrotoluene
DoD	Department of Defense
EBS	Enhanced Biodegradation System
ES	Enforcement Standard
ºF	Degrees Fahrenheit
FS	Feasibility Study
ft/ft	Feet per foot
GAC	Granular Activated Carbon
GEMS	Groundwater and Environmental Monitoring System (WDNR)
gpm	Gallons per minute
GRA	General Response Action
HDPE	High-Density Polyethylene
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HWTTU	Hazardous Waste Thermal Treatment Unit
IFCR	In-Field Conditions Report
IRM	Interim Remedial Measures
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MIRM	Modified Interim Remedial Measures
mg/l	Milligrams per liter
MNA	Monitored Natural Attenuation
MSL	Mean Sea Level
OSWER	Office of Solid Waste and Emergency Response
NC	Nitrocellulose
NC Area	Nitrocellulose Production Area
NCP	National Oil and Hazardous Substances Contingency Plan
NG	Nitroglycerin
NPS	National Park Service
NR	Natural Resources
NPDWR	National Primary Drinking Water Regulations
NSDWR	National Secondary Drinking Water Regulations
O&M	Operation and Maintenance
PAL	Preventive Action Limit
PBG	Propellant Burning Ground
PDS	Prairie du Sac
PP	Proposed Plan
ppt	Inches of Precipitation
PSTS	Pilot-Scale Treatability Study
RA	Remedial Action

RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RSL	Regional Screening Level
RI	Remedial Investigation
SPS	SpecPro Professional Services, LLC
RI/FS	Remedial Investigation/Feasibility Study
SMCL	**S**econdary Maximum Contaminant Level
SVE	Soil Vapor Extraction
SVOC	Semi-volatile Organic Compounds
TBC	To be considered
TCE	Trichloroethene or Trichloroethylene
THQ	Total Hazard Quotient
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WDHFS	Wisconsin Department of Health and Family Services
WDNR	Wisconsin Department of Natural Resources
WDOT	Wisconsin Department of Transportation
Wis. Adm. Code	Wisconsin Administrative Code
WPDES	Wisconsin Pollutant Discharge Elimination System
WP&L	Wisconsin Power and Light
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) was prepared by SpecPro Professional Services, LLC (SPS), for the Department of Army (Army) for investigation and remediation activities at the former Badger Army Ammunition Plant (BAAP) in Sauk County, Wisconsin. This RI/FS presents updated groundwater investigation results and the analysis of remediation alternatives for contaminated groundwater at the BAAP in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

Environmental cleanup decision-making under CERCLA follows a prescribed sequence: Remedial Investigation (RI), Feasibility Study (FS), Proposed Plan (PP), and Record of Decision (ROD). Under the Defense Environmental Restoration Program (DERP), the Department of Defense (DoD) has conducted investigation and cleanup activities at BAAP. The DoD Manual, DERP Management, dated March 9, 2012 outlines the policies and procedures the Army must follow when conducting environmental restoration.

The RI serves as the mechanism for collecting data to characterize site conditions, determine the nature and extent of the contamination, and assess risks to human health and the environment from this contamination.

This RI/FS was prepared to serve as a principal source for decision-making relating to remediation of groundwater impacts from the BAAP. The report provides a summary of historic and current groundwater investigation and remediation efforts by the Army and describes the development and re-evaluation of groundwater remedial action alternatives for the BAAP.

The Army’s preferred alternative or remedy will be presented in the PP; the remedy will be based on the results of this RI/FS. The PP will briefly summarize the remedial investigation and the alternatives evaluated in this RI/FS, highlighting the key factors that led to identifying the preferred alternative. The Army will submit the Proposed Plan to the regulatory agencies and then the public for review. After this review, the Army will release a Decision Document (DD) that documents the selected remedy, certifies that the remedy selection process was carried out in accordance with CERCLA, and addresses public comments on the Proposed Plan. Included within the DD is the Army’s ROD.

The In-field Conditions Report (IFCR), issued by the Wisconsin Department of Natural Resources (WDNR) in 1987, and subsequent amendments, calls for groundwater monitoring and reporting at the BAAP. The current site-wide groundwater monitoring program follows the IFCR dated September 4, 2013 and subsequent revisions up through July 24, 2018.

The initial site-wide RI and FS were completed in 1993 and 1994 (ABB-ES, 1993 and 1994). Soil and groundwater remedial alternatives were analyzed, selected, and approved by the Army and state and federal regulators for the PBG and Deterrent Burning Ground (DBG) areas, and their associated groundwater contaminant plumes. In addition to the PBG and DBG areas and their associated plumes, the Central Plume and Nitrocellulose Production Area (NC Area) Plume have since been identified through further groundwater investigations; however, remedial investigations and actions were previously completed in these areas. These activities were documented and reported to the WDNR. These efforts have met soil remediation action goals and have received regulatory closure. Investigation of groundwater has been ongoing at the BAAP from 1980 to the present. The interim groundwater remedial action for the Propellant Burning Ground (PBG) Plume began in 1990 and continued through 2015. Groundwater monitoring associated with the current sites addressed under Resource Conservation and Recovery Act (RCRA) closure will continue indefinitely (30 years or more) until the WDNR approves case closure.

In December of 2011, the Army completed and submitted to the WDNR, a Revised Alternative Feasibility Study, Groundwater Remedial Strategy report. The selected groundwater remedy was Monitored Natural Attenuation (MNA). Due to the relatively long remedial timeframe for the MNA remedy to achieve the proposed cleanup levels, the proposed remedy included construction and operation of a municipal drinking water system that would provide residents in the communities surrounding the former BAAP with drinking water while groundwater contamination continued to diminish over time. During an evaluation by the Army's Office of General Counsel it was determined the Army did not have the legal or funding authority to procure and operate a municipal water system as identified in the 2011 Revised Alternative Feasibility Study.

While a draft Decision Document (DD) for Site-Wide Groundwater was being prepared in 2012, the Army identified several areas where the draft DD did not meet both legal and policy requirements. Specifically, a human health risk assessment was not prepared, incorrect legal standards were identified for the selected groundwater remedy and key components of the proposed response action were outside the Army's authority.

Since 2012, the Army has monitored groundwater, which included installing new monitoring wells and continued evaluation of the contaminant plumes through groundwater monitoring. In addition, the Army has completed the systematic shutdown of the Interim Remedial Measures (IRM) and Modified Interim Remedial Measures (MIRM) being conducted at the Propellant Burning Ground. A summary of the Army’s actions to address the WDNR’s conditions of approval is provided in Appendix A.

In 2017, the Army coordinated with the WDNR and the public regarding the need to align with Badger Site-Wide Groundwater remedy selection to comply with legal, policy, and funding authorities. The Army communicated the need to reevaluate the groundwater remedy in a letter dated July 25, 2017. This RI/FS includes the HHRA which is based on groundwater data collected from 2015 through 2018.

2.0 SITE BACKGROUND

2.1 Site Description

The BAAP, located in south-central Wisconsin within Sumpter and Merrimac Townships in Sauk County, was constructed in 1942 to produce smokeless gunpowder and solid rocket propellant as munitions components for World War II by the Army. BAAP is located on the Sauk Prairie, between the Baraboo Range and the Wisconsin River.

Production of nitric acid, sulfuric acid, oleum (also known as fuming sulfuric acid), nitrocellulose (NC), and nitroglycerin (NG) occurred in support of munitions components production. Production periods were as follows: World War II (1942 to 1945), Korean War (1951 to 1958), and Vietnam Conflict (1966 to 1975). A portion of the BAAP property was transferred post-World War II under the Formerly Used Defense Sites (FUDS) program. BAAP was maintained on stand-by status during the non-production eras and determined to be excess in 1997. Excess hazardous substances were disposed at primarily two locations on-site: the PBG and the DBG. The production and waste disposal practices during operational periods were burning and burial (landfilling), and this impacted the soil and groundwater at the BAAP with multiple contaminants.

After the closure, BAAP land consisted of 7,275 acres that the Army has transferred and divided between the United States Department of Agriculture (USDA), Wisconsin Department of Transportation (WDOT), United States Department of Health Services on behalf of the Bluffview Sanitary District (BSD), Bureau of Indian Affairs (BIA) on behalf of the Ho Chunk Nation and the National Park Service (NPS) on behalf of the WDNR. The property that comprised BAAP is being used as agricultural and grazing land (USDA), Highway 78 (WDOT), recreational land (NPS/WDNR), agricultural and industrial land (Ho Chunk), and a wastewater treatment plant (BSD). The Army still maintains ownership of two cemeteries on the former BAAP.

The primary land use to the north of the BAAP is recreational at Devil’s Lake State Park, managed by the WDNR. This area is not impacted by past activities at BAAP as it is hydrologically upgradient. Lake Wisconsin and the Wisconsin River, to the south and southeast of the BAAP, are hydraulically connected to the groundwater beneath the BAAP. Lake Wisconsin was formed in 1914 by the Wisconsin Power and Light (WP&L) dam on the Wisconsin River, near Prairie du Sac (see Figure 1).

Agricultural and residential property is located to the east, south, and west of the BAAP. The agricultural and residential property is in the townships of Merrimac, Prairie du Sac, and Sumpter. The 2016 United States Census estimated the Township of Merrimac population at 1,010 residents, the Township of Prairie du Sac population at 1,132 residents, and the Township of Sumpter population at 1,224 residents.

2.2 Site History

2.2.1 Production and Standby Periods

During World War II, BAAP employed approximately 7,500 workers and produced approximately 271 million pounds of single- and double-base propellant. Oleum and smokeless powder production began in 1943. Rocket paste powder production began in 1945. The solvent less extrusion smokeless propellant process was installed in 1944 and 1945. A portion of the BAAP property was transferred during 1945 under the FUDS program. From 1945 to 1951, the BAAP was in standby status.

BAAP was reactivated for the Korean War in 1951. Reactivation activities were completed by 1954. Facilities for the manufacture of Ball Powder® propellant were constructed during 1954 and 1955. A facility to recycle old cannon powder as a source of NC for the new propellant was also constructed in 1954 and 1955. BAAP remained in production until the Korean War ended and the propellant magazines were full, approximately 1958. During the Korean War, approximately 286 million pounds of single- and double-base propellant were manufactured with a peak production employment of 5,022 employees. The BAAP was in standby status again from 1958 to 1966.

BAAP was reactivated in 1966 for the Vietnam Conflict. The BAAP manufactured Ball Powder® propellant, rocket propellant, and smokeless propellant from 1966 to 1975. In 1972, construction included new sewage treatment systems, new acid production, and new nitroglycerin (NG) production facilities. During the Vietnam Conflict, approximately 487 million pounds of single- and double-base propellant were manufactured with a peak production employment of 5,400 employees. The BAAP was placed in standby status in 1975 and was declared excess in 1997, which began the dismantling/demolition process.

2.2.2 Waste Disposal Practices

The PBG area has been identified as a source area of groundwater contamination. The PBG Plume source area includes Landfill #1, PBG Waste Pits, 1949 Pit, and the Racetrack Area (see Figure 1). During production periods, the PBG Waste Pits, 1949 Pit, and the Racetrack Area were used for disposal of waste and excess production chemicals, primarily solvents [benzene, carbon tetrachloride (CTET), and trichloroethene (TCE)], and explosives [dinitrotoluene (DNT)]. Excess chemicals and munitions components were placed in open pits and burned to dispose of them. Ash, asphalt, concrete, slag, wood, and other metallic and nonmetallic wastes were disposed of in Landfill #1. Additional information about source area investigations, remedial actions, and regulatory acceptance is provided in Section 3.1.

The DBG area has been identified as a source area of groundwater contamination. The DBG Plume source area includes the DBG Waste Pits, Landfill #3, and Landfill #5 (see Figure 1). During production periods, the DBG Waste Pits were used to dispose of waste and excess production chemicals, primarily explosives (DNT). Excess chemicals and munitions components were placed in open-topped metal tanks and burned to dispose of them. Coal ash, construction rubble, trash, and burned garbage were disposed of in Landfill #3. Coal ash, demolition debris, laboratory waste, and office waste were disposed of in Landfill #5. Additional information about source area investigations, remedial actions, and regulatory acceptance is provided in Section 3.2.

The Nitroglycerin (NG) Production and Rocket Paste Production areas have been identified as source areas of groundwater contamination for the Central Plume (see Figure 1). Process wastewater was conveyed in open ditches from the north-central to the south side of BAAP where it subsequently flowed to the Settling Ponds and Spoils Disposal Areas, and eventually to the Wisconsin River (see Figure 1). The wastewater may have contained various production chemicals (i.e., DNT, lead, nitrocellulose, and nitroglycerin). Additional information about source area investigations, remedial actions, and regulatory acceptance is provided in Section 3.3.

The Smokeless Powder and Nitrocellulose (NC) Production areas have been identified as source areas of groundwater contamination for the NC Area Plume (see Figure 1). The Smokeless Powder and NC Production areas manufactured single-base propellant across approximately 800 acres of land. DNT was a component of the manufacturing process. Process wastewater (containing production waste) was conveyed through a network of underground piping that lead to an open ditch near the wastewater treatment plant (WWTP), see Figure 1. The process wastewater may have leaked into the soil beneath the piping network or beneath the production buildings. Additional information about source area investigations, remedial actions, and regulatory acceptance is provided in Section 3.4.

Sanitary wastewater was conveyed through a network of underground piping and treated at the on-site WWTP, see Figure 1. Some remote production areas treated sanitary wastewater in small leaching systems.

2.2.3 Demolition and Restoration

Environmental investigation and restoration activities began at the BAAP in 1977. Between 2002 and 2012, most of the structures at the BAAP were demolished and placed into the on-site Landfills 3118 and 3646, located on the east-central portion of the BAAP (see Figure 1). Landfills 3118 and 3646 are State of Wisconsin licensed facilities that were permitted to accept asbestos, demolition debris, and contaminated soil. Landfills 3118 and 3646 were closed in 2008 and 2013 in accordance with State of Wisconsin regulatory approval, respectively. Demolition activities included: removal of all process chemicals, equipment, piping, process and storage tanks, munitions and explosives. Many of the concrete slabs that laid underneath these structures have been removed and have either been disposed of or recycled for beneficial reuse.

2.3 Environmental Setting

2.3.1 Topography

The land surface features at the BAAP is the result of glaciation. The BAAP is located on the southern edge of the Baraboo Range, also commonly referred to as the Baraboo Hills. The terminal moraine, deposited by the leading edge of the last glacier as it moved from east to west, extends from north to south across the central portion of the BAAP. The topography in the eastern two-thirds of the BAAP consists of gently rolling hills with numerous depressions. The western third of the BAAP is an outwash plain that is nearly level to gently sloping towards the southwest.

2.3.2 Climate

The climate in the BAAP area is typically continental with some influence from the Great Lakes system. Average annual temperatures in the region vary from 39 degrees Fahrenheit (°F) to 50°F. The freeze-free season is typically 80 to 180 days. From 1971 to 2000, the Southwest Wisconsin Divisional Climate Summary included the following averages: Winter: 19.7°F, 3.44 inches of precipitation (ppt); Spring: 45.8°F, 9.24 ppt; Summer: 69.2°F, 13.14 ppt; Fall: 48.0°F, 8.10 ppt (Wisconsin State Climatology Office Website, 2010). Precipitation for the area averages approximately 30 inches annually. Typically, 70% of this rainfall occurs during the growing season; April through September. The one year and ten year predicted maximum 24-hour rainfall totals for Sauk County are 2.3 and 4.1 inches, respectively.

2.3.3 Surface Water Hydrology

Surface drainage consists of overland flow to the west, south, and east. Much of the run-off collects in isolated depressions on-site and infiltrates or evaporates. The ditches in the northwest portion of the BAAP drain toward the Ballistics Pond and subsequently to the west of the BAAP and Highway 12 (see Figure 1). The surface water from the Nitroglycerin, Rocket Paste, and Magazine Areas, located in the central and southeast areas of the BAAP, discharges to the Settling Ponds in the south-central portion of BAAP (see Figure 1). The Settling Ponds are manmade areas that received wastewater from production but are now almost entirely dry except in severe rain events. The Settling Ponds area drains to the south and east and discharged into Gruber’s Grove Bay, on Lake Wisconsin (see Figure 1).

2.3.4 Geology

A thick sequence of unconsolidated sediments was deposited during multiple glaciation events. A glacial terminal moraine transects the BAAP from north to south, as shown in Figure 2. Figure 2 is a map depicting the geological features at the surface. This map was adapted from the Geology of Sauk County by Attig and Clayton, 1990. Bisecting BAAP from north to south is the terminal moraine shown in dark green (gj) and classified as thick till of the Johnstown Moraine. Thinner glacial till, shown in light green (gd), is found east of the terminal moraine.

On the far eastern side of BAAP is a unit classified as a collapsed meltwater-stream sediment (sc). West of the terminal moraine is stream sediment (sj) of the Johnstown Moraine, shown in pink. There is also a unit of stream sediment (ss) shown cutting through the terminal moraine in the southern portion of BAAP. This stream sediment unit is younger than the Johnstown sediment, contains ice rafted boulders, and was deposited by floodwater during the drainage of glacial Lake Wisconsin during the Elderon Phase of glaciation.

Based on the borings advanced at BAAP, the glacial till varies in thickness from 10 to 90 feet. Outwash sand and gravel or fluvial deposits (stream sediment) lie beneath the till. The water table does not intersect the till beneath BAAP, only the outwash is in contact with the groundwater. West of the terminal moraine, a thick sequence of glacial outwash sand and gravel was deposited (sj). Glacial tills to the east are primarily silty sands with cobbles and boulders. Several feet of clay and silt (loess) overlie the glacial sediments.

Figures 3 and 4 are generalized geologic cross sections that show thickness of the unconsolidated sediment (sand and gravel) overlying bedrock. These two cross sections were adapted from figures in *Hydrogeology and Simulation of Groundwater Flow in Sauk County, Wisconsin* (Gotkowitz et al, 2005). The unconsolidated sediment and bedrock unit thicknesses were derived by reviewing boring logs from wells at and near BAAP. Bedrock geology at BAAP is dominated by the Eau Claire Formation (Cambrian age) beneath most of BAAP, with some Precambrian metamorphosed quartzite, granite, and rhyolite. The Eau Claire Formation consists of sandstone/shale/siltstone/dolomite. The Baraboo Range to the north of the BAAP contains Precambrian conglomerate and quartzite, which are part of the Baraboo Syncline, rising approximately 500 feet above the BAAP. The bedrock surface dips steeply toward the south, where soil deposits quickly thicken to a maximum of approximately 250 feet. Along the northern BAAP boundary, soil deposits are thin or absent and bedrock outcrops are common. Figure 5 illustrates the bedrock surface beneath and surrounding BAAP. This bedrock surface map was based on available monitoring well, production well, and residential well construction logs. The bedrock surface drops 200 feet in the northern third of BAAP and flattens out in the southern two-thirds of BAAP.

Figure 3 shows the Bluffview Well #3 on the far left penetrating the entire Eau Claire Formation and entering the Baraboo quartzite. A layer of shale is shown to underlie the western half of BAAP. The shale layer acts as an aquitard, which retards groundwater in the sand and gravel aquifer and the upper sandstone aquifer from moving downward into the lower sandstone aquifer. The Eau Claire Formation is shown to thin out to the east and acts as both an aquitard and an aquifer based on the thickness of the sandstone. The Bluffview Well #3 draws its water from the Eau Claire Formation.

Figure 4 is a cross section that runs from the Baraboo Range south to the Village of Prairie du Sac (PDS). This section also shows the Bluffview Well #3 on the far left and the PDS Well #3 on the far right. The PDS Well #3 penetrates through the Eau Claire Formation and a layer of shale before entering the Mt. Simon Formation (sandstone). The shale layer is shown to be present from just north of the Bluffview Well #3 down to PDS. The shale layer was also found in the Bluffview Well #4 well located at the Bluffview Sanitary District’s wastewater treatment plant (WWTP). This shale layer acts as an aquitard, which restricts groundwater from migrating deeper into the Mt. Simon Formation. Based on the well log, the PDS Well #3 has a water depth at the ground surface, whereas the local water table is located 45 feet below ground. This implies that the PDS Well #3 is a flowing or artesian well. The thick sequence of the Eau Claire Formation and the shale layer protect the PDS Well #3 from contaminants on the surface and in the sand and gravel aquifer. Monitoring well PBN-1405F is shown at the BAAP boundary and penetrates through the layer of shale. PBN-1405F was installed in 2014 by the Army to verify that contaminants have not migrated through the shale layer.

Geologic cross sections depicting stratigraphic relationships between the various soil units, bedrock units, and water table are orientated in Figure 6. Figures 7, 8, 9, 10, and 11 are geologic cross sections that are orientated through the PBG area. Figures 12 and 13 are geologic cross sections that are orientated through the DBG area. Figure 14 is a geologic cross section orientated through the Central Plume area. Figure 15 is a geologic cross section orientated through the NC Area Plume area. The terminal moraine is shown in many sections, represented as glacial till (SP-SM or SM-SP), and consists mostly of varying grain sizes of sand with fines and some gravel/cobbles/boulders. Based on the cross sections, the glacial till is not present beneath the water table. Beneath the glacial till lies sand of varying grain sizes that was deposited by glacial fluvial processes (glacial outwash). The sand outwash contains many pockets of gravel with some being localized and others interconnecting. The gravel layers have been encountered up to 40 feet thick. A uniform layer of gravel exists near the bedrock surface, south of the PBG. A layer of clay and silt (CL-ML), up to 30 feet thick, is present in the DBG area. As shown in Figure 12, the fine-grained layer appears to pinch out approximately 1,300 feet east of the DBG. Both Figure 12 and 13 show the fine-grained unit located beneath the water table. The bedrock shown in each cross section consists of the Eau Claire Formation.

2.3.5 Hydrogeology

Two major aquifers and one minor aquifer are present beneath the BAAP: the surficial sand and gravel aquifer, the Eau Claire Formation, and the deeper Mt. Simon Formation (sandstone aquifer), respectively. The sand and gravel aquifer and the Eau Claire are un-confined to semi-confined and possibly hydraulically connected. The Eau Claire Formation varies between 80 to 280 feet below ground surface (bgs). The Mt. Simon Formation is located approximately 400 feet bgs and is mostly present to the east and south of BAAP. The general direction of groundwater flow is south to southeast. Steep gradients exist along the northern boundary of the BAAP. The gradient flattens substantially in the central and southern portions of the BAAP. Recharge to the sand and gravel aquifer is limited by infiltration through a fine-grained loess unit (silt/clay) in some areas.

As previously mentioned, Figures 3 and 4 shows that the Eau Claire Formation contains at least one uniform shale layer that acts as an aquitard, which retards groundwater in the sand and gravel aquifer from moving downward into the lower sandstone aquifer (Mt. Simon Formation). The Eau Claire Formation also contains many thinner layers of shale and thick sequences of dolomite that act as an aquitard.

The regional groundwater flow direction in the BAAP area is south-southeast towards the Wisconsin River as depicted in *Water-Table Elevation Map of Sauk County, Wisconsin* (Gotkowitz and Zeiler, 2003) and *Hydrogeology and Simulation of Groundwater Flow in Sauk County, Wisconsin* (Gotkowitz et al, 2005). This direction of flow correlates well with the groundwater contours generated by collecting water levels in the BAAP monitoring wells. Figure 16 depicts the groundwater contours at BAAP during September 2017. Figure 17 depicts the groundwater contours near the PBG during September 2017.

The Wisconsin River acts as a discharge point for groundwater east and south of BAAP. As depicted in *Water Resources of Wisconsin Lower Wisconsin River Basin* (Hindall and Borman, 1974) groundwater on both the west and east sides of the Wisconsin River discharges into the Wisconsin River. The Lake Wisconsin reservoir, caused by the hydroelectric dam on the Wisconsin River, influences groundwater flow across the BAAP. Lake Wisconsin is north of the dam where there is an approximate 40-foot surface water drop. The water level in Lake Wisconsin is elevated above the water table for much of the southeastern portion of the BAAP. Anywhere the elevation in Lake Wisconsin is higher than the water table, the water in Lake Wisconsin will discharge to the groundwater. Subsequently, Lake Wisconsin discharges to the groundwater in the Gruber's Grove Bay area and continues to discharge to the groundwater until it reaches the WP&L dam. The net result is groundwater flow parallel to Lake Wisconsin with discharge to the Wisconsin River south of the dam. Groundwater in the northeast portion of the BAAP is higher in elevation than Lake Wisconsin; therefore, the groundwater discharges to Lake Wisconsin in this area.

3.0 SOURCE INVESTIGATIONS AND REMEDIAL MEASURES

The Army has conducted numerous investigations and remedial actions at the former BAAP property. Groundwater investigation activities at BAAP began in 1980 and continue today. The Army proposed and the WDNR approved the site-wide groundwater investigations for RCRA licensed units which included the PBG, DBG, Central Plume, and NC Area Plume areas. Figure 18 shows the locations of the monitoring wells, the four groundwater plumes, and the source areas for each plume.

The RCRA licensed units served as source areas of the four groundwater contaminant plumes being addressed through the Army's CERCLA authority. These remedial activities have been well documented and documentation has been provided to the WDNR. The closure activities conducted by the Army have minimized the potential exposure to contaminated soil at BAAP. The Army has received closure approval from the WDNR on all soil related investigations and response actions at BAAP.

3.1 Propellant Burning Ground

The PBG is located in the southwestern portion of the BAAP. The PBG is comprised of the following areas: Waste Pits, 1949 Pit, Racetrack/Hazardous Waste Thermal Treatment Unit (HWTTU) area, and Landfill #1. The location and layout of the PBG is shown in Figure 19.

The PBG Waste Pits consisted of three waste pits (WP-1, WP-2, and WP-3) and an open burning area. The Waste Pits were approximately 40 feet in diameter and 12 to 15 feet deep. The PBG Waste Pits became active sometime between 1942 and 1949 and were last used in 1983. Approximately 2,280 cubic yards of soil were removed from the Waste Pits, from ground surface to approximately 23 feet deep in 1999. The soil was transported off-site and incinerated by a licensed hazardous waste contractor. The PBG Waste Pits were filled with clean soil to grade.

The 1949 Pit was a waste disposal area active between 1949 and 1962 located adjacent to the PBG Waste Pits (see Figure 19). The 1949 Pit contains approximately 58,080 cubic yards of waste, propellant, and construction materials. The area was no longer used, covered, and vegetated by 1968. A clay and geomembrane barrier cap was installed at the 1949 Pit in 1998 to inhibit the movement of contaminants in the soil. The *1949 Pit Phase One Cap, Final Construction Report* (Olin Corporation, 1999) was submitted and approved by the WDNR in 1999.

The Racetrack/HWTTU area consisted of an oval gravel road, three refuse pits, and burning plates, as well as the HWTTU. In 1995, three-fourths of the Racetrack/HWTTU area was closed with a soil cover to prevent contact with residual lead in the soil. The *Final Documentation Report For Soil Cover Construction Racetrack And Thermal Treatment Unit Closure* (Olin Corporation, 1996) was approved by the WDNR. Contaminated soil from the remaining portion of the Racetrack area was excavated and disposed in 1997 and the WDNR letter dated December 2, 1997 indicated that no additional remedial actions were required for this area.

Landfill #1 is a closed demolition debris disposal facility located northeast of the PBG that was used between 1942 and 1959. The area was covered with soil and vegetated by 1974. The facility contains approximately 19,500 cubic yards of ash, slag, asphalt, concrete, wood, and other metallic and nonmetallic wastes. To reduce infiltration, a composite cap including two feet of clay and geomembrane barrier cap was installed and completed in September 1997. The *Landfill #1 Final Cap Construction Report* was submitted to WDNR in January 1998. Regulatory approval of the Landfill #1 cap was received in a Liability, Clarification and Current Environmental Conditions letter report dated August 27, 2014.

DNT and organic solvent-containing materials are known to have been disposed of at the PBG through open burning and burial during production periods. Subsequently, localized impacts to soil consisted of 2,4-DNT, 2,6-DNT, polycyclic aromatic hydrocarbons, benzene, CTET, TCE, arsenic, chromium, lead, selenium, and zinc above soil cleanup remedial action objectives.

A soil vapor extraction (SVE) system operated at the PBG Waste Pits from 1997 to 1999. SVE wells were installed within each of the three waste pits. Approximately 1,600 pounds of solvent-related volatile organic compounds (VOCs) were successfully removed from within the vadose zone. The SVE system was shut down after achieving satisfactory removal of VOCs from the waste pits.

A pilot biotreatment system was installed at Waste Pit 1 in 1999. A Pilot-Scale Treatability Study was conducted in 2000 to evaluate the effectiveness of bacterial degradation of DNT by naturally occurring bacteria in the soil (in-situ). The system extracted groundwater beneath Waste Pit 1, treated the water with phosphate, and reinjected it into the soil column above the waste pit. Oxygen was added to the vadose zone by injecting air through the former SVE system wells, which now served as air injection wells. Carbohydrate (ethanol) injection wells for the control of nitrate byproduct were installed downgradient, but never used. Monitoring results indicated the indigenous bacteria were aerobically biodegrading DNT in the soil column successfully; therefore, the Army decided to go full-scale with the biotreatment system.

The Biologically Enhanced Subsurface Treatment (BEST) system was installed in 2000 to reduce the soil and groundwater contaminants beneath the PBG Waste Pits. The BEST system operated from 2001 to 2005. From 2001 through 2003, additional air injection wells were installed to aid bacterial degradation of DNT in the groundwater. The air injection wells were in operation until 2006. Evaluation of the BEST system indicated effective DNT reduction in soil and groundwater occurred during the operation of the system.

In 2005, Shaw Environmental, Inc. (Shaw) investigated the PBG source area to evaluate the existing soil conditions beneath each PBG Waste Pit (WP-1, WP-2 and WP-3) and evaluate the BEST system performance. Investigation activities are presented in further detail in the *January 2005 Field Activities Technical Memorandum, Propellant Burning Ground* (Shaw Environmental, Inc., 2005). This investigation included drilling borings through each waste pit and collecting soil samples for laboratory analysis. These soil borings and samples were collected at pre-specified intervals corresponding to previous borings, thus allowing for direct comparison to previous concentrations of VOCs and DNTs. Soil sample results for DNT were compared to previous soil samples collected beneath the waste pits during 1991, 1997, 2002, and

2003. Appendix B contains a site map and tables comparing the DNT concentrations from the January 2005 memorandum prepared by Shaw. This investigation determined that DNT concentrations had been reduced and CTET, chloroform, TCE, and other VOCs were no longer present in the soil beneath the PBG Waste Pits. A summary of the VOC soil sample results is provided in Table 1. No additional soil sampling has been conducted.

Based in the soil boring data provided in the *January 2005 Field Activities Technical Memorandum*, the DNT contaminated soil beneath the PBG Waste Pits has vertically migrated into the groundwater. Table 5 in Appendix B provides a comparison of the DNT soil results beneath Waste Pit 2.

In 2006, a draft Alternative Feasibility Study was completed to re-evaluate the interim remedial actions for soils at the PBG and determine the final remedy. The selected remedy included the previous remedial actions: soil vapor extraction, partial soil excavation and incineration, and full-scale bioremediation. The final remedy chosen included removal of the bioremediation system, installation of an impermeable cap, and continued groundwater monitoring and remediation. On March 17, 2008, the WDNR approved the final remedy for the PBG subsurface soil.

Removal of the BEST system was completed in 2008. The PBG Waste Pits were then capped with a clay and geomembrane barrier cap, according to regulatory requirements. The *Construction Documentation Report, PBG Phase 2, Cap and Construction* (SpecPro, Inc., 2009) report was submitted to the WDNR and approved in a letter report dated March 25, 2009.

Based on the 2005 Shaw soil investigation data, the DNT soil contaminant mass was calculated to be 34,810 pounds. This DNT contaminated soil is located beneath the PBG Waste Pit cap. Input parameters and calculations are provided in Table 2.

The Waste Pits, 1949 Pit, Racetrack/HWTTU, and Landfill #1 areas are regularly inspected. Signage, fencing, and vegetation are inspected and maintained. Cap and cover areas are inspected annually for erosion, settlement, undesirable vegetation, and other deficiencies. Annual cap and cover maintenance reports are submitted to the WDNR and United States Environmental Protection Agency (USEPA).

In addition to the annual inspection and in accordance with condition of the final approval, the U.S. Army Corps of Engineers (USACE) completed a five-year review of the PBG in 2013 and 2019. Results of the 2013 review were provided to the WDNR on June 26, 2013. The 2013 five-year review focused on groundwater contaminant concentration trends, cap maintenance activities, and possible modifications to the maintenance and monitoring of the PBG site remedy. These three items were evaluated for the period from 2008 to 2012. The 2013 five-year review concluded that concentration trends for some individual wells were either increasing or probably increasing but the overall plume stability was found to be stable, decreasing, or did not exhibit a trend. The 2013 five-year review also concluded that maintenance records showed that the PBG cap system was being properly maintained and in acceptable condition. Results of the 2019 five-year review are not currently available.

Table 1
Propellant Burning Ground - Volatile Organic Compounds Soil Sample Results (2005)
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

		Volatile Organic Compounds		
Sample Number	Sample Interval (ft bgs)	Carbon Tetrachloride	Trichloroethylene	Chloroform
PBB 0501 010	20 - 30	<0.060	<0.060	<0.060
PBB 0501 022	21 - 22	<0.060	<0.060	<0.060
PBB 0501 026	25 - 26	<0.060	<0.060	<0.060
PBB 0501 030	20 - 30	<0.060	<0.060	<0.060
PBB 0501 031	30 - 31	<0.060	<0.060	<0.060
PBB 0501 040	30 - 40	<0.060	<0.060	<0.060
PBB 0501 041	40 - 41	<0.060	<0.060	<0.060
PBB 0501 050	40 - 50	<0.060	<0.060	<0.060
PBB 0501 051	50 - 51	<0.060	<0.060	<0.060
PBB 0501 060	50 - 60	<0.060	<0.060	<0.060
PBB 0501 061	60 - 61	<0.060	<0.060	<0.060
PBB 0501 070	60 - 70	<0.060	<0.060	<0.060
PBB 0501 071	70 - 71	<0.060	<0.060	<0.060
PBB 0501 080	70 - 80	<0.060	<0.060	<0.060
PBB 0501 080	90 - 91	<0.060	<0.060	<0.060
PBB 0501 090	80 - 90	<0.060	<0.060	<0.060
PBB 0501 091	90 - 91	<0.060	<0.060	<0.060
PBB 0501 100	90 - 100	<0.060	<0.060	<0.060
PBB 0502 010	104 - 105	<0.060	<0.060	<0.060
PBB 0502 023	22 - 23	<0.060	<0.060	<0.060
PBB 0502 029	28 - 29	<0.060	<0.060	<0.060
PBB 0502 030	20 - 30	<0.060	<0.060	<0.060
PBB 0502 035	34 - 35	<0.060	<0.060	<0.060
PBB 0502 040	30 - 40	<0.060	<0.060	<0.060
PBB 0502 050	40 - 50	<0.060	<0.060	<0.060
PBB 0502 053	52 - 53	<0.060	<0.060	<0.060
PBB 0502 060	50 - 60	<0.060	<0.060	<0.060

Table 1
Propellant Burning Ground - Volatile Organic Compounds Soil Sample Results (2005)
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Sample Number	Sample Interval (ft bgs)	Carbon Tetrachloride	Trichloroethylene	Chloroform
PBB 0502 070	60 - 70	<0.060	<0.060	<0.060
PBB 0502 080	70 - 80	<0.060	<0.060	<0.060
PBB 0502 080	80 - 90	<0.060	<0.060	<0.060
PBB 0502 090	80 - 90	<0.060	<0.060	<0.060
PBB 0502 100	90 - 100	<0.060	<0.060	<0.060
PBB 0502 105	104 - 105	<0.060	<0.060	<0.060
PBB 0503 010	60 - 70	<0.060	<0.060	<0.060
PBB 0503 013	12 - 13	<0.060	<0.060	<0.060
PBB 0503 020	10 - 20	<0.060	<0.060	<0.060
PBB 0503 030	20 - 30	<0.060	<0.060	<0.060
PBB 0503 040	30 - 40	<0.060	<0.060	<0.060
PBB 0503 050	40 - 50	<0.060	<0.060	<0.060
PBB 0503 055	54 - 55	<0.060	<0.060	<0.060
PBB 0503 060	50 - 60	<0.060	<0.060	<0.060
PBB 0503 070	60 - 70	<0.060	<0.060	<0.060
PBB 0503 080	70 - 80	<0.060	<0.060	<0.060
PBB 0503 090	80 - 90	<0.060	<0.060	<0.060
PBB 0503 100	90 - 100	<0.060	<0.060	<0.060
PBB 0503 105	100 - 105	<0.060	<0.060	<0.060

ft bgs - feet below ground surface
All results are expressed in milligrams per kilogram (mg/kg)
Samples collected by Shaw Environmental, Inc., in January 2005
Samples were analyzed by CT Laboratories using method SW8260B
Boring PBB 0501 was drilled beneath Propellant Burning Ground (PBG) Waste Pit 1.
Boring PBB 0502 was drilled beneath PBG Waste Pit 2.
Boring PBB 0503 was drilled beneath PBG Waste Pit 3.

Table 2
DNT-Impacted Soil Contaminant Mass Estimate
Propellant Burning Ground and Deterrent Burning Ground Source Areas
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Source Location	Average Concentration (mg/Kg)	Interval Depth (ft bgs)	Interval Thickness (ft)	Length (ft)	Width (ft)	Total Volume (ft3)	Mass Volume (lbs)
Propellant Burning Ground							
Waste Pit #1 (upper zone)	7,776	22 - 31	9	50	40	18,000	17,493
Waste Pit #1 (lower zone)	45.6	31 - 91	60	50	40	120,000	684
Waste Pit #2 (upper zone)	3,746	23 - 43	20	40	30	24,000	11,236
Waste Pit #2 (lower zone)	191	43 - 105	62	40	30	74,400	1,776
Waste Pit #3 (upper zone)	1,618	13 - 20	7	30	20	4,200	849
Waste Pit #3 (lower zone)	528	20 - 90	70	30	20	42,000	2,772
Total DNT Soil Contaminant Mass							**34,810**
Deterrent Burning Ground							
Waste Pit #1	1,950	10 - 30	20	70	35	49,000	11,942
Waste Pits #2 and #3	1,050	20 - 50	30	280	40	336,000	44,093
Total DNT Soil Contaminant Mass							**56,035**

cm - centimeters
cm3 - cubic centimeters
ft - feet
ft3 - cubic feet
lbs - pounds
mg/Kg - milligrams per kilogram
bgs - below ground surface
Deterrent Burning Ground estimate is based on data from 1991 to 1998.
Propellant Burning Ground estimate is based on data from 2005.
Soil bulk density = 125 lbs/ft3 = 0.002002 Kg/cm3
Mass volume (lbs) = average concentration (mg/kg) x soil bulk density (kg/cm3) x 28,317 (cm3/ft3) x total volume (ft3) x (1 kg/10^6 mg) x 2.204586 (lb/kg)

3.1.1 Interim Remedial Measures/Modified Interim Remedial Measures

Groundwater contamination in monitoring wells at the PBG was first detected in 1982 (Tsai, 1988). In 1989, the Army evaluated interim remedial measures (IRM). The goals of the early groundwater remedial action were to: 1) curb the advancement of the plume, 2) reduce contaminants within the plume, and 3) be compliant with local, state, and federal regulations.

The IRM groundwater pump and treat system began operations during June 1990 by pumping approximately 350 gallons per minute (gpm). The IRM groundwater treatment system originally consisted of one source control well (SCW-1) and three boundary control wells (BCW-1, BCW-2, and BCW-3) located within the BAAP boundary. The groundwater was treated with liquid phase granular activated carbon (GAC) treatment. BCW-4 was installed in 1993 but was never connected to the IRM. By April 1998, BCW-1, BCW-2, and BCW-3 were shut down and SCW-1 and SCW-2R (installed in 1997) were pumping approximately 310 gpm. Figure 19 shows the locations of the former IRM extraction wells and the former boundary control wells.

Extracted groundwater from the IRM extraction wells was pumped through a GAC system that removed VOCs and DNT from the water by adsorption. The treated water then flowed through a pipeline and discharged into Lake Wisconsin near Gruber’s Grove Bay.

An evaluation of the IRM was conducted in 1993 to address new regulatory requirements. This evaluation concluded that the PBG Plume was not being entirely captured by the IRM system. The PBG Plume was extending beneath and east of the three original boundary control wells. A groundwater treatment system was designed to augment the existing IRM system.

This augmented groundwater treatment system called the MIRM system began operations on June 20, 1996. The MIRM groundwater treatment system originally consisted of six boundary extraction wells (EW-161, EW-162, EW-163, EW-164, EW-165, and EW-166) pumping a combined 3,000 gpm. These MIRM extraction wells were located along the southern BAAP boundary (see Figure 19). Four additional extraction wells (EW-167, EW-168, EW-169, and EW-170) were installed along the axis of the plume in 2005 (see Figure 19). The pumping of these extraction wells was refined over the years to optimize removal of groundwater contaminants including the replacement of EW-163 with EW-163R and EW-170 with EW-170R. Until use of the MIRM was discontinued in 2015, the five pumping MIRM extraction wells (EW-163R, EW-167, EW-168, EW-169, and EW-170R) extracted groundwater from the PBG Plume at a combined rate of approximately 2,400 gpm. The water from the MIRM extraction wells flowed through air strippers for treatment of VOCs then passed through a GAC system to remove DNT and additional VOCs. The treated water then flowed through a pipeline and discharged into Lake Wisconsin.

Since the PBG Waste Pits were capped in 2008, the DNT concentrations in monitoring wells near the PBG Waste Pits have dropped significantly. The mass of DNT being removed from the groundwater by the IRM system had also reduced dramatically, indicating the IRM system had effectively removed most of the available contaminant mass in the groundwater near the source area. This implied that further operation of the IRM system would not be cost-effective. The Army submitted an *Interim Remedial Measures Shutdown Plan (Badger Technical Services*

(BTS, LLC), October 2012 that outlined a systematic approach to restoring natural groundwater conditions so that PBG Plume dynamics and attenuation could be evaluated. Based on the WDNR's December 11, 2012 approval letter, the IRM was shut down on December 17, 2012. The Army's June 17, 2014 letter to the WDNR summarized the monitoring activities conducted during 2013 and 2014 and requested that the IRM system be dismantled. The WDNR's August 4, 2014 letter approved the dismantling of the IRM system. During 2014, the IRM extraction wells were abandoned and the IRM treatment building was demolished.

Like the IRM, the MIRM system had reached its limitations of effective contaminant removal and its operation would no longer be cost efficient. To that end, the Army submitted a *Modified Interim Remedial Measures Shutdown Plan (Badger Technical Services, LLC), January 2014* that outlined a systematic approach to restoring natural groundwater conditions so that PBG Plume dynamics and attenuation could be evaluated. Based on the WDNR's August 4, 2014 approval letter, the MIRM was completely shut down on August 31, 2015. The Army's June 27, 2016 letter to the WDNR summarized the monitoring activities conducted between 2014 and 2016 and requested that the MIRM system be dismantled. The WDNR's July 15, 2016 letter approved the dismantling of the MIRM system. During 2016, the MIRM extraction wells were abandoned. Ownership of the MIRM treatment building was transferred from the Army to the BSD in July 2016.

3.2 Deterrent Burning Ground

The DBG area consists of seven acres and is located in the northeastern portion of BAAP. The DBG area was used as a sand borrow pit from the 1940s until the early 1960s, and a waste disposal site from the 1940s to the 1970s. The DBG consisted of three burn areas within a man-made depression, approximately three acres in size and 20 feet deep.

Coal ash from the power plant, construction rubble, trash, and burned garbage were deposited in Landfill #3, which is part of the DBG. From 1966 through 1971 the remaining portion of the DBG was used for open burning in open-topped metal tanks of deterrent, a liquid organic extract from surplus propellant, composed mostly of DNT and di-n-butyl phthalate, as well as minor amounts of diphenylamine, benzene, and nitrocellulose. Structural timbers, asphalt shingles, cardboard, paper, and office waste were also burned in the pits. Subsurface soils at the DBG were found to be impacted with DNT, n-nitrosodiphenylamine, arsenic, and chromium. The majority of the impacts were found in the shallowest portion of the pit, with arsenic and chromium in limited areas of the site. Investigations also showed DNT spread vertically in the subsurface soils and reached groundwater.

Landfill #5 is located to the northeast of the DBG. During operations, the landfill reportedly received solid waste, including office waste, demolition debris, laboratory waste, and coal ash from the power plant between 1979 and 1988. No hazardous materials were reported to have been disposed in Landfill #5. In 1988, the landfill was closed with a clay barrier cap which received regulatory approval from the WDNR on September 20, 1989.

An interim corrective action consisting of the removal and off-site incineration of DBG waste pit soil occurred in 1999 and 2000. Impacted soil from the three pits was excavated to a depth of approximately 15 feet. The total volume of the excavated and incinerated soil was approximately 4,260 cubic yards. Each pit was backfilled with clean fill to pre-excavation grades. This removed the surface soil contaminated with the highest DNT levels and metals.

In 2001, the backfilled area was covered with an interim geomembrane cap, facilitating additional soil and groundwater studies to better understand site conditions. On April 24, 2002, the *Draft Alternative Feasibility Study - Deterrent Burning Ground Waste Pits Subsurface Soil* (Stone & Webster, Inc., 2002) was submitted to request a permit modification to perform the remedial action, including partial excavation and incineration (completed in 2000), geosynthetic clay and geomembrane barrier cap installation, institutional controls, and groundwater monitoring. In accordance with conditions set forth in the WDNR *Final Determination of Remedy for the Deterrent Burning Ground*, dated October 14, 2002, an Enhanced Biodegradation System (EBS) and a geosynthetic clay and geomembrane barrier cap were installed at the DBG during 2003. The cap also encompassed Landfill #3. Due to limited groundwater contamination and the low risk to potential receptors, active groundwater remediation was not required by the WDNR.

The EBS was installed beneath the cap in the area of the three DBG waste pits. The EBS was designed to enhance naturally occurring biodegradation of DNT in subsurface soil by maintaining soil moisture, nutrients and soil gas oxygen beneath the cap. Water and nutrients were introduced into the soil column through a network of piping. The water infiltration rate was kept below the average annual percolation rate.

The Army suspended all operation and monitoring associated with the EBS following the infiltration event in June 2008. This decision was based on the lack of a water resource sufficient to provide the volume needed for continued treatment, problems with the soil moisture and respirometry monitoring equipment and a lack of consistent evidence to show that the EBS was effectively enhancing degradation beyond what was occurring naturally. The WDNR was notified of the EBS discontinuance in a letter report from the Army dated November 17, 2011. This letter provided information on the operation and monitoring of the EBS from 2003 to 2008.

Based on investigation data presented in the *Draft Alternative Feasibility Study - Deterrent Burning Ground Waste Pits Subsurface Soil* (Stone & Webster, Inc., 2002), the DNT soil contaminant mass was calculated to be 56,035 pounds. This DNT contaminated soil is located beneath the engineered cap. Input parameters are provided in Table 2. Concentrations and volume data were used to derive a mass volume in pounds. It should be noted that the soil data used in the calculation was collected from soil borings conducted between 1991 to 1998. No additional soil sampling has been conducted since 1998. Based in the soil boring data, DNT isoconcentration map, and cross sections provided in the *Draft Alternative Feasibility Study*, the DNT contaminated soil beneath the DBG cap is estimated to be 26 feet above the water table. This separation distance implies that the water table (groundwater surface) does not currently intersect with soil contaminated with DNT. Prior to the cap being constructed in 2003, rainwater would have mixed with contaminated soil in the DBG waste pits and vertically infiltrated down towards the groundwater table.

The DBG cap and Landfill #5 areas are regularly inspected. Signage, fencing, and vegetation are inspected and maintained. Cap areas are inspected annually for erosion, settlement, undesirable vegetation, and other deficiencies. Annual cap and cover maintenance reports are submitted to the WDNR and USEPA.

In accordance with the condition of the final approval, the USACE completed a five-year review of the DBG in 2013 and 2019. Results of the 2013 review were provided to the WDNR on June 26, 2013. The 2013 five-year review focused on groundwater contaminant concentration trends, cap maintenance activities, and new technologies potentially applicable to address remaining impacted soil beneath the DBG cap. The 2013 five-year review concluded that most of the groundwater concentration trends were either stable or decreasing with some individual wells indicating increasing or probably increasing trends. The 2013 five-year review concluded that maintenance records showed that the DBG cap system was being properly maintained and in acceptable condition. No new technologies were identified that were not previously evaluated during the remedy selection or could be implemented without negatively impact to the DBG cap. Results of the 2019 five-year review are not currently available.

3.3 Central Plume Area

Based on the knowledge of groundwater flow and monitoring results, the detection of DNT in groundwater during 2004 at the Water's Edge Subdivision indicated another source of DNT groundwater contamination existed besides the PBG and DBG. The Water's Edge Subdivision is located on the north side of Gruber's Grove Bay and at the southern portion of the Central Plume (shown in inset B on Figure 20). Based on the groundwater flow direction and the groundwater contaminant detections, the source of 2,6-DNT contaminated groundwater was believed to be in the north-central portion of BAAP where nitroglycerin, rocket paste, and rocket propellant were produced (see Figure 1). However, several investigations/excavations to date have not determined a specific source of DNT contamination (e.g., landfill or disposal area). It is believed that the broad production area may have caused the groundwater impacts. In 2004, 2,6-DNT was first detected within two residential wells located in the Water's Edge Subdivision. The 2,6-DNT concentration in two residential wells exceeded the Chapter NR 140 Enforcement Standard (ES). In 2005, the Army replaced these two residential wells, WE-RM385 and WE-RR541.

In 2006, the USDA installed a well (USDA 6) in the southeast portion of BAAP to provide water to cows. The USDA 6 well is located approximately 4,300 feet north of the Water's Edge Subdivision (see Figure 20). Sampling results indicated 2,6-DNT exceeded the Chapter NR 140 ES. The following is a summary of the DNT source investigations that were conducted in the Central Plume area.

3.3.1 DNT Source Investigation

Groundwater data and historical production standard operating procedures were reviewed. Based on these reviews, the investigation of the source of DNT contamination focused on the Rocket Paste production area (see Figure 1). Containers of production chemicals, which contained DNT, were transported by rail to each Pre-Mix House from the Bag Loading House. Nitrocellulose and nitroglycerin were added to the chemical mixture in each Pre-Mix House. The resulting slurry was then pumped to the Final Mix Houses. The Rocket Paste production area was not connected to the main industrial sewer network, so production related wash waters were discharged to open ditches. The surface water from the Nitroglycerin, Rocket Paste, and Magazine Areas, located in the central and southeast areas of the BAAP, discharges to the Settling Ponds in the south-central portion of BAAP (see Figure 1). The Settling Ponds are manmade areas that received wastewater from production. The Settling Ponds area drains to the south and east and discharged into Gruber's Grove Bay (see Figure 1).

From 2007 to 2010, multiple soil boring investigations were conducted at locations where releases of DNT may have occurred. Soil samples were analyzed for semi-volatiles including DNT. Soil removal activities were conducted around production buildings and along ditches and drainage pathways leading from the Rocket Paste and Nitroglycerin production areas. In addition, sewer removal and adjacent soil excavation was completed in this area. All contaminated soil and sewer piping were disposed of in the on-site licensed Landfill 3646. The WDNR was provided with multiple reports on the investigation and remediation activities. The WDNR provided the Army with multiple case closure letters. Based on these activities, there remains no source of DNT contaminated soil in the Central Plume.

3.4 Nitrocellulose Production Area

Based on the groundwater flow direction and the groundwater contaminant detections, the source of DNT contaminated groundwater is believed to be from the northwestern section of BAAP where nitrocellulose (NC) was manufactured. The completed NC was used to manufacture single-base propellants such as smokeless powder or double-base propellants such as rocket grains or Ball Powder. DNT was added to the manufacturing process in various production buildings. Investigations have determined that there are several potential sources of DNT contamination and it appears that the broad production area may have caused the groundwater impacts.

During 2007, the Army conducted a site-wide investigation into potential sources of DNT contamination in the groundwater. Several monitoring wells, including RIM-0705, were installed within the NC Production Area. Groundwater sampling determined that DNT was present within RIM-0705. This prompted soil investigations into the source of the DNT contamination. The following is a summary of the DNT source investigations that were conducted in the NC Production Area.

3.4.1 DNT Source Investigation

The former DNT Screen House (located just north of monitoring well RIM-0705) was used in the production of smokeless powder. Containers of solid DNT were brought to the DNT Screen House and the solid DNT was broken up and screened to remove foreign material. The screened DNT was then distributed to mixing operations within NC Production Area. As part of the daily operating procedures in the DNT Screen House, accumulated residue on the floors was washed into a floor drain, which discharged out to a concrete process sewer sump. During 2008, 2009, and 2010, soil investigations were conducted within and beneath the sump along with the soil surrounding and beneath the DNT Screen House. These investigations determined that DNT contaminated soil was present. Remediation activities during 2008, 2009, and 2010 included the removal of sewer piping along with the surrounding contaminated soil, removal of the concrete sump along with the surrounding contaminated soil, and the contaminated soil surrounding and beneath the DNT Screen House. All contaminated soil and sewer piping were disposed of in the on-site licensed Landfill 3646.

Nine Hydro-jet Houses (located north of the DNT Screen House) were used during production of smokeless powder. During 2008, 2009, and 2010, soil investigations were conducted beneath the building basement concrete slabs. These investigations determined that DNT contaminated soil was present beneath the concrete slabs. Expansion joints and cracks within the concrete slabs were believed to be migration pathways for the DNT to penetrate beneath the basement slabs. Remediation activities during 2010 included the removal of the concrete slabs and the surrounding contaminated soil. All contaminated soil and concrete were disposed of in the on-site licensed Landfill 3646.

Additional soil investigation and removal activities were conducted around other NC Production Area buildings and the sewer piping network.

The WDNR was provided with multiple reports on the investigation and remediation activities. The WDNR provided the Army with multiple case closure letters. Based on these activities, there remains no source of DNT contaminated soil near the NC Production Area.

4.0 GROUNDWATER CHARACTERIZATION

4.1 Groundwater Quality Regulations

Both the USEPA and WDNR have published groundwater quality regulations related to groundwater associated with public drinking water systems and residential wells.

4.1.1 Federal Groundwater Quality Regulations

The regulatory requirements described below, are the most relevant requirements as they relate to groundwater access for domestic purposes. These requirements are considered to be protective of human health.

4.1.1.1 *National Primary Drinking Water Regulations*

Through the Safe Water Drinking Act, the USEPA has established National Primary Drinking Water Regulations (NPDWRs) that set mandatory water quality standard for drinking water contaminants. These are enforceable standards called “maximum contaminant levels” (MCLs) which are established to protect the public against consumption of drinking water contaminants that present a risk to human health. A copy of the NPDWRs (May 2009) is provided in Appendix C.

Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to Maximum Contaminant Level Goals (see below) as feasible using the best available treatment technology and taking cost into consideration. For this reason, MCLs are not always risk based values and may be higher than purely risk-based goals or screening criteria. MCLs are enforceable standards for public water systems.

Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

4.1.1.2 *National Secondary Drinking Water Regulations*

The USEPA has also established National Secondary Drinking Water Regulations (NSDWRs) that set non-mandatory water quality standards for 15 contaminants. These are non-enforceable standards called "secondary maximum contaminant levels" (SMCLs). They are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL. A copy of the NSDWRs (May 2009) is provided in Appendix C.

4.1.1.3 *Tapwater Regional Screening Level*

The USEPA has developed tapwater regional screening levels (RSLs) using risk assessment guidance from CERCLA. The tapwater RSLs are risk-based concentrations derived from standardized equations combining exposure information assumptions with USEPA toxicity data. The screening levels are considered by the USEPA to be protective for humans (including sensitive groups) over a lifetime. These values are derived solely on the basis of risk and do not consider the cost or feasibility of treating groundwater to these risk-based limits. A copy of the tapwater RSLs (November 2017) is provided in Appendix C.

The tapwater RSLs were developed considering potential exposure to chemicals in groundwater associated with domestic use of the groundwater as a drinking water source, as well as other normal domestic water uses, such as bathing, doing laundry, and washing dishes. Exposure to chemicals in groundwater are incorporated into the tapwater RSLs for both ingestion and dermal contact with the water, as well as inhalation of the portion of the chemicals in groundwater that are volatilized from the water as it is used (e.g., for bathing).

4.1.2 State Groundwater Quality Standards

Chapter NR 140 establishes groundwater quality standards referred to as Enforcement Standards (ES) and Preventive Action Limits (PAL) for groundwater beneath the State of Wisconsin. These Chapter NR 140 groundwater quality standards are also used for evaluating groundwater monitoring data. The Chapter NR 140 ESs and PALs are listed within Table 1 - Public Health Groundwater Quality Standards and Table 2 - Public Welfare Groundwater Quality Standards (see Appendix C). The Public Welfare Groundwater Quality Standards listed in Table 2 (e.g., sulfate) are guidelines established to address cosmetic and aesthetic effects of substances present in drinking water supplies (e.g., taste). A copy of the Chapter NR 140 Groundwater Quality standards (February 2017) is provided in Appendix C.

4.1.2.1 *Enforcement Standards*

The groundwater NR 140 ESs are protective of public health and welfare on the premise that the groundwater may be ingested through use as drinking water. All NR 140 ESs listed in Table 1 of Chapter NR 140 are Public Health Groundwater Quality Standards. The Chapter NR 140 ES concentrations are equal to or more stringent than the federal MCLs. Further references to groundwater standard exceedances will reference the NR 140 ES.

4.1.2.2 *Preventive Action Limits*

The Chapter NR 140 PALs serve “to inform the WDNR of potential groundwater contamination problems (and to) establish the level of groundwater contamination at which the WDNR is required to commence efforts to control the contamination”. The Chapter NR 140 PALs are used early in the investigation process given the uncertainty over the nature and extent of contamination. The Chapter NR 140 ESs are used to define contaminants potential of concern and areas warranting remedial action where the current or future groundwater is used for drinking water purposes.

4.2 Groundwater Sampling Program

The Army has been monitoring the nature and extent of groundwater contamination since the early 1980s. Based on the current understanding of the BAAP groundwater plumes, not all monitoring wells are currently being used to define the current plume areas. Figure 18 identifies monitoring well locations which were initially installed to characterize groundwater quality and which wells are being monitored by the Army to define the nature and extent of groundwater contamination. Any area outside the property transferred with groundwater access restrictions may be used for residential use. Figure 20 identifies the residential well locations currently being monitored by the Army. Both Figures 18 and 20 show the boundaries of the four groundwater contamination plumes. Figure 21 displays the current monitoring well and residential well sampling frequencies, groundwater plumes, and groundwater flow directions. The groundwater plumes are displayed in two ways on Figure 21: areas that exceed the Chapter NR 140 PAL and areas that exceed the Chapter NR 140 ES. Groundwater areas exceeding the Chapter NR 140 PALs are provided for informational purposes since this data is not used for remedy selection. These plume boundaries displayed on Figure 21 are approximate and based on DNT and VOC groundwater data collected during 2018. The DBG Plume boundaries do not include sulfate groundwater data. The sulfate data will be discussed in Section 4.5.2.2 of this report.

The current groundwater sampling program including monitoring wells and residential wells is being conducted according to sampling plans agreed upon by the Army and WDNR. Sampling plans are routinely modified based on requests from the WDNR.

A total of 166 monitoring wells are sampled at varying frequencies: 5 quarterly (four times per year), 119 semi-annual (twice per year), 35 annual (once per year), and 7 biennial (once every two years); see Figure 21. Table 3 provides the location, well construction information, and sample frequency for the 166 monitoring wells currently being sampled by the Army. Appendix D details the groundwater sampling program. Table 4 provides the location and well construction information for the 137 monitoring wells that are not currently being sampled. There are currently 303 monitoring wells associated with BAAP (see Figure 18).

A total of 54 residential wells are sampled at varying frequencies: 2 quarterly (four times per year) and 52 annually; see Figure 21. Table 5 provides the well construction information and sample frequency for the 54 residential wells currently being sampled by the Army. Table 6 provides the well construction information for the residential wells that are not currently being sampled and shown on Figure 20. Well construction and depth information was not available for many residential wells due to the lack of information provided on well logs. Information regarding the construction and depths of residential wells near BAAP in 1993 was included in the *Final Remedial Investigation Report* (ABB Environmental Services, Inc., 1993).

Concurrent with this RI/FS report preparation, yet independent of this effort, the United Stated Geological Survey (USGS) is performing a comprehensive review of the BAAP groundwater monitoring program. The intention of the review is to evaluate the existing program and determine if modifications could be made to strengthen the value of the data generated from the monitoring effort. No modifications are being proposed, at this time, to the previously approved monitoring program; however, results of the USGS evaluation may result in suggested modifications to enhance the program.

Table 3
Monitoring Well Construction Information – Sampling Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
S1111	751	3038	1/2/80	487,414	2,044,310	99.0	848.79	846.80	4.0	20.3	n/a	OW	Sand	A	Annual	Central
NLN-8203A	258	3118	5/5/82	494,954	2,045,545	115.5	884.12	881.80	4.0	10.0	n/a	OW	Sand	A	Annual	Central
NLN-8203B	259	3118	5/6/82	494,946	2,045,534	127.5	884.87	882.70	4.0	2.0	n/a	PZ	Sand	B	Annual	Central
NLN-8203C	260	3118	5/5/82	494,954	2,045,532	138.5	885.17	882.70	4.0	2.0	n/a	PZ	Sand	C	Annual	Central
NPM-8901	506	3487	10/25/89	497,388	2,041,526	100.0	862.92	861.50	4.0	20.0	n/a	OW	Sand	A	Annual	Central
RIM-1003	491	3487	5/3/10	492,555	2,043,661	114.3	885.06	882.78	2.5	15.0	n/a	OW	Sand	A	Annual	Central
RIM-1004	494	3487	5/5/10	489,552	2,044,244	70.5	836.40	833.60	2.5	15.0	n/a	OW	Sand	A	Annual	Central
RIN-0701C	443	3487	10/12/07	497,385	2,041,541	180.0	863.86	860.76	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-0702C	444	3487	10/16/07	494,729	2,042,699	201.0	887.98	885.81	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-0703C	445	3487	10/17/07	489,062	2,044,835	207.0	857.55	854.83	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-1002A	492	3487	5/4/10	492,556	2,046,082	92.2	862.81	860.46	2.5	15.0	n/a	OW	Sand	A	Annual	Central
RIN-1002C	493	3487	6/1/10	492,569	2,046,079	179.8	862.95	860.86	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-1003A	495	3487	5/5/10	489,061	2,044,797	90.5	857.10	854.66	2.5	15.0	n/a	OW	Sand	A	Annual	Central
RIN-1004B	498	3487	5/13/10	486,645	2,044,721	146.7	859.31	856.74	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	Central
RIN-1005A	496	3487	5/17/10	489,311	2,045,864	60.5	828.61	826.74	2.5	15.0	n/a	OW	Sand	A	Annual	Central
RIN-1005C	497	3487	5/17/10	489,317	2,045,865	147.0	828.75	826.49	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-1501B	538	3487	10/23/15	492,538	2,046,945	123.5	845.87	842.86	2.5	10.0	n/a	PZ	Sand	B	Annual	Central
RIN-1501C	539	3487	10/27/15	492,538	2,046,939	165.2	845.86	842.80	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-1501D	540	3487	10/30/15	492,578	2,046,076	237.8	863.54	860.86	2.5	5.0	n/a	PZ	Sand	D	Annual	Central
RIN-1502B	541	3487	9/22/15	489,765	2,046,626	103.4	824.29	821.41	2.5	5.0	n/a	PZ	Sand	B	Annual	Central
RIN-1502C	542	3487	9/25/15	489,768	2,046,631	143.1	824.40	821.44	2.5	5.0	n/a	PZ	Sand	C	Annual	Central
RIN-1502D	543	3487	10/2/15	489,772	2,046,636	213.3	824.33	821.35	2.5	5.0	213	PZ	Sand	D	Annual	Central
RPM-8901	507	3487	10/16/89	494,718	2,042,698	124.3	888.62	886.20	4.0	19.5	n/a	OW	Sand	A	Annual	Central
NLN-1001A	331	3646	4/21/10	495,613	2,044,708	111.5	882.62	880.28	4.0	15.0	n/a	OW	Sand	A	Annual	Central
NLN-1001C	332	3646	4/19/10	495,615	2,044,701	154.5	882.52	880.36	4.0	5.0	n/a	PZ	Sand	C	Annual	Central
SEN-0501A	580	4330	1/27/05	484,159	2,043,454	32.0	784.56	784.64	3.8	15.0	n/a	OW	Sand	A	Semi-Annual	Central
SEN-0501B	581	4330	1/27/05	484,158	2,043,458	87.0	784.71	784.87	3.8	10.0	n/a	PZ	Sand	B	Semi-Annual	Central
SEN-0501D	582	4330	1/27/05	484,156	2,043,462	190.0	784.98	785.22	3.8	10.0	194	PZ	Sand	D	Semi-Annual	Central
SEN-0502A	583	4330	1/28/05	484,107	2,044,412	33.0	786.46	786.47	3.8	15.0	n/a	OW	Sand	A	Semi-Annual	Central
SEN-0502D	584	4330	1/12/05	484,103	2,044,417	187.0	786.24	786.76	3.8	10.0	190	PZ	Sand	D	Semi-Annual	Central
SEN-0503A	585	4330	1/26/05	484,524	2,044,148	55.5	809.56	809.63	3.8	15.0	n/a	OW	Sand	A	Semi-Annual	Central
SEN-0503B	586	4330	1/25/05	484,518	2,044,150	110.0	809.17	809.39	3.8	10.0	n/a	PZ	Sand	B	Semi-Annual	Central
SEN-0503D	587	4330	1/19/05	484,514	2,044,152	213.0	809.31	809.31	3.8	10.0	214	PZ	Sand	D	Semi-Annual	Central
ELM-8901	216	2813	1/18/89	501,113	2,043,592	165.0	922.57	920.50	4.0	19.5	n/a	OW	Sand	A	Semi-Annual	DBG
ELM-8907	220	2813	4/18/89	500,500	2,044,492	150.3	916.21	913.70	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELM-8908	221	2813	4/1/89	500,503	2,044,033	145.0	906.05	903.00	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELM-8909	222	2813	4/13/89	501,298	2,043,256	155.0	921.86	919.60	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELM-9501	234	2813	6/27/95	498,219	2,046,902	69.0	843.28	840.70	4.0	15.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELN-0801B	455	2813	4/15/08	498,220	2,046,894	105.0	843.87	841.37	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	DBG
ELN-0801C	456	2813	4/15/08	498,213	2,046,896	150.5	843.82	841.42	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG

Table 3
Monitoring Well Construction Information – Sampling Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
ELN-0801E	457	2813	10/23/08	498,221	2,046,909	207.7	842.70	840.10	2.5	5.0	187	PZ	Rock	E	Semi-Annual	DBG
ELN-0802A	458	2813	10/28/08	498,661	2,045,219	107.5	878.47	876.20	2.5	15.0	n/a	OW	Sand	A	Biennial	DBG
ELN-0802C	459	2813	10/30/08	498,663	2,045,211	180.8	878.47	876.10	2.5	5.0	n/a	PZ	Sand	C	Biennial	DBG
ELN-1001B	460	2813	5/11/10	497,078	2,047,480	96.1	809.31	806.98	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	DBG
ELN-1001C	461	2813	5/12/10	497,094	2,047,476	160.2	809.24	806.58	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG
ELN-1001E	462	2813	6/23/10	497,110	2,047,472	245.5	809.34	806.46	2.5	5.0	230	PZ	Rock	E	Semi-Annual	DBG
ELN-1002A	463	2813	6/8/10	496,066	2,049,181	70.3	835.13	832.55	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELN-1002B	464	2813	6/9/10	496,056	2,049,188	116.2	835.15	832.39	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	DBG
ELN-1002C	465	2813	6/15/10	496,075	2,049,195	164.1	835.15	832.13	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG
ELN-1002E	466	2813	6/17/10	496,063	2,049,200	236.5	834.75	831.97	2.5	5.0	219	PZ	Rock	E	Semi-Annual	DBG
ELN-1003A	467	2813	7/7/10	497,862	2,048,208	31.2	801.87	799.89	2.5	15.0	n/a	OW	Sand	A	Quarterly	DBG
ELN-1003B	468	2813	7/6/10	497,867	2,048,198	96.5	801.40	798.74	2.5	5.0	n/a	PZ	Sand	B	Quarterly	DBG
ELN-1003C	469	2813	7/6/10	497,873	2,048,186	160.1	801.82	799.24	2.5	5.0	n/a	PZ	Sand	C	Quarterly	DBG
ELN-1003E	470	2813	7/1/10	497,876	2,048,172	230.6	801.62	799.12	2.5	5.0	213	PZ	Rock	E	Quarterly	DBG
ELN-1502A	533	2813	10/19/15	499,322	2,046,218	130.3	902.15	899.20	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELN-1502C	534	2813	10/14/15	499,317	2,046,221	203.0	902.36	899.30	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG
ELN-1503A	535	2813	10/8/15	499,385	2,047,058	88.7	862.42	859.26	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELN-1503C	536	2813	10/7/15	499,377	2,047,057	162.6	862.29	859.54	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG
ELN-1504B	537	2813	9/11/15	497,531	2,048,387	39.8	780.51	778.34	2.0	5.0	n/a	PZ	Sand	B	Quarterly	DBG
ELN-8203A	210	2813	3/24/82	501,516	2,044,336	157.5	927.79	925.20	4.0	10.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELN-8203B	211	2813	3/25/82	501,502	2,044,325	166.0	927.43	925.50	4.0	2.0	n/a	PZ	Sand	B	Semi-Annual	DBG
ELN-8203C	212	2813	3/24/82	501,517	2,044,323	176.0	926.93	925.30	4.0	2.0	n/a	PZ	Sand	C	Semi-Annual	DBG
ELN-8902B	224	2813	4/18/89	501,013	2,044,130	178.5	920.38	918.00	4.0	5.0	n/a	PZ	Sand	B	Semi-Annual	DBG
ELN-9107A	227	2813	11/10/91	500,568	2,045,411	126.0	897.72	895.30	3.8	10.0	n/a	OW	Sand	A	Semi-Annual	DBG
ELN-9107B	228	2813	11/9/91	500,527	2,045,437	145.0	895.96	893.90	3.8	10.0	n/a	OW	Sand	B	Semi-Annual	DBG
ELN-9402AR	231	2813	2/15/94	501,014	2,044,060	145.0	920.92	919.00	4.0	15.0	n/a	OW	Sand	A	Semi-Annual	DBG
S1134R	236	2813	6/8/95	501,504	2,043,991	151.0	922.06	920.60	4.0	15.0	n/a	OW	Sand	A	Semi-Annual	DBG
DBM-8201	301	3037	3/23/82	500,846	2,043,148	174.7	918.76	916.70	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	DBG
DBM-8202	302	3037	3/20/82	501,147	2,042,937	157.4	920.35	917.80	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	DBG
DBM-8903	306	3037	2/16/89	500,499	2,043,488	133.0	898.94	896.40	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	DBG
DBN-1001B	472	3037	5/25/10	501,062	2,043,113	159.5	912.07	909.77	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	DBG
DBN-1001C	473	3037	5/27/10	501,063	2,043,094	197.0	912.00	909.78	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG
DBN-1001E	474	3037	6/30/10	501,065	2,043,076	279.9	912.50	909.95	2.5	5.0	258	PZ	Rock	E	Semi-Annual	DBG
DBN-1002C	476	3037	6/17/10	500,487	2,044,488	210.1	916.12	913.72	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	DBG
DBN-1002E	477	3037	7/12/10	500,511	2,044,485	280.6	916.24	913.84	2.5	5.0	265	PZ	Rock	E	Semi-Annual	DBG
DBN-9501A	314	3037	10/24/95	500,312	2,043,686	120.0	889.10	886.70	3.8	10.0	n/a	OW	Sand	A	Semi-Annual	DBG
DBN-9501B	315	3037	10/20/95	500,315	2,043,703	172.5	889.65	887.00	3.8	10.0	n/a	PZ	Sand	B	Semi-Annual	DBG
DBN-9501C	316	3037	10/18/95	500,298	2,043,710	228.5	890.03	887.50	3.8	10.0	n/a	PZ	Sand	C	Semi-Annual	DBG
DBN-9501E	317	3037	10/10/95	500,286	2,043,697	255.5	890.17	887.90	3.8	10.3	229	PZ	Rock	E	Semi-Annual	DBG
S1121	755	3038	1/18/80	496,303	2,047,578	59.3	815.58	813.90	4.0	20.2	n/a	OW	Sand	A	Semi-Annual	DBG

Table 3
Monitoring Well Construction Information – Sampling Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
RIM-0703	440	3487	10/4/07	499,282	2,034,376	113.0	889.23	886.53	2.5	15.0	n/a	OW	Sand	A	Annual	NC
RIM-0705	442	3487	10/10/07	497,844	2,035,152	106.0	884.38	881.30	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	NC
RIM-1002	478	3487	4/29/10	499,282	2,034,869	110.2	891.01	888.51	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	NC
RIN-1001A	480	3487	4/28/10	497,066	2,035,221	106.8	884.38	882.05	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	NC
RIN-1001C	481	3487	5/24/10	497,097	2,035,225	181.4	884.02	882.01	2.5	5.0	n/a	PZ	Sand	C	Annual	NC
RIN-1007C	479	3487	6/15/10	497,858	2,035,155	175.3	883.81	881.41	2.5	5.0	n/a	PZ	Sand	C	Annual	NC
S1125	504	3487	12/26/79	496,508	2,036,418	126.5	895.93	894.90	4.0	20.3	n/a	OW	Sand	A	Semi-Annual	NC
PBM-0001	367	2814	7/14/00	491,611	2,035,455	134.5	890.23	887.54	4.0	25.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBM-0002	368	2814	8/4/00	491,527	2,035,422	131.5	886.46	884.75	4.0	25.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBM-0006	372	2814	8/1/00	491,477	2,035,323	124.5	879.02	875.89	4.0	25.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBM-0008	374	2814	8/12/00	491,355	2,035,323	122.0	876.62	874.66	4.0	25.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBM-8907	637	2814	3/3/89	487,689	2,034,443	92.7	849.45	846.60	4.0	10.0	n/a	OW	Sand	A	Annual	PBG
PBM-8909	639	2814	3/1/89	492,402	2,035,472	124.4	883.66	880.60	4.0	20.0	n/a	OW	Sand	A	Biennial	PBG
PBM-9801	360	2814	10/13/98	491,877	2,035,466	123.5	890.46	887.85	4.0	15.0	n/a	OW	Sand	A	Annual	PBG
PBN-1001C	595	2814	6/8/10	485,968	2,035,767	199.7	840.01	837.71	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-1003C	592	2814	6/3/10	487,681	2,034,448	189.6	848.21	846.51	2.5	5.0	n/a	PZ	Sand	C	Annual	PBG
PBN-1302A	770	2814	10/16/13	484,705	2,036,460	84.7	830.23	828.30	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-1302B	771	2814	10/17/13	484,705	2,036,453	136.2	829.65	827.60	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-1302C	772	2814	10/22/13	484,705	2,036,448	187.6	828.98	827.00	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-1302D	773	2814	10/29/13	484,705	2,036,442	245.1	828.35	826.50	2.5	5.0	245	PZ	Sand	D	Semi-Annual	PBG
PBN-1303A	774	2814	11/5/13	484,651	2,036,981	130.5	884.88	883.00	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-1303B	775	2814	11/12/13	484,651	2,036,968	176.5	883.71	881.60	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-1303C	776	2814	11/20/13	484,652	2,036,963	232.0	883.67	881.60	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-1303D	777	2814	11/22/13	484,652	2,036,958	287.0	883.42	881.60	2.5	5.0	287	PZ	Sand	D	Semi-Annual	PBG
PBN-1304A	778	2814	12/3/13	484,642	2,037,502	116.0	871.81	869.40	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-1304B	779	2814	12/10/13	484,642	2,037,496	163.1	871.49	869.80	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-1304C	780	2814	12/17/13	484,642	2,037,489	218.0	872.00	869.70	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-1304D	781	2814	1/14/14	484,642	2,037,484	273.0	872.03	869.50	2.5	5.0	273	PZ	Sand	D	Semi-Annual	PBG
PBN-1401A	782	2814	2/19/14	491,036	2,035,501	132.2	887.30	884.57	2.5	15.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-1401B	783	2814	2/12/14	491,035	2,035,494	163.7	887.09	884.57	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-1401C	784	2814	2/10/14	491,035	2,035,488	203.3	887.08	884.57	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-1404B	791	2814	3/11/14	487,745	2,035,891	179.5	895.08	892.18	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-1404C	792	2814	3/4/14	487,742	2,035,888	239.3	895.04	892.18	2.5	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-1404D	793	2814	2/26/14	487,737	2,035,885	299.8	894.49	892.18	2.5	5.0	300	PZ	Sand	D	Semi-Annual	PBG
PBN-1405F	794	2814	3/25/14	484,824	2,035,411	319.7	806.29	803.77	2.5	5.0	212	PZ	Rock	F	Biennial	PBG
PBN-8202A	613	2814	5/1/82	491,539	2,035,491	118.5	886.15	884.09	4.0	10.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-8202B	614	2814	3/9/82	491,537	2,035,480	133.0	885.49	883.48	4.0	2.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-8202C	615	2814	3/8/82	491,529	2,035,490	141.2	885.43	882.47	4.0	2.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-8205A	622	2814	3/13/82	490,334	2,035,262	112.5	878.52	875.80	4.0	10.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-8205B	623	2814	3/11/82	490,343	2,035,252	124.3	877.80	875.88	4.0	2.0	n/a	PZ	Sand	B	Semi-Annual	PBG

Table 3
Monitoring Well Construction Information – Sampling Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
PBN-8205C	624	2814	3/11/82	490,330	2,035,250	133.5	878.31	875.80	4.0	2.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-8502A	632	2814	10/1/85	489,416	2,035,667	138.1	898.88	895.80	5.0	9.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-8503A	633	2814	10/3/85	489,407	2,034,266	94.8	851.45	848.10	5.0	9.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-8902BR	795	2814	3/24/14	489,418	2,035,684	160.0	898.87	896.82	2.5	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-8902C	645	2814	3/19/89	489,415	2,035,630	193.3	897.12	894.50	4.0	5.2	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-8903B	646	2814	3/8/89	489,457	2,034,281	125.0	847.93	844.90	4.0	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-8903C	647	2814	3/9/89	489,457	2,034,316	160.0	846.96	844.10	4.0	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-8912A	654	2814	3/2/89	486,338	2,034,980	103.4	855.86	852.60	4.0	20.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-8912B	655	2814	4/15/89	486,312	2,034,979	138.0	856.34	852.60	4.0	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-9112C	665	2814	10/24/91	486,280	2,034,972	183.4	854.48	852.20	3.8	10.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-9112D	666	2814	10/16/91	486,253	2,034,965	231.0	853.31	851.20	3.8	10.0	n/a	PZ	Sand	D	Semi-Annual	PBG
PBN-9301B	668	2814	3/19/93	489,365	2,036,994	160.5	875.03	872.20	3.9	10.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-9301C	669	2814	3/16/93	489,353	2,037,006	227.5	874.64	872.22	3.9	10.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-9303B	673	2814	3/9/93	486,123	2,036,945	93.5	816.16	813.49	3.9	10.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-9303C	674	2814	3/14/93	486,126	2,036,969	164.5	815.05	812.45	3.9	10.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-9303D	675	2814	3/11/93	486,127	2,036,990	224.5	813.98	811.41	3.9	10.0	223	PZ	Sand	D	Semi-Annual	PBG
PBN-9304D	687	2814	10/19/93	484,890	2,035,315	210.0	806.09	804.10	4.0	10.0	210	PZ	Sand	D	Semi-Annual	PBG
PBN-9902D	691	2814	7/1/99	484,798	2,035,025	222.5	811.53	809.50	4.0	5.0	217	PZ	Sand	D	Semi-Annual	PBG
PBN-9903A	692	2814	6/23/99	483,859	2,035,680	76.0	826.91	825.18	4.0	15.0	n/a	OW	Sand	A	Semi-Annual	PBG
PBN-9903B	693	2814	7/8/99	483,859	2,035,687	112.0	827.17	825.00	4.0	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
PBN-9903C	694	2814	7/15/99	483,861	2,035,693	163.0	827.33	824.99	4.0	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-9903D	695	2814	7/13/99	483,861	2,035,698	208.0	827.52	825.10	4.0	5.0	196	PZ	Sand	D	Semi-Annual	PBG
PBM-9001D	981	3485	8/25/90	477,175	2,038,945	210.5	831.52	829.00	4.0	10.0	n/a	PZ	Sand	D	Semi-Annual	PBG
PBM-9002D	982	3485	8/18/90	475,994	2,038,132	204.5	821.31	818.70	4.0	10.0	n/a	PZ	Sand	D	Biennial	PBG
PBN-9101C	561	3493	10/25/91	477,125	2,038,954	152.5	830.11	828.00	3.8	10.0	n/a	PZ	Sand	C	Semi-Annual	PBG
PBN-9102B	562	3493	9/28/91	476,019	2,038,141	115.0	821.19	819.00	3.8	10.0	n/a	PZ	Sand	B	Biennial	PBG
PBN-9102C	563	3493	9/30/91	476,028	2,038,105	161.3	821.90	819.90	3.8	10.0	n/a	PZ	Sand	C	Biennial	PBG
SWN-9102C	569	3493	10/27/91	479,341	2,035,141	152.5	836.41	834.40	3.8	10.0	n/a	PZ	Sand	C	Annual	PBG
SWN-9102D	570	3493	10/23/91	479,341	2,035,185	185.0	836.66	834.50	4.0	10.0	n/a	PZ	Sand	D	Annual	PBG
SWN-9103B	571	3493	10/4/91	479,353	2,036,656	113.4	836.63	834.70	3.8	10.0	n/a	PZ	Sand	B	Semi-Annual	PBG
SWN-9103C	572	3493	10/2/91	479,351	2,036,622	162.8	836.80	834.60	4.0	10.0	n/a	PZ	Sand	C	Semi-Annual	PBG
SWN-9103D	573	3493	10/1/91	479,352	2,036,701	209.1	837.10	835.00	4.0	10.0	210	PZ	Sand	D	Semi-Annual	PBG
SWN-9103E	574	3493	11/10/91	479,352	2,036,753	237.9	837.38	835.00	3.8	10.0	210	PZ	Rock	E	Semi-Annual	PBG
SWN-9104C	575	3493	10/13/91	479,357	2,037,722	164.0	834.87	832.80	3.8	10.0	n/a	PZ	Sand	C	Semi-Annual	PBG
SWN-9104D	576	3493	10/9/91	479,359	2,037,678	197.0	835.33	833.50	3.8	10.0	n/a	PZ	Sand	D	Semi-Annual	PBG
SWN-9105B	577	3493	10/12/91	478,954	2,038,812	112.5	832.73	830.50	3.8	10.0	n/a	PZ	Sand	B	Annual	PBG
SWN-9105C	578	3493	10/11/91	478,924	2,038,828	147.0	832.88	830.80	3.8	10.0	n/a	PZ	Sand	C	Annual	PBG
SWN-9105D	579	3493	10/10/91	478,885	2,038,855	200.5	833.35	831.20	3.8	10.0	n/a	PZ	Sand	D	Annual	PBG
S1147	709	3499	10/10/83	484,928	2,034,512	70.8	817.07	815.70	5.0	25.0	n/a	OW	Sand	A	Semi-Annual	PBG
S1148	710	3499	10/10/83	484,691	2,035,563	56.7	803.72	802.10	5.0	25.0	n/a	OW	Sand	A	Semi-Annual	PBG

Table 3
Monitoring Well Construction Information – Sampling Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
SPN-8903B	718	3499	3/22/89	484,935	2,034,532	93.7	818.14	815.10	4.0	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
SPN-8903C	719	3499	4/13/89	484,907	2,034,501	127.7	818.13	815.30	4.0	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
SPN-8904B	720	3499	3/9/89	484,691	2,035,540	75.0	804.23	801.60	4.0	5.0	n/a	PZ	Sand	B	Semi-Annual	PBG
SPN-8904C	721	3499	3/30/89	484,694	2,035,642	106.5	803.25	800.70	4.0	5.0	n/a	PZ	Sand	C	Semi-Annual	PBG
SPN-9103D	725	3499	10/8/91	484,909	2,034,440	200.5	819.29	816.70	3.8	10.0	n/a	PZ	Sand	D	Semi-Annual	PBG
SPN-9104D	726	3499	10/1/91	484,693	2,035,601	206.0	802.61	800.80	3.8	10.0	212	PZ	Sand	D	Semi-Annual	PBG

Notes

OW = Water Table Observation Well
PZ = Piezometer
DBG = Deterrent Burning Ground Plume
Central = Central Plume
NC = Nitrocellulose Production Area Plume
PBG = Propellant Burning Ground Plume
Screen Level references the typical well depth configuration

Table 4
Monitoring Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
S1112	752	3038	1/4/80	490,050	2,045,210	91.7	838.03	836.40	4.0	20.3	n/a	OW	Sand	A	Not Sampled	Central
S1113	753	3038	11/23/79	491,611	2,048,037	66.1	821.58	820.00	4.0	20.2	n/a	OW	Sand	A	Not Sampled	Central
S1114	754	3038	11/20/79	491,603	2,048,038	105.4	821.46	820.10	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	Central
NLM-9202R	270	3118	12/21/92	494,989	2,046,317	118.2	885.15	882.90	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
NLN-8201A	252	3118	4/23/82	495,556	2,045,494	120.3	890.65	888.60	4.0	10.0	n/a	OW	Sand	A	Not Sampled	Central
NLN-8201B	253	3118	4/22/82	495,566	2,045,487	132.5	891.28	889.00	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	Central
NLN-8201C	254	3118	4/7/82	495,552	2,045,485	142.0	890.54	888.60	4.0	2.0	n/a	PZ	Sand	C	Not Sampled	Central
NLN-8202A	255	3118	4/30/82	495,648	2,046,075	102.9	873.61	872.53	4.0	10.0	n/a	OW	Sand	A	Not Sampled	Central
NLN-8202B	256	3118	4/23/82	495,646	2,046,087	115.0	873.69	871.97	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	Central
NLN-8204A	261	3118	5/8/82	494,911	2,045,873	125.5	892.72	891.00	4.0	10.0	n/a	OW	Sand	A	Not Sampled	Central
NLN-8204B	262	3118	5/8/82	494,899	2,045,877	137.5	893.44	891.60	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	Central
NLN-8204C	263	3118	5/7/82	494,901	2,045,867	150.0	893.54	891.60	4.0	2.0	n/a	PZ	Sand	C	Not Sampled	Central
NLN-8205B	265	3118	5/10/82	494,905	2,046,159	136.5	899.28	896.90	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	Central
NLN-8205C	266	3118	5/10/82	494,917	2,046,156	147.5	897.99	896.30	4.0	2.0	n/a	PZ	Sand	C	Not Sampled	Central
NLN-9205AR	269	3118	11/13/92	494,913	2,046,170	132.0	897.82	895.30	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
RPM-9101	509	3487	10/26/91	492,702	2,045,303	105.8	874.04	871.80	3.8	10.0	n/a	OW	Sand	A	Not Sampled	Central
S1120	502	3487	1/17/80	493,313	2,044,061	122.8	880.14	877.40	4.0	20.2	n/a	OW	Sand	A	Not Sampled	Central
S1150	505	3487	10/10/83	496,772	2,037,797	138.0	897.56	895.60	5.0	25.0	n/a	OW	Sand	A	Not Sampled	Central
NLM-0301R	271	3646	7/23/03	495,613	2,045,778	112.0	881.20	877.92	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
NLM-0302R	272	3646	1/9/04	496,404	2,045,533	127.0	894.50	891.70	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
NLM-0401	296	3646	8/3/04	495,912	2,046,255	112.0	869.29	866.66	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
NLM-1001	330	3646	4/14/10	496,509	2,044,604	106.0	880.22	878.00	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
NLN-0701A	297	3646	6/6/07	495,491	2,045,250	125.0	887.47	884.87	4.0	15.0	n/a	OW	Sand	A	Not Sampled	Central
NLN-0701C	298	3646	6/5/07	495,491	2,045,242	155.0	887.29	884.79	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	Central
ELM-9110	229	2813	11/13/91	501,635	2,044,708	154.0	923.03	920.80	3.8	15.0	n/a	OW	Sand	A	Not Sampled	DBG
ELN-8904A	225	2813	3/30/89	501,790	2,044,600	162.0	926.34	924.10	4.0	20.0	n/a	OW	Sand	A	Not Sampled	DBG
ELN-8904B	226	2813	4/2/89	501,721	2,044,645	199.0	926.61	924.80	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	DBG
LOM-8901	656	2814	2/17/89	492,014	2,036,131	157.5	918.08	915.90	4.0	20.0	n/a	PZ	Sand	A	Not Sampled	PBG
LOM-9101	661	2814	10/10/91	492,618	2,036,184	151.0	917.76	915.50	3.8	10.0	n/a	PZ	Sand	A	Not Sampled	PBG
LOM-9102	662	2814	10/25/91	493,326	2,036,375	148.0	912.46	910.30	3.8	10.0	n/a	OW	Sand	A	Not Sampled	PBG
LON-8902A	657	2814	2/19/89	491,571	2,036,136	159.0	927.95	918.50	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
LON-8903A	659	2814	2/20/89	491,581	2,036,311	158.0	926.36	919.20	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
LON-8903B	660	2814	2/20/89	491,579	2,036,275	198.0	927.41	919.50	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
LON-9502BR	683	2814	6/1/95	491,573	2,036,166	203.5	927.54	919.30	4.0	18.5	n/a	PZ	Sand	B	Not Sampled	PBG
PBM-0003	369	2814	8/8/00	491,440	2,035,388	120.5	875.95	876.89	4.0	25.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-0004	370	2814	7/25/00	491,356	2,035,354	125.5	877.62	875.64	4.0	25.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-0005	371	2814	7/19/00	491,566	2,035,322	128.0	883.58	881.22	4.0	25.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-0007	373	2814	7/24/00	491,417	2,035,323	120.9	874.47	872.56	4.0	25.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-1201	764	2814	11/15/12	491,516	2,035,458	118.5	882.56	880.24	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-1202	765	2814	11/19/12	491,507	2,035,442	118.5	881.48	879.01	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG

Table 4
Monitoring Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
PBM-1203	766	2814	11/20/12	491,496	2,035,425	118.4	880.18	877.69	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8201	605	2814	3/18/82	491,409	2,034,559	100.7	857.36	855.70	4.0	20.0	n/a	PZ	Sand	A	Not Sampled	PBG
PBM-8203	607	2814	3/16/82	490,778	2,034,771	108.8	868.42	862.70	4.0	20.0	n/a	PZ	Sand	A	Not Sampled	PBG
PBM-8204	608	2814	3/17/82	490,553	2,035,006	115.5	875.72	869.00	4.0	20.0	n/a	PZ	Sand	A	Not Sampled	PBG
PBM-8205	609	2814	5/3/82	490,547	2,035,178	123.8	877.11	874.50	4.0	20.0	n/a	PZ	Sand	A	Not Sampled	PBG
PBM-8501	625	2814	9/22/85	489,712	2,034,851	121.6	862.73	859.30	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8502	626	2814	9/17/85	489,417	2,034,654	101.7	849.42	845.40	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8503	627	2814	9/18/85	489,414	2,035,277	150.5	886.29	882.90	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8504	628	2814	9/24/85	488,819	2,035,043	125.4	866.47	863.80	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8505	629	2814	9/28/85	488,223	2,035,056	111.0	863.97	861.30	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8506	630	2814	10/4/85	487,043	2,035,032	98.2	848.18	845.10	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8905	635	2814	3/6/89	489,403	2,033,827	98.1	855.64	852.30	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8906	636	2814	4/30/89	489,509	2,036,227	136.0	886.34	883.70	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8908	638	2814	3/14/89	487,520	2,035,745	125.0	888.68	885.50	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-8911	640	2814	3/7/89	493,411	2,035,391	111.0	884.45	881.60	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-9803	526	2814	10/7/98	491,595	2,035,352	121.7	885.16	882.64	4.0	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-9901	361	2814	6/4/99	491,934	2,035,484	130.0	891.56	888.90	4.0	105.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-9902	362	2814	6/4/99	491,664	2,035,482	132.0	890.94	888.35	4.0	110.0	n/a	OW	Sand	A	Not Sampled	PBG
PBM-9903	363	2814	6/4/99	491,628	2,035,319	126.0	882.42	880.87	4.0	105.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-1001A	593	2814	5/3/10	485,984	2,035,770	79.3	840.37	838.17	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-1001B	594	2814	6/2/10	485,976	2,035,768	139.9	839.93	838.23	2.5	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-1002A	589	2814	5/20/10	488,451	2,035,897	130.8	893.90	891.70	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-1002B	590	2814	5/19/10	488,447	2,035,927	176.5	894.27	892.27	2.5	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-1002C	591	2814	6/9/10	488,450	2,035,908	216.8	893.48	891.48	2.5	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-1301A	767	2814	9/16/13	491,295	2,035,639	130.0	899.97	897.35	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-1301B	768	2814	9/12/13	491,310	2,035,602	159.5	897.32	894.58	2.5	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-1301C	769	2814	9/10/13	491,265	2,035,609	200.0	897.14	894.54	2.5	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-1402A	785	2814	2/4/14	490,204	2,035,272	113.6	878.31	876.47	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-1402B	786	2814	2/10/14	490,204	2,035,277	132.9	878.77	876.47	2.5	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-1402C	787	2814	2/18/14	490,204	2,035,282	162.8	878.74	876.47	2.5	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-1403A	788	2814	2/27/14	489,290	2,035,682	135.7	901.24	899.00	2.5	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-1403B	789	2814	2/26/14	489,290	2,035,687	157.2	901.22	899.05	2.5	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-1403C	790	2814	2/20/14	489,290	2,035,693	192.0	901.64	899.27	2.5	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8201A	610	2814	3/18/82	492,093	2,035,482	117.8	884.59	881.50	4.0	10.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-8201B	611	2814	3/10/82	492,091	2,035,469	131.5	883.77	881.50	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-8201C	612	2814	3/10/82	492,101	2,035,476	141.0	883.98	881.50	4.0	2.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8203A	616	2814	3/15/82	490,314	2,034,600	96.5	860.01	857.60	4.0	10.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-8203B	617	2814	3/15/82	490,311	2,034,613	108.5	860.26	857.60	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-8203C	618	2814	3/15/82	490,300	2,034,606	117.5	860.17	857.60	4.0	2.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8204B	620	2814	3/13/82	490,027	2,035,049	120.5	874.74	873.00	4.0	2.0	n/a	PZ	Sand	B	Not Sampled	PBG

Table 4
Monitoring Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
PBN-8204C	621	2814	3/12/82	490,026	2,035,062	131.5	875.59	873.00	4.0	2.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8501A	631	2814	9/18/85	489,413	2,035,044	121.9	874.51	871.30	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-8504A	634	2814	9/30/85	487,634	2,035,066	112.7	860.03	857.20	5.0	9.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-8901B	641	2814	1/22/89	489,397	2,035,022	159.9	872.55	870.00	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-8901C	642	2814	4/19/89	489,395	2,035,102	198.1	878.03	875.50	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8901D	643	2814	1/21/89	489,397	2,035,047	238.2	874.19	871.50	4.0	5.0	n/a	PZ	Sand	D	Not Sampled	PBG
PBN-8904B	648	2814	3/19/89	487,673	2,035,060	144.0	859.32	856.70	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-8904C	649	2814	4/16/89	487,651	2,035,092	180.5	859.87	857.70	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8910A	650	2814	2/22/89	491,156	2,035,501	128.0	889.82	886.80	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-8910B	651	2814	2/28/89	491,159	2,035,539	166.7	892.09	889.10	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-8910C	652	2814	2/3/89	491,154	2,035,464	192.0	887.11	884.70	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-8910D	653	2814	4/29/89	491,142	2,035,388	237.0	884.42	880.90	4.0	5.0	n/a	PZ	Sand	D	Not Sampled	PBG
PBN-9106C	663	2814	10/22/91	487,104	2,035,032	201.0	848.71	846.10	3.8	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9106D	664	2814	10/12/91	487,107	2,035,008	251.0	847.53	845.80	3.8	10.0	n/a	PZ	Sand	D	Not Sampled	PBG
PBN-9302B	670	2814	3/5/93	487,005	2,036,974	154.5	873.31	871.26	3.9	10.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-9302C	671	2814	2/26/93	487,017	2,036,966	204.0	873.76	872.24	3.9	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9302D	672	2814	3/7/93	487,001	2,036,953	289.5	874.93	870.72	3.9	10.0	288	PZ	Sand	D	Not Sampled	PBG
PBN-9304A	684	2814	10/12/93	484,886	2,035,343	50.0	805.93	804.00	4.0	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-9304B	685	2814	10/19/93	484,897	2,035,329	86.0	805.77	804.00	4.0	10.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-9304C	686	2814	10/21/93	484,866	2,035,315	115.0	806.41	804.50	4.0	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9306C	667	2814	3/22/90	489,507	2,036,238	227.5	886.51	884.06	3.9	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9401B	677	2814	8/8/94	486,957	2,038,337	127.7	852.23	850.50	4.0	10.3	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-9401C	678	2814	8/9/94	486,981	2,038,338	167.8	852.96	851.00	4.0	10.4	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9401D	679	2814	8/3/94	486,971	2,038,337	267.0	853.01	850.90	4.0	10.0	277	PZ	Sand	D	Not Sampled	PBG
PBN-9402B	680	2814	8/24/94	485,560	2,038,160	95.5	816.36	813.90	4.0	10.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-9402C	681	2814	8/22/94	485,560	2,038,150	135.0	816.35	813.80	4.0	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9402D	682	2814	8/18/94	485,557	2,038,140	225.0	816.14	813.70	4.0	10.0	n/a	PZ	Sand	D	Not Sampled	PBG
PBN-9404AR	676	2814	2/18/94	490,017	2,035,038	118.0	873.63	871.30	4.0	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-9901A	696	2814	6/22/99	484,812	2,034,889	59.0	810.38	808.39	4.0	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-9901B	697	2814	6/29/99	484,808	2,034,889	107.0	809.93	808.46	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-9901C	698	2814	6/28/99	484,799	2,034,890	163.0	810.00	808.45	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
PBN-9901D	699	2814	6/23/99	484,790	2,034,891	216.0	810.95	808.52	4.0	5.0	216	PZ	Sand	D	Not Sampled	PBG
PBN-9902A	688	2814	6/22/99	484,805	2,035,024	60.0	811.54	808.91	4.0	15.0	n/a	OW	Sand	A	Not Sampled	PBG
PBN-9902B	689	2814	7/8/99	484,803	2,035,020	111.0	810.72	808.41	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
PBN-9902C	690	2814	7/7/99	484,800	2,035,029	168.0	811.23	809.16	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
S1109	600	2814	2/14/80	488,537	2,032,975	107.3	856.64	855.10	4.0	20.4	n/a	OW	Sand	A	Not Sampled	PBG
S1117	601	2814	2/13/80	490,355	2,034,837	119.1	867.92	862.30	4.0	20.2	n/a	OW	Sand	A	Not Sampled	PBG
SWN-0501B	237	3493	12/15/05	480,635	2,039,879	155.6	860.07	860.40	4.0	10.0	n/a	PZ	Sand	B	Not Sampled	PBG
SWN-0501C	238	3493	12/13/05	480,634	2,039,894	206.6	860.28	860.60	4.0	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
SWN-0501D	239	3493	12/9/05	480,635	2,039,906	262.9	860.38	860.50	4.0	10.0	n/a	PZ	Sand	D	Not Sampled	PBG

Table 4
Monitoring Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	NAD83 Northing (feet)	NAD83 Easting (feet)	Well Depth (feet)	Top of Casing Elevation	Ground Elevation	Well Diameter (inches)	Screen Length (feet)	Bedrock Depth (feet)	Well Type	Aquifer	Screen Level	Sample Frequency	Plume Area
SWN-0501E	240	3493	11/30/05	480,635	2,039,917	290.3	860.53	860.70	2.0	10.0	253	PZ	Rock	E	Not Sampled	PBG
SWN-0502B	241	3493	12/22/05	479,887	2,039,265	155.8	856.10	856.30	4.0	10.0	n/a	PZ	Sand	B	Not Sampled	PBG
SWN-0502C	242	3493	12/20/05	479,885	2,039,280	201.5	856.39	856.50	4.0	10.0	n/a	PZ	Sand	C	Not Sampled	PBG
SWN-0502D	243	3493	12/7/05	479,886	2,039,273	244.9	856.19	856.30	4.0	10.0	n/a	PZ	Sand	D	Not Sampled	PBG
SWN-0502E	244	3493	12/13/05	479,893	2,039,267	260.0	856.27	856.50	2.0	10.0	240	PZ	Rock	E	Not Sampled	PBG
S1102	701	3499	11/5/79	484,693	2,036,063	64.6	809.25	807.70	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
S1103	702	3499	11/2/79	484,689	2,036,056	120.1	809.02	807.50	4.0	5.1	n/a	PZ	Sand	C	Not Sampled	PBG
S1106	705	3499	11/14/79	484,794	2,039,567	135.7	839.91	838.10	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
S1133	708	3499	2/19/80	484,746	2,032,920	97.0	828.28	828.20	4.0	5.2	n/a	PZ	Sand	B	Not Sampled	PBG
S1149	711	3499	10/10/83	485,128	2,036,476	60.8	807.75	806.10	5.0	25.0	n/a	OW	Sand	A	Not Sampled	PBG
S1152AR	727	3499	4/12/95	484,582	2,036,036	56.0	812.48	809.80	4.0	15.0	n/a	OW	Sand	A	Not Sampled	PBG
S1152B	713	3499	9/26/85	484,582	2,036,049	73.6	813.26	810.30	4.0	5.0	n/a	OW	Sand	B	Not Sampled	PBG
SPN-8901C	714	3499	3/29/89	484,722	2,032,922	121.0	830.09	827.80	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
SPN-8902A	715	3499	2/22/89	484,748	2,033,808	71.0	823.67	820.80	4.0	20.0	n/a	OW	Sand	A	Not Sampled	PBG
SPN-8902B	716	3499	3/15/89	484,741	2,033,827	98.8	823.61	820.30	4.0	5.0	n/a	PZ	Sand	B	Not Sampled	PBG
SPN-8902C	717	3499	4/14/89	484,745	2,033,868	129.0	822.48	820.00	4.0	5.0	n/a	PZ	Sand	C	Not Sampled	PBG
SPN-9102D	724	3499	10/9/91	484,733	2,033,650	182.8	824.11	821.60	3.8	10.0	n/a	PZ	Sand	D	Not Sampled	PBG

Notes

OW = Water Table Observation Well
PZ = Piezometer
DBG = Deterrent Burning Ground Plume
Central = Central Plume
PBG = Propellant Burning Ground Plume
Screen Level references the typical well depth configuration

Table 5
Residential Well Construction Information – Sampling Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer	Sample Frequency	Plume Area
USDA 1	828	3497	11/4/79	575	12	263	Rock	Annual	Central
USDA 2	829	3497	7/18/96	227	6	n/a	Sand	Annual	Central
USDA 3	126	3497	10/21/80	270	6	235	Rock	Annual	Central
USDA 6	128	3497	3/7/06	140	8	n/a	Sand	Annual	Central
WE-QN039	158	3497	11/15/01	100	6	n/a	Sand	Annual	Central
WE-QR441	157	3497	1/29/02	118	5	n/a	Sand	Annual	Central
WE-RD430	159	3497	12/10/02	80	6	n/a	Sand	Annual	Central
WE-RM383	153	3497	6/10/03	81	6	n/a	Sand	Annual	Central
WE-RR542	156	3497	9/20/03	100	6	n/a	Sand	Annual	Central
WE-RR598	169	3497	3/10/04	106	6	n/a	Sand	Annual	Central
WE-SQ001	165	3497	1/15/05	179	6	n/a	Sand	Annual	Central
WE-SQ002	170	3497	1/20/05	100	6	n/a	Sand	Annual	Central
WE-SQ017	164	3497	3/10/05	180	5	n/a	Sand	Annual	Central
WE-TF023	174	3497	2/22/06	178	5	n/a	Sand	Annual	Central
WE-TM599	129	3497	10/2/06	120	5	n/a	Sand	Annual	Central
WE-UA297	433	3497	7/17/07	180	6	n/a	Sand	Annual	Central
WE-UK125	431	3497	12/29/07	283	5	243	Rock	Annual	Central
WE-XD828	434	3497	8/19/13	80	6	n/a	Sand	Annual	Central
WE-XK342	435	3497	8/27/14	80	6	n/a	Sand	Annual	Central
WE-YW972	436	3497	5/14/18	121	6	n/a	Sand	Annual	Central
WE-ZE512	437	3497	12/22/18	324	6	205	Rock	Quarterly	Central
Anderson-R	411	3497		26	n/a	n/a	Sand	Annual	DBG
Brey	817	3497		85	6	n/a	Sand	Annual	DBG
Curto	412	3497		n/a	n/a	n/a	unknown	Annual	DBG
Gibbs	839	3497		n/a	n/a	n/a	unknown	Annual	DBG
Grosse	415	3497		110	n/a	n/a	Sand	Annual	DBG
Groth	842	3497	1/5/89	219	6	169	Rock	Annual	DBG
Gruber-D	417	3497		n/a	n/a	n/a	Sand	Annual	DBG
Hendershot	418	3497		20	n/a	n/a	Sand	Annual	DBG
Howery	419	3497		n/a	n/a	n/a	unknown	Annual	DBG
Kopras	874	3497	5/28/88	260	6	217	Rock	Annual	DBG
Lukens	860	3497	7/25/08	29	1	n/a	Sand	Annual	DBG
Melum	423	3497	7/6/06	100	5	n/a	Sand	Annual	DBG
Nowotarski	891	3497	11/16/99	88	2	n/a	Sand	Annual	DBG
Olah	904	3497		30	n/a	n/a	Sand	Annual	DBG
Osterland	422	3497		n/a	n/a	n/a	unknown	Annual	DBG
Purcell-D	163	3497	7/26/19	344	6	216	Rock	Quarterly	DBG
Purcell-G	916	3497		n/a	n/a	n/a	unknown	Annual	DBG
Raschein	424	3497		n/a	n/a	n/a	unknown	Annual	DBG
Reif	427	3497		n/a	n/a	n/a	unknown	Annual	DBG
Revers	425	3497	5/8/89	80	6	n/a	Sand	Annual	DBG
Roll	426	3497		n/a	n/a	n/a	unknown	Annual	DBG
Schumann	428	3497		n/a	n/a	n/a	Sand	Annual	DBG
Spear	803	3497	3/1/93	159	n/a	n/a	Sand	Annual	DBG
Wenger	414	3497		n/a	n/a	n/a	Sand	Annual	DBG
Zurbachen-A	967	3497	8/28/78	176	6	173	Rock	Annual	DBG
Apel	998	3497	11/21/92	178	6	n/a	Sand	Annual	PBG
Delaney	152	3497	8/25/99	301	6	265	Rock	Annual	PBG
Judd	862	3497		180	n/a	n/a	Sand	Annual	PBG
Krumenauer	875	3497	4/8/90	156	6	n/a	Sand	Annual	PBG
Mittenzwei	800	3497		131	n/a	n/a	Sand	Annual	PBG
PDS-3	911	3497	6/11/91	554	15	186	Rock	Annual	PBG
Ramaker-J	917	3497		310	n/a	n/a	Rock	Annual	PBG
Schlender	931	3497		280	n/a	n/a	Rock	Annual	PBG

<u>Notes</u>

DBG = Deterrent Burning Ground Plume
Central = Central Plume
PBG = Propellant Burning Ground Plume

Table 6
Residential Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer
Anderson	804	3497		n/a	n/a	n/a	unknown
Andres	631	3497	2016	n/a	n/a	n/a	Sand
Andres	130	3497		n/a	n/a	n/a	unknown
Askey-1	178	3497	8/6/49	166	6	n/a	Sand
Askey-2	932	3497	3/12/77	256	6	200	Rock
Ballweg	131	3497		n/a	n/a	n/a	unknown
Bauer	807	3497	9/18/79	65	6	n/a	Sand
Behrens	197	3497		n/a	n/a	n/a	unknown
Bender	119	3497		n/a	n/a	n/a	unknown
Bickford-1	809	3497	2/13/67	187	18	n/a	Sand
Bickford-2	810	3497	2/13/67	152	18	n/a	Sand
Bickford-D	808	3497	6/30/65	152	18	n/a	Sand
Block	117	3497	7/26/01	101	6	n/a	Sand
Bluffview #1	813	3497	5/31/60	280	8	175	Rock
Bluffview #2	n/a	3497	1/1/60	n/a	8	n/a	Sand
Bluffview #3	n/a	3497	4/22/42	435	16	199	Rock
Brabender	171	3497		n/a	n/a	n/a	unknown
Bram	168	3497	1/1/94	n/a	n/a	n/a	unknown
Carlson	124	3497		n/a	n/a	n/a	unknown
Checky	132	3497		126	5	n/a	Sand
Christie	820	3497		n/a	n/a	n/a	unknown
Clark-M	821	3497		n/a	n/a	n/a	unknown
Clark-S	822	3497		n/a	n/a	n/a	unknown
Co-op County Partners	948	3497	6/20/88	276	6	n/a	Sand
Coves Court	147	3497		372	8	196	Rock
Cramer	825	3497		n/a	n/a	n/a	unknown
YR846	628	3497	10/18/16	120	5	n/a	Sand
Crow	160	3497		n/a	n/a	n/a	unknown
Dahir	827	3497		n/a	n/a	n/a	unknown
Danube	830	3497		n/a	n/a	n/a	unknown
Delaney-L	175	3497	10/1/74	263	6	225	Rock
Deppe	413	3497		n/a	n/a	n/a	Sand
Dischler-B	926	3497		n/a	n/a	n/a	unknown
Dorman	182	3497		n/a	n/a	n/a	unknown
Dybul	133	3497		n/a	n/a	n/a	Sand
Dyrud-Witte	907	3497	7/23/74	178	6	140	Rock
E12671	609	3497		n/a	n/a	n/a	Sand
E12680	611	3497		n/a	n/a	n/a	Sand
E12690A	613	3497		n/a	n/a	n/a	Sand
E12734	621	3497		n/a	n/a	n/a	Sand
E12742	622	3497		n/a	n/a	n/a	Sand
Eilertson-N	929	3497	10/17/69	120	6	n/a	Sand
Eilertson-S	834	3497	9/14/83	290	6	n/a	Rock

Table 6
Residential Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer
Elsing	194	3497	8/2/99	275	6	n/a	Sand
Emery	167	3497	1/1/91	n/a	n/a	n/a	unknown
Engh	184	3497	10/21/74	288	6	240	Rock
Fehn	121	3497		n/a	n/a	n/a	unknown
Fenbert	902	3497		n/a	n/a	n/a	unknown
Fentress	195	3497		n/a	n/a	n/a	unknown
Ferry	836	3497	10/12/44	178	6	n/a	Sand
Franks	134	3497		n/a	n/a	n/a	unknown
Ganser	187	3497	10/20/89	273	6	228	Rock
Gasner	113	3497		n/a	n/a	n/a	unknown
Gentz	865	3497		100	n/a	n/a	Sand
Gjertson	196	3497		n/a	n/a	n/a	unknown
Gleason	135	3497	8/8/92	242	5	n/a	Sand
Goelz	173	3497		n/a	n/a	n/a	unknown
Goette	845	3497	10/31/01	570	6	n/a	Rock
Greimel	841	3497		n/a	n/a	n/a	unknown
Grosse-garage	416	3497		n/a	n/a	n/a	Sand
Gruber-North	970	3497	8/25/75	240	6	170	Rock
Haasl	189	3497	11/29/73	270	6	245	Rock
Halweg-J	846	3497		n/a	n/a	n/a	unknown
Hankins	847	3497	9/16/08	221	6	206	Rock
Hannah	848	3497		n/a	n/a	n/a	unknown
Hanson	963	3497	4/9/90	307	6	278	Rock
Harpold	918	3497		206	6	198	Rock
Hasheider	852	3497	7/8/87	198	6	n/a	Sand
Heidenreich	853	3497	3/25/82	235	6	n/a	Rock
Henning	854	3497		n/a	n/a	n/a	unknown
Henry	855	3497	10/15/82	75	6	n/a	Sand
Herr	136	3497		191	6	n/a	Sand
Hill	137	3497		97	6	n/a	Sand
Hutter-R	857	3497		n/a	n/a	n/a	unknown
IA214	n/a	3497	10/31/94	625	6	169	Rock
Jackson	176	3497	12/7/95	255	6	225	Rock
Jacobson	185	3497		n/a	n/a	n/a	unknown
Jannenga	188	3497	7/17/74	272	6	230	Rock
Jewell	859	3497		n/a	n/a	n/a	unknown
Johnson	138	3497		102	6	n/a	Sand
Johnson-K	139	3497		150	6	n/a	Sand
Jonas	115	3497		n/a	n/a	n/a	unknown
Jones	889	3497		n/a	n/a	n/a	unknown
Kamps	863	3497	8/19/77	267	6	225	Rock
Kaufman/Schmitz	183	3497	10/3/76	263	6	237	Rock

Table 6
Residential Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer
Kindschi-1	867	3497	5/26/77	140	14	n/a	Sand
Kindschi-3	n/a	3497		n/a	n/a	n/a	Sand
Kindschi-3	868	3497	2/19/82	181	14	n/a	Sand
Kindschi-4	n/a	3497		n/a	n/a	n/a	Sand
Kindschi-A	866	3497		n/a	n/a	n/a	unknown
Kindschi-J	869	3497		n/a	n/a	n/a	unknown
Kindschi-V	870	3497		n/a	n/a	n/a	unknown
Kirner	843	3497	2/27/91	534	5	226	Rock
Klepper	140	3497		101	5	n/a	Sand
Kohlman	109	3497		n/a	n/a	n/a	unknown
Kowalke	181	3497		n/a	n/a	n/a	unknown
Kyori	826	3497		n/a	n/a	n/a	unknown
Lang	877	3497	6/12/97	325	6	202	Rock
Lautenbach	600	3497	8/7/18	80	6	n/a	Sand
Lenerz	193	3497	7/13/05	276	6	230	Rock
Lins-2	n/a	3497		162	n/a	n/a	Sand
Lins-4	n/a	3497		190	n/a	n/a	Sand
Lins-K	878	3497	3/21/96	288	6	248	Rock
Lins-R	879	3497		275	n/a	240	Rock
Lochner	880	3497		n/a	n/a	n/a	unknown
Lohr	881	3497		n/a	n/a	n/a	unknown
Lund	420	3497	8/7/06	100	5	n/a	Sand
Lytle	915	3497		n/a	n/a	n/a	unknown
Maple Park Condos	166	3497	9/24/64	270	8	165	Rock
Markgraf	885	3497	10/8/57	236	6	223	Rock
Maschman	120	3497	10/30/96	117	5	n/a	Sand
Matz-Gary	179	3497	8/11/77	248	6	210	Rock
Matz-Terry	886	3497	8/10/59	122	4	n/a	Sand
McAuliffe-J	887	3497	12/20/88	300	6	242	Rock
McClaren	890	3497		n/a	n/a	n/a	unknown
McCoy	177	3497	6/8/81	249	6	n/a	Sand
Meier	953	3497	1/6/44	187	6	n/a	Sand
Mittenzwei-2	141	3497		n/a	n/a	n/a	unknown
MK967	n/a	3497	10/19/98	122	6	n/a	Sand
Moely-B	979	3497		100	n/a	n/a	Sand
Mohrbacher	142	3497		n/a	n/a	n/a	unknown
Mueller-A	896	3497	2/6/80	164	12	n/a	unknown
Mueller-C	897	3497	12/23/67	240	6	n/a	unknown
Mueller-J	899	3497	2/20/91	523	5	224	Rock
Mueller-S	895	3497		n/a	n/a	n/a	unknown
Mueller-SM	894	3497		n/a	n/a	n/a	unknown
Mullen	900	3497		n/a	n/a	n/a	unknown

Table 6
Residential Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer
Nelson	905	3497	2/28/74	280	6	250	Rock
Nelson-D	901	3497		179	6	n/a	Sand
Nolden	n/a	3497		198	n/a	n/a	Sand
Ohlsen	903	3497		n/a	n/a	n/a	unknown
Orbitec	324	3497	9/15/08	160	6	100	Rock
Paulson	123	3497		n/a	n/a	n/a	unknown
PDS Dam	961	3497	5/15/95	285	6	192	Rock
PDS-4	n/a	3497	3/23/12	580	30	n/a	Rock
Peetz	906	3497		n/a	n/a	n/a	unknown
Pierce	143	3497		n/a	n/a	n/a	unknown
Powell	833	3497	6/21/78	191	6	n/a	Sand
Premo	801	3497		122	n/a	n/a	Sand
Price	180	3497		n/a	n/a	n/a	unknown
Priebe	913	3497	4/15/57	76	9	n/a	Sand
Raetzke	940	3497	9/28/79	100	6	n/a	Sand
Ramaker	144	3497		82	6	n/a	Sand
Raschka	148	3497		120	5	n/a	Sand
Richards	118	3497		n/a	n/a	n/a	unknown
Riley	122	3497		n/a	n/a	n/a	unknown
Riley-M	145	3497		n/a	n/a	n/a	unknown
Robertson	640	3497		n/a	n/a	n/a	Sand
Rodgers	146	3497		140	5	n/a	Sand
Roth-G	924	3497	5/26/88	298	6	231	Rock
Roth-John	192	3497	9/26/88	298	6	250	Rock
Ruhland	927	3497		n/a	n/a	n/a	unknown
SC375	637	3497	6/22/04	142	6	n/a	Sand
SC388	610	3497	7/19/04	82	6	n/a	Sand
Schwarz	198	3497		n/a	n/a	n/a	unknown
Sereg	933	3497		175	n/a	n/a	Sand
Shimniok	934	3497		n/a	n/a	n/a	unknown
Sinklair-1	110	3497	4/10/00	130	6	n/a	Sand
Sinklair-2	111	3497		n/a	n/a	n/a	unknown
Sinklair-3	112	3497		n/a	n/a	n/a	unknown
SMD	172	3497		n/a	n/a	n/a	unknown
Smith	114	3497	6/13/96	35	2	n/a	Sand
Spurgeon	190	3497	9/16/76	256	6	215	Rock
Stensberg	162	3497	6/16/69	265	6	200	Rock
Stepenske	858	3497	9/13/86	150	6	n/a	Sand
Steuber	944	3497		n/a	n/a	n/a	unknown
Stima	942	3497		n/a	n/a	n/a	unknown
Stratton	943	3497		n/a	n/a	n/a	unknown
SU393	641	3497	4/5/05	129	6	n/a	Sand

Table 6
Residential Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer
Summer Oaks	945	3497	9/1/81	320	6	185	Rock
SWS2	n/a	3497		n/a	n/a	n/a	unknown
Tesch	947	3497		n/a	n/a	n/a	unknown
TG671	633	3497	1/26/06	141	6	n/a	Sand
TR267	615	3497	4/26/04	97	5	n/a	Sand
Troestler	186	3497	6/1/77	279	6	255	Rock
TS854	626	3497		100	5	n/a	Sand
Tschudy-Herman	950	3497		n/a	n/a	n/a	unknown
Tschudy-Herman 2	108	3497	5/5/99	79	6	n/a	Sand
TU541	638	3497	4/4/05	140	5	n/a	Sand
TU813	635	3497	5/17/05	120	5	n/a	Sand
TV887	604	3497	8/2/05	76	5	n/a	Sand
Unger	199	3497		n/a	n/a	n/a	unknown
Urban	161	3497	4/29/80	275	6	225	Rock
USDA 4	127	3497	3/15/94	273	6	238	Rock
Valley of Our Lady	954	3497		565	6	190	Rock
VM039	632	3497	2/22/06	120	5	n/a	Sand
Volker	952	3497	4/8/75	258	6	175	Rock
Wells	991	3497	5/23/89	108	6	n/a	Sand
Werderits	116	3497	10/2/90	67	6	n/a	Sand
Weum	802	3497	7/7/01	158	5	n/a	Sand
Weynand	939	3497		n/a	n/a	n/a	Sand
Wicklund	957	3497		n/a	n/a	n/a	unknown
Wiley	958	3497		n/a	n/a	n/a	unknown
Witte	962	3497		n/a	n/a	n/a	unknown
Woods	429	3497	9/12/98	86	6	n/a	Sand
WW440	n/a	3497	3/12/12	505	n/a	53	Rock
XE308	939	3497	6/14/13	35	1	n/a	Sand
XG515	618	3497	11/25/13	119	6	n/a	Sand
XG526	614	3497	3/6/14	120	6	n/a	Sand
XG527	639	3497	3/7/14	142	6	n/a	Sand
XI081	620	3497	12/3/13	99	5	n/a	Sand
XL970	617	3497	9/9/14	122	6	n/a	Sand
XP869	616	3497	8/5/15	118	6	n/a	Sand
XR620	602	3497	9/1/15	86	4	n/a	Sand
XT998	605	3497	2/23/16	71	4	n/a	Sand
XU003	606	3497	3/30/16	80	4	n/a	Sand
XW317	608	3497	7/20/16	92	4	n/a	Sand
XW533	627	3497	5/4/16	120	5	n/a	Sand
Yanke	191	3497	9/13/77	307	6	285	Rock
YF504	612	3497	3/31/11	100	5	n/a	Sand
YJ530	636	3497	7/21/13	120	5	n/a	Sand

Table 6
Residential Well Construction Information – Sampling Not Required by WDNR
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well Name	Well ID	License	Date Installed	Well Depth (feet)	Well Diameter (inches)	Bedrock Depth (feet)	Aquifer
YL970	645	3497	11/14/14	100	5	n/a	Sand
YM397	n/a	3497	5/12/15	180	6	n/a	Sand
YP340	623	3497	2/23/16	79	5	n/a	Sand
YQ555	630	3497	6/9/16	118	5	n/a	Sand
YR160	601	3497	8/17/16	100	5	n/a	Sand
YR845	629	3497	10/18/16	119	5	n/a	Sand
YR846	628	3497	10/18/16	120	5	n/a	Sand
Zander	849	3497	9/16/45	229	6	n/a	Sand
Zeck	964	3497	10/11/72	240	6	n/a	unknown
Zick	965	3497	8/26/97	141	6	n/a	Sand
Zick-2	125	3497	1/23/06	117	6	n/a	Sand
ZS447	619	3497	7/26/18	93	5	n/a	Sand
Zurbachen-D	968	3497		n/a	n/a	n/a	unknown

4.3 Well Identification and Designation

All sampled monitoring wells and residential wells are given a unique three-digit numeric well ID, i.e. 360. This well ID is used to track the well data in the on-site groundwater databases as well as the WDNR's on-line accessible Groundwater and Environmental Monitoring System (GEMS) database.

In general, groundwater monitoring wells are identified by a three-part alphanumeric code, i.e. PBN-1404B. The first two letters of the well identification are determined by the source area or waste management unit, i.e. BG, DB, EL, NL, NP, RI, PB, SE, and SP. The exception to this is the "S" series wells installed in the 1980s. The third letter determines if the well is part of a well nest "N" or a stand-alone water table monitoring well "M". The next two numbers determine what year the well was installed, i.e. 2010 = 10 or 2015 = 15. The last two numbers indicate the order that well was installed during that year, i.e. 05 is the fifth well installed that year for that source area. The last letter determines the vertical positioning of the well screen. Wells labeled "A" are screened at or near the water table surface. Wells labeled "B" are screened below the water table, approximately 1/3 of the depth between the water table and bedrock. Wells labeled "C" are screened below the water table, approximately 2/3 of the depth between the water table and bedrock. Wells labeled "D" are screened below the water table and just above the top of the bedrock. Wells labeled "E" are screened below the water table and below the top of the bedrock. Wells labeled "F" are screened below the confining layer of bedrock (shale) in a lower bedrock aquifer. The static groundwater level in an "F" well is higher than the water table and indicates an artesian condition. There are exceptions to the well depth labeling as some monitoring wells installed during the 1980s were drilled shallower than the 1/3 or 2/3 distance between the water table and bedrock.

4.4 Groundwater Properties

4.4.1 Water Level Elevation and Flow Direction

Water level data collected from BAAP monitoring wells indicate groundwater depths ranging from 22 to 144 feet bgs or 744 to 788 feet above mean sea level (MSL). Figure 16 is a representation of the groundwater elevation surface in September 2017. The groundwater contours shown in Figure 16 are drawn at 5-foot intervals. The groundwater flow direction is generally to the south-southeast. In the southeast corner of BAAP, groundwater flow is deflected slightly to the south, due to influences from Lake Wisconsin. Due to the large number of monitoring wells, the elevation measurements for a sampling round are taken within a 30-day period. Due to the groundwater being highly conductive, the groundwater table does not radically change after precipitation and snowmelt events. The Lake Wisconsin Reservoir, located to the east and southeast of BAAP, is formed by the WP&L dam, which results in a constant lake elevation of approximately 774 feet MSL. Below the dam, the water elevation drops abruptly to 736 feet MSL as the lake reverts to the flowing Wisconsin River. The rapid change in water elevations at the dam results in a dramatic hydraulic drop in groundwater elevations around the dam. Groundwater discharges to the Reservoir in the northeastern portion of BAAP. The Reservoir discharges to the sand and gravel aquifer when adjacent groundwater levels are lower than the Reservoir level. About three miles north of the WP&L dam, the

Reservoir transitions from recharging to discharging to the underlying sand and gravel aquifer. Directly south of the WP&L dam, the Wisconsin River resumes with groundwater discharging to the river.

Figure 17 depicts the groundwater contours near the PBG during September 2017. The groundwater contours shown in Figure 17 are drawn at 0.5-foot intervals. This small contour interval was chosen to show the variability in the groundwater surface. The engineered cap (geomembrane barrier and compacted clay) of the 1949 Pit and PBG Waste Pits influences the local groundwater flow. The engineered cap is diverting surface water from percolating into the subsurface. Depression contours 778 and 778.5 feet MSL are shown through the PBG Waste Pits. The groundwater contours shown in Figure 17 show that the cap is protecting the subsurface.

4.4.2 Hydraulic Conductivity

Hydraulic conductivity values were calculated based on aquifer testing at two former MIRM extraction wells located near the PBG in 2005. The aquifer tests, which were comprised of a pump test followed by a step test, were conducted at former extraction wells EW-169 in February 2005 and at EW-167 in March 2005. The tests were conducted by continuously pumping the extraction wells over a period of time and measuring the drawdown in nearby observation wells. Observation wells (PBN-8504A, PBM-8505, and PBM-8904C) were monitored for the test at EW-169, which lasted two- and one-half days. The aquifer test at EW-169 yielded a hydraulic conductivity value between $1.39\text{x}10^{-02}$ to $6.27\text{x}10^{-02}$ centimeters per second (cm/sec). The aquifer test at extraction well EW-167 lasted seven days and drawdown was measured in four nearby observation wells (PBM-8503, PBN-8502A, PBN-8901C, and PBN-8902C). The results of this testing yielded a hydraulic conductivity value between $4.85\text{x}10^{-02}$ and $9.60\text{x}10^{-02}$ cm/sec. Testing methodology is presented in further detail in the *Draft Corrective Measures Implementation Report, MIRM Extraction Well Realignment Project* (Shaw Environmental, Inc., 2006).

During the RI (ABB-ES, 1993), slug tests were performed on monitoring wells across the BAAP. The 1993 RI report included hydraulic conductivity values for many monitoring wells. Table 7 summarizes the hydraulic conductivity data for each of the four groundwater plumes. The average calculated hydraulic conductivity of 25 monitoring wells in the PBG Plume was $4.2\text{x}10^{-02}$ cm/sec. The hydraulic conductivity values obtained during the MIRM pump tests correlated well with the average value obtained from the 1993 RI slug tests. The average calculated hydraulic conductivity of 17 monitoring wells in the DBG Plume was $2.5\text{x}10^{-02}$ cm/sec. There was limited slug test data from the 1993 RI report for monitoring wells in the Central Plume. Slug test data was collected during 2010 from three monitoring wells associated with Landfill 3646 (*Feasibility Report Contiguous Addition to Landfill 3646, SpecPro, Inc., October 2010*). These three monitoring wells are located in northeast corner of the Central Plume (see Figure 18). The average calculated hydraulic conductivity of three monitoring wells in the Central Plume was $3.7\text{x}10^{-02}$ cm/sec. There is no available hydraulic conductivity data for monitoring wells associated with the NC Area Plume. Due to the similarities in soil types between the PBG Plume and NC Area Plume, the PBG Plume hydraulic conductivity value of $4.2\text{x}10^{-02}$ cm/sec is being used for the NC Area Plume.

Table 7
Field Hydraulic Conductivity Test Results
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Plume Area	Well	Level Type	Hydraulic Conductivity (cm/sec)	Soil Type at Screen Interval	Reference
PBG	PBM-8911	A	4x10^{-2}	Sand	1993 RI
PBG	PBN-8203B	B	1x10^{-3}	Sand	1993 RI
PBG	PBN-8203C	C	7x10^{-4}	Sand	1993 RI
PBG	PBN-8901B	B	3x10^{-2}	Gravel with sand	1993 RI
PBG	PBN-8901C	C	3x10^{-2}	Sand	1993 RI
PBG	PBN-8901D	D	5x10^{-2}	Sand	1993 RI
PBG	PBN-8902B	B	1x10^{-2}	Sand	1993 RI
PBG	PBN-8902C	C	2x10^{-2}	Sand	1993 RI
PBG	PBN-8903B	B	1x10^{-2}	Sand	1993 RI
PBG	PBN-8903C	C	4x10^{-2}	Sand	1993 RI
PBG	PBN-8904C	C	2x10^{-2}	Sand	1993 RI
PBG	PBN-8910B	B	2x10^{-1}	Gravel with sand	1993 RI
PBG	PBN-8910C	C	2x10^{-2}	Sand	1993 RI
PBG	PBN-8910D	D	5x10^{-2}	Sand with gravel	1993 RI
PBG	PBN-9106C	C	2x10^{-2}	Sand	1993 RI
PBG	PBN-9112C	C	8x10^{-3}	Sand	1993 RI
PBG	PBN-9112D	D	3x10^{-2}	Sand	1993 RI
PBG	LON-8902B	B	4x10^{-2}	Gravel with cobbles	1993 RI
PBG	LON-8903B	B	1x10^{-1}	Sand and gravel	1993 RI
PBG	SPN-8901C	C	4x10^{-2}	Sand and gravel	1993 RI
PBG	SPN-8902B	B	1x10^{-2}	Sand	1993 RI
PBG	SPN-8902C	C	3x10^{-2}	Sand	1993 RI
PBG	SPN-8903B	B	4x10^{-2}	Sand and gravel	1993 RI
PBG	SPN-8904B	B	2x10^{-2}	Sand and gravel	1993 RI
PBG	SPN-8904C	C	2x10^{-2}	Sand	1993 RI
Average - PBG Plume			**4.2x10^{-2}**		
DBG	DBM-8901	A	3x10^{-2}	Sand	1993 RI
DBG	DBN-8902A	A	8x10^{-2}	Silt and clay	1993 RI
DBG	DBN-8904A	A	3x10^{-2}	Sand	1993 RI
DBG	DBN-8904B	B	5x10^{-2}	Gravel with sand	1993 RI
DBG	DBM-8905	A	6x10^{-3}	Sand	1993 RI
DBG	DBM-8201	A	7x10^{-3}	Silty clay	1993 RI
DBG	ELN-9107A	A	5x10^{-3}	Sand	1993 RI

Table 7
Field Hydraulic Conductivity Test Results
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Plume Area	Well	Level Type	Hydraulic Conductivity (cm/sec)	Soil Type at Screen Interval	Reference
DBG	ELN-9107B	B	$2x10^{-2}$	Sand	1993 RI
DBG	ELM-9110	A	$2x10^{-2}$	Sand	1993 RI
DBG	ELM-8901	A	$8x10^{-3}$	Silty sand	1993 RI
DBG	ELN-8904A	A	$4x10^{-2}$	Sand	1993 RI
DBG	ELM-8905	A	$1x10^{-2}$	Sand with gravel	1993 RI
DBG	ELM-8906B	B	$5x10^{-2}$	Gravel and sand	1993 RI
DBG	ELM-8908	A	$4x10^{-2}$	Sand with gravel	1993 RI
DBG	ELM-8909	A	$3x10^{-2}$	Sand	1993 RI
DBG	ELN-8203C	C	$6x10^{-3}$	Sand	1993 RI
DBG	ELN-8204A	A	$3x10^{-4}$	Silty sand	1993 RI
Average - DBG Plume			**$2.5x10^{-2}$**		
Central	NLM-1001	A	1x10-2	Sand	Landfill 3646
Central	NLN-1001A	A	1x10-2	Sand	Landfill 3646
Central	NLN-1001C	C	6x10-2	Sand	Landfill 3646
Average - Central Plume			**$3.7x10^{-2}$**		

PBG - Propellant Burning Ground Plume
DBG - Deterrent Burning Ground Plume
Central - Central Plume
cm/sec - centimeters per second
Level Type - typical well depth configuration
1993 RI - Final Remedial Investigation Report (United States Army Environmental Center, April 1993)
Landfill 3646 - Feasibility Report Contiguous Addition to Landfill 3646 (SpecPro, Inc., October 2010)
There is no hydraulic conductivity data for the Nitrocelluose Production Area Plume wells; assume same value as PBG.

4.4.3 Hydraulic Gradient

Monitoring wells are screened at various depths and assigned an alphabetical designation after the number of the well ID. Letter designation A is the shallow water table interval, and B, C, D, E, and F are piezometric intervals that increase in depth from B to F. The piezometers ending in E were constructed so that the screen was located in the bedrock. It should be noted that the unconsolidated sand and gravel aquifer is unconfined vertically.

As evident from the groundwater elevation map showing the September 2017 data (Figure 16), the area south of BAAP has a much steeper horizontal hydraulic gradient than the area to the north. Data sets from each groundwater plume were used to calculate horizontal hydraulic gradient. Groundwater elevations from the sampling periods of September 2017, April 2018, and September 2018 were used to calculate an average hydraulic gradient for each plume area shown in Table 8. The average hydraulic gradient calculated for the PBG area wells was 0.00183 feet per foot (ft/ft). The average hydraulic gradient calculated for the DBG area wells was 0.00108 ft/ft. The hydraulic gradient calculated for the Central Plume area wells was 0.00097 ft/ft. The average hydraulic gradient calculated for the NC area wells was 0.00079 ft/ft.

Vertical groundwater movement is evaluated by comparing groundwater levels from the different aquifer layers to determine vertical gradient. Monitoring well clusters, where two or more wells have screens positioned at different depths within the aquifer, are used to examine differences in the potentiometric groundwater surface between different layers of the aquifer. Vertical hydraulic gradients were evaluated for nested well pairs in the four plume areas. Table 9 summarizes the vertical groundwater gradients for the chosen well nests. Gradients were evaluated from the groundwater elevation data collected during the September 2017, April 2018, and September 2018 monitoring events. Positive vertical gradients indicate groundwater is flowing upward and negative vertical gradients indicated groundwater is flowing downward.

Four of the seven well pairs in the PBG exhibited an upward vertical groundwater gradient between deep to shallow wells; which would hinder groundwater contaminants from migrating deeper into the sand aquifer. All the DBG well pairs exhibited a downward vertical groundwater gradient between shallow to deep wells; which would allow groundwater contaminants to migrate deeper into the sand aquifer. Three of the four well pairs in the Central Plume exhibited an upward vertical groundwater gradient between deep to shallow wells; which would hinder groundwater contaminants from migrating deeper into the sand aquifer. The two well pairs in the NC Area Plume exhibited an upward vertical groundwater gradient between deep to shallow wells; which would hinder groundwater contaminants from migrating deeper into the sand aquifer.

Table 8
Horizontal Groundwater Gradient
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Plume Area	Well Pair	Well Distance (ft)	Sept 2017 Well Elevation (ft msl)	Sept 2017 Elevation Difference (ft)	Sept 2017 Gradient (ft/ft)	Apr 2018 Well Elevation (ft msl)	Apr 2018 Elevation Difference (ft)	Apr 2018 Gradient (ft/ft)	Sept 2018 Well Elevation (ft msl)	Sept 2018 Elevation Difference (ft)	Sept 2018 Gradient (ft/ft)	Average Gradient (ft/ft)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/day)	Effective Porosity	Average Groundwter Flow Velocity (ft/day)	Average Groundwter Flow Velocity (ft/yr)
PBG	PBN-1401A	6,340	778.96	9.89	0.00156	780.05	9.96	0.00157	778.82	10.02	0.00158	0.00183	$4.2\text{x}10^{-2}$	119	0.26	0.84	306
	S1148		769.07			770.09			768.80								
	SPN-8904B	5,440	769.37	10.79	0.00198	770.00	11.81	0.00217	768.71	11.56	0.00213						
	SWN-9103B		758.58			758.19			757.15								
DBG	DBM-8202	6,200	786.35	6.03	0.00097	787.13	7.19	0.00116	786.62	6.88	0.00111	0.00108	$2.5\text{x}10^{-2}$	72	0.26	0.30	109
	ELN-1003A		780.32			779.94			779.74								
	DBN-1001B	6,030	785.73	5.95	0.00099	786.29	6.93	0.00115	785.72	6.59	0.00109						
	ELN-1003B		779.78			779.36			779.13								
Central	NPM-8901	6,630				783.04	5.46	0.00082				0.00097	$3.7\text{x}10^{-2}$	105	0.26	0.39	143
	RIN-1002A					777.58											
	RIN-1002A	8,260				777.58	9.20	0.00111									
	SEN-0503A					768.38											
NC	RIM-1002	2,210	787.47	1.87	0.00085	788.52	1.66	0.00075	787.13	1.71	0.00077	0.00079	$4.2\text{x}10^{-2}$	119	0.26	0.36	132
	RIN-1001A		785.60			786.86			785.42								

ft - Feet
ft msl - Feet Mean Sea Level
ft/ft - Feet per Foot
Central Plume elevations were collected during June 2018
Groundwater flow velocity = (hydraulic conductivity)(hydraulic gradient)/effective porosity
Hydraulic conductivity conversion: 1 cm/sec = 2834 ft/day

Table 9
Vertical Groundwater Gradient
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

	Well Pair	Well ID	Layer	Screen Midpoint Elevation	Groundwater Elevation (ft msl)			Vertical Groundwater Gradient (ft/ft)			
					Sep-17	Apr-18	Sep-18	Sep-17	Apr-18	Sep-18	Average
Propellant Burning Ground	PBN-1401A	782	A	759.90	778.96	780.05	778.82				
	PBN-1401B	783	B	723.39	778.98	780.07	778.83				
	PBN-1401C	784	C	683.78	778.94	780.05	778.82	-0.00026	0.00000	0.00000	-0.00009
	PBN-8205A	622	A	768.30	778.07	779.14	777.87				
	PBN-8205B	623	B	752.63	778.04	779.13	777.86				
	PBN-8205C	624	C	743.30	778.12	779.20	777.90	0.00200	0.00240	0.00120	0.00187
	PBN-8502A	632	A	762.21	776.65	777.73	776.49				
	PBN-8902BR	795	B	739.37	776.71	777.77	776.54				
	PBN-8902C	645	C	703.80	775.77	776.87	775.59	-0.01507	-0.01472	-0.01541	-0.01507
	PBN-1404B	791	B	715.18	775.20	776.12	774.79				
	PBN-1404C	792	C	655.34	775.14	776.06	774.72				
	PBN-1404D	793	D	594.89	774.38	775.29	773.98	-0.00682	-0.00690	-0.00673	-0.00682
	S1148	710	A	757.90	769.07	770.09	768.80				
	SPN-8904B	720	B	729.10	769.37	770.00	768.71				
	SPN-8904C	721	C	696.70	769.47	770.09	768.83				
	SPN-9104D	726	D	599.80	769.40	770.10	768.78	0.00209	0.00006	-0.00013	0.00067
	PBN-9903A	692	A	756.68	767.56	768.12	766.84				
	PBN-9903B	693	B	715.50	768.02	768.59	767.30				
	PBN-9903C	694	C	664.49	768.08	768.65	767.35				
	PBN-9903D	695	D	619.60	768.07	768.61	767.31	0.00372	0.00357	0.00343	0.00357
	SWN-9103B	571	B	726.30	758.58	758.19	757.15				
	SWN-9103C	572	C	676.80	758.73	758.36	757.30				
	SWN-9103D	573	D	630.90	758.56	758.18	757.15				
	SWN-9103E	574	E	602.10	758.67	758.30	757.21	0.00072	0.00089	0.00048	0.00070
	PBN-9101C	561	C	680.50	744.75	744.33	744.40				
	PBM-9001D	981	D	623.50	745.03	744.60	744.66	0.00491	0.00474	0.00456	0.00474
Deterrent Burning Ground	DBM-8202	302	A	770.45	786.35	787.13	786.62				
	DBN-1001B	472	B	752.77	785.73	786.29	785.72				
	DBN-1001C	473	C	715.28	784.11	783.97	783.36				
	DBN-1001E	474	E	632.55	784.54	784.38	783.71	-0.01313	-0.01994	-0.02110	-0.01806
	DBN-9501A	314	A	771.70	783.49	783.38	782.79				
	DBN-9501B	315	B	719.50	783.51	783.38	782.76				
	DBN-9501C	316	C	664.00	783.49	783.36	782.78				
	DBN-9501E	317	E	637.55	783.38	783.26	782.66	-0.00082	-0.00089	-0.00097	-0.00089
	ELN-8203A	210	A	772.70	783.79	783.64	783.00				
	ELN-8203B	211	B	760.50	783.43	783.12	782.52				
	ELN-8203C	212	C	750.30	783.46	783.14	782.54	-0.01473	-0.02232	-0.02054	-0.01920
	ELM-9501	234	A	779.20	781.23	780.88	780.36				
	ELN-0801B	455	B	738.87	781.33	781.05	780.49				
	ELN-0801C	456	C	693.42	781.38	781.04	780.54				
	ELN-0801E	457	E	634.93	780.25	780.98	780.44	-0.00679	0.00069	0.00055	-0.00185
	ELN-1003A	467	A	776.19	780.32	779.94	779.74				
	ELN-1003B	468	B	704.74	779.78	779.36	779.13				
	ELN-1003C	469	C	641.64	779.92	779.50	779.23				
	ELN-1003E	470	E	571.02	779.50	779.09	778.83	-0.00400	-0.00414	-0.00444	-0.00419

Table 9
Vertical Groundwater Gradient
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

	Well Pair	Well ID	Layer	Screen Midpoint Elevation	Groundwater Elevation (ft msl)			Vertical Groundwater Gradient (ft/ft)			
					Sep-17	Apr-18	Sep-18	Sep-17	Apr-18	Sep-18	Average
Central Plume	RIN-1002A	492	A	775.76	no data	777.58	no data				
	RIN-1002C	493	C	683.56		777.57					
	RIN-1501D	540	D	625.56		777.54			-0.00027		-0.00027
	RIN-1005A	496	A	773.74	no data	775.19	no data				
	RIN-1005C	497	C	681.99		775.24			0.00054		0.00054
	SEN-0501A	580	A	760.14	no data	767.37	no data				
	SEN-0501B	581	B	702.87		767.51					
	SEN-0501D	582	D	600.22		767.77			0.00250		0.00250
	SEN-0503A	585	A	761.63	no data	768.38	no data				
	SEN-0503B	586	B	704.39		768.61					
	SEN-0503D	587	D	601.31		768.67			0.00181		0.00181
NC Plume	RIM-0705	442	A	782.80	786.26	no data	786.04				
	RIN-1007C	479	C	708.61	786.30		786.06	0.00054		0.00027	0.00040
	RIN-1001A	480	A	782.75	785.60	no data	785.42				
	RIN-1001C	481	C	703.10	785.61		785.41	0.00013		-0.00013	0.00000

Layer designation
- A = shallow zone in sand and gravel aquifer
- B = intermediate zone in sand and gravel aquifer
- C = deep zone in sand and gravel aquifer
- D = bottom zone in sand and gravel aquifer
- E = top of bedrock aquifer

ft msl - Feet Mean Sea Level
ft/ft - Feet per Foot
Central Plume elevations were collected during June 2018
Gradient determined between shallow and deep well for each well cluster
Vertical Groundwater Gradient = (h2 - h1) / (z1 - z2)
- h1 = shallow well groundwater elevation
- h2 = deep well groundwater elevation
- z1 = shallow well screen midpoint elevation
- z2 = deep well screen midpoint elevation

4.4.4 Groundwater Flow Velocity

The advective groundwater flow velocity is derived from the hydraulic conductivity value, horizontal gradient, and effective porosity. Advective groundwater movement does not take into account dispersion, diffusion, or chemical retardation of groundwater contaminants, which can increase or decrease the rate of groundwater flow. It is a calculated value that provides an estimate of the rate of groundwater flow over time. The mathematical formula for determining advective groundwater flow velocity (v) is:

$v = Ki/n_e$ Where:

K = hydraulic conductivity (feet/day)
i = hydraulic gradient (feet/feet)
n_e = effective porosity

The average hydraulic conductivity values found in Table 7 were used in the groundwater flow velocity calculations. The average hydraulic conductivities for the PBG, DBG, Central, and NC Area Plumes are $4.2\text{x}10^{-02}$ cm/sec or 119 ft/day, $2.5\text{x}10^{-02}$ cm/sec or 72 ft/day, $3.7\text{x}10^{-02}$ cm/sec or 105 ft/day, and $4.2\text{x}10^{-02}$ cm/sec or 119 ft/day, respectively.

The effective porosity is estimated at 0.26 or 26%. Average horizontal gradients of 0.00183 ft/ft for the PBG, 0.00108 ft/ft for the DBG, 0.00097 ft/ft for the Central Plume, and 0.00079 ft/ft for the NC Area Plume were used to calculate the groundwater flow velocities.

The calculated average groundwater flow velocities as shown in Table 8 equal 0.84 ft/day for the PBG, 0.30 ft/day for the DBG, 0.39 ft/day for the Central, and 0.36 ft/day for the NC Area. These groundwater flow velocity values equate to 306 ft/year for the PBG Plume, 109 ft/year for the DBG Plume, 143 ft/year for the Central Plume, and 132 ft/year for the NC Area Plume.

4.5 Nature and Extent of Groundwater Contamination

Groundwater investigation activities at BAAP began in 1980 and continue today. Site-wide groundwater-related assessment activities, agreed upon by the Army and WDNR, include the following: soil vapor surveys; monitoring well drilling, installation, and surveying; water level measurements; pump testing; and monitoring well and residential well sampling.

The groundwater sampling results were compared to the Wisconsin NR 140 PAL Groundwater Standards to identify contaminants of potential concern (COPCs) for the four groundwater plumes at BAAP. The COPCs for each groundwater plume are further discussed in the following sections.

4.5.1 Propellant Burning Ground Plume

Groundwater contamination in monitoring wells associated with the PBG was first detected in 1982 (Tsai, 1988). The draft final (Phase 1) RI report (January 1990) indicated that groundwater contamination had migrated beyond the southern BAAP boundary. An off-site groundwater monitoring program was initiated in January 1990. In late April 1990, sampling results from residential wells south of BAAP showed that two residential wells had been contaminated with CTET and one residential well contaminated with chloroform. The maximum concentrations of CTET and chloroform in the residential wells were 80 micrograms per liter (µg/l) and 9.9 µg/l, respectively. It was determined that a VOC plume (PBG Plume) had migrated south from the PBG Waste Pits, past the BAAP's southern boundary, and then easterly to the Wisconsin River below the WP&L dam. The Army replaced the three impacted residential wells. Prior to well replacement, bottled water had been provided to the affected residences.

The PBG Plume originates at the PBG and extends south beyond the BAAP boundary. South of BAAP, the plume turns southeast towards the Wisconsin River due to the influence of the WP&L dam, just north of Prairie du Sac. The PBG Plume shown in Figure 21 represents the area where groundwater concentrations exceed a NR 140 PAL or ES for one or more of the following compounds: CTET, ethyl ether (diethyl ether), TCE, 2,4-DNT, 2,6-DNT, or total DNT. All six DNT isomers (2,3-DNT, 2,4-DNT, 2,5-DNT, 2,6-DNT, 3,4-DNT, and 3,5-DNT) have been detected in the PBG Plume, mostly in the PBG Waste Pits. The PBG Plume boundaries shown in Figure 21 are approximate and based on total DNT and VOC groundwater data collected during 2018 from both monitoring wells and residential wells. Table 10 summarizes the groundwater analytical results from the August 2018 residential well sampling event. Table 11 summarizes the groundwater analytical results from the September 2018 monitoring well sampling event. Isoconcentration maps and cross sections were prepared for CTET, ethyl ether, TCE, and total DNT. The isoconcentration maps were prepared using all groundwater data collected during 2018. The isoconcentration cross sections were prepared mainly using groundwater data collected during August and September 2018. Supplemental groundwater data from November 2014 was used to complete the isoconcentration cross sections. These contaminants, CTET, ethyl ether, TCE, and total DNT, have shown consistent exceedances of the NR 140 ES in multiple monitoring wells to facilitate the construction of isoconcentration maps.

During 2015, 2016, 2017, and 2018, bromodichloromethane, CTET, chloroform, 2,4-DNT, 2,6-DNT, total DNT, ethyl ether, nitrate, and TCE have been COPCs in the PBG Plume. The PBG Plume groundwater results from the August and September 2018 sampling events were evaluated for COPCs that exceeded a Chapter NR 140 PAL Groundwater Standard.

Three monitoring wells had NR 140 PAL exceedances for bromodichloromethane during September 2018. Bromodichloromethane was not detected in any residential wells that were sampled during August 2018.

A total of six monitoring wells had NR 140 ES exceedances for CTET during September 2018. In addition, thirty-one monitoring wells had NR 140 PAL exceedances for CTET during September 2018. Three residential wells (Apel, Krumenauer, and Schlender) had CTET detections that were below the NR 140 PAL during August 2018. Since 2010, CTET has been detected in these three residential wells, that are located east of the PBG Plume (see Figure 20).

A total of ten monitoring wells had NR 140 PAL exceedances for chloroform during September 2018. One residential well had a chloroform detection that was below the NR 140 PAL during August 2018.

Table 10
Residential Well Groundwater Analytical Results
August 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

August '18 Round	Level of Detection	Level of Quantitation
2,3-DNT	0.0057	0.029
2,4-DNT	0.0076	0.029
2,5-DNT	0.0029	0.029
2,6-DNT	0.0038	0.029
3,4-DNT	0.0038	0.029
3,5-DNT	0.0038	0.029

*Level of detection and level of quantitation may change each round.

☐ = Under PAL and ES
🟨 = Over Preventive Action Limit (PAL)
🟧 = Over Enforcement Standard (ES)
▨ = No PAL or ES established
🟦 = Not Tested
ND = Compound was not detected

All results are expressed as µg/l (micrograms per liter)

Last Name	Well No.	Well Name	Shared With	Analyzed By	Sample Date	Toluene	Dichlorodifluoromethane	Chloromethane	Chloroform	Carbon Tetrachloride	Trichloroethene	Ethyl Ether	1,1,1-Trichloroethane	1,1,2-Trichloroethane	2,6-Dinitrotoluene	2,4-Dinitrotoluene	2,3-Dinitrotoluene	3,4-Dinitrotoluene	2,5-Dinitrotoluene	3,5-Dinitrotoluene	Dinitrotoluene, Total
Anderson	411	Anderson-R		CT Lab	8/21/2018	ND	ND	ND	ND	ND	0.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Apel	998	Apel		CT Lab	8/20/2018	ND	ND	ND	ND	0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cornelius	426	Cornelius		CT Lab	8/21/2018	ND	ND	0.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Curto	412	Curto	*Nimmow*	CT Lab	8/21/2018	ND	0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Delaney	152	Delaney		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	0.16	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gibbs	839	Gibbs		CT Lab	8/22/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Grosse	415	Grosse		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Groth	842	Groth		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
				CT Lab (D)	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gruber	417	Gruber-D		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hendershot	418	Hendershot		CT Lab	8/21/2018	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Howery	419	Howery				Pump not working; well not sampled															
Judd	862	Judd		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kopras	874	Kopras	*Miller*	CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Krumenauer	875	Krumenauer		CT Lab	8/21/2018	ND	ND	ND	ND	0.16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lukens	860	Lukens		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Melum	423	Melum		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mittenzwei	800	Mittenzwei		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nowotarski	891	Nowotarski				Not available; well not sampled															
Olah	904	Olah		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Osterland	422	Osterland		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Peckosh	817	Peckosh		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Prairie du Sac Utilities	911	PDS-3		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Purcell	163	Purcell-D		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
				CT Lab (D)	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Purcell	916	Purcell-G		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ramaker	917	Ramaker-J		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Raschein	424	Raschein		CT Lab	8/21/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Reif	427	Reif		CT Lab	8/22/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
				CT Lab (D)	8/22/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Revers	425	Revers		CT Lab	8/22/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Schlender	931	Schlender	*Koenig, Ballweg*	CT Lab	8/20/2018	ND	ND	ND	0.13	0.48	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Schumann	428	Schumann		CT Lab	8/22/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Spear	803	Spear		CT Lab	8/20/2018	ND	ND	ND	ND	ND	ND	ND	ND	0.2	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	158	WE-QN039	*Hilgemann, Layton*	CT Lab	8/7/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	157	WE-QR441	*Hemberger, Pattarozzi, Heath*	CT Lab	8/7/2018	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	159	WE-RD430	*Ford, Madden, Bastien/Eddy*	CT Lab	8/7/2018	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	153	WE-RM383	*Good, Rossing*	CT Lab	8/7/2018	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	164	WE-SQ017	*Thompson*	CT Lab	8/7/2018	ND	ND	ND	1.7	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	165	WE-SQ001	*Rosenau, Schwarz*	CT Lab	8/7/2018	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 10
Residential Well Groundwater Analytical Results
August 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

August '18 Round	Level of Detection	Level of Quantitation
2,3-DNT	0.0057	0.029
2,4-DNT	0.0076	0.029
2,5-DNT	0.0029	0.029
2,6-DNT	0.0038	0.029
3,4-DNT	0.0038	0.029
3,5-DNT	0.0038	0.029

*Level of detection and level of quantitation may change each round.

☐ = Under PAL and ES
🟨 = Over Preventive Action Limit (PAL)
🟧 = Over Enforcement Standard (ES)
▨ = No PAL or ES established
🟦 = Not Tested
ND = Compound was not detected

All results are expressed as µg/l (micrograms per liter)

Last Name	Well No.	Well Name	Shared With	Analyzed By	Sample Date	Toluene	Dichlorodifluoromethane	Chloromethane	Chloroform	Carbon Tetrachloride	Trichloroethene	Ethyl Ether	1,1,1-Trichloroethane	1,1,2-Trichloroethane	2,6-Dinitrotoluene	2,4-Dinitrotoluene	2,3-Dinitrotoluene	3,4-Dinitrotoluene	2,5-Dinitrotoluene	3,5-Dinitrotoluene	Dinitrotoluene, Total
Water's Edge Group	156	**WE-RR542**	*Cairnes, Sherpe*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	169	**WE-RR598**	*Hall, Chow, Hartmann, Wenger*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	170	**WE-SQ002**	*Neumaier, Ramaker*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	174	**WE-TF023**	*Hilgemann*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	129	**WE-TM599**	*Riordan*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	431	**WE-UK125**	*Gust, Haag, Lochner*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	432	**WE-UK124**	*Whalen*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	433	**WE-UA297**	*Krisko*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	434	**WE-XD828**	*Riethmiller*	**CT Lab**	8/7/2018										ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	435	**WE-XK342**	*Brandherm*	**CT Lab**	8/7/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
				CT Lab (D)	8/7/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Water's Edge Group	436	**WE-YW972**	*Dietzen*	**CT Lab**	8/7/2018	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wenger	414	**Wenger**		**CT Lab**	8/20/2018	ND	ND	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zurbachen	967	**Zurbachen-A**		**CT Lab**	8/22/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dairy Forage Res Ctr	828	**USDA 1**		**CT Lab**	8/21/2018										ND	ND	ND	ND	ND	ND	ND
Dairy Forage Res Ctr	829	**USDA 2**		**CT Lab**	8/21/2018										ND	ND	ND	ND	ND	ND	ND
Dairy Forage Res Ctr	126	**USDA 3**		**CT Lab**	8/21/2018										ND	ND	ND	ND	ND	ND	ND
Dairy Forage Res Ctr	128	**USDA 6**		**CT Lab**	8/22/2018										ND	ND	ND	ND	ND	ND	ND

(D) = Duplicate

CT Lab = CT Laboratories, LLC

Table 11
Groundwater Analytical Results
September 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C											
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,1-Dichloroethane**	**1,1-Dichloroethene**	**1,1,1-Trichloroethane**	**Bromodichloromethane**	**Carbon Disulfide**	**Carbon Tetrachloride**	**Chloroform**	**Chloromethane**	**Ethyl Ether**	**Tetrachloroethene**	**Trichloroethene**	**Nitrate, Total**
DBG PLUME AREA WELLS																	
DBM-8201	301	A	154.6-174.6	Sep-18	**3.005**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBM-8202	302	A	137.3-157.3	Sep-18	**0.608**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBM-8202 (dup)	302	A	137.3-157.3	Sep-18	**0.562**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBM-8903	306	A	113-133	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-1001B	472	B	154.5-159.5	Sep-18	**0.5978**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-1001C	473	C	192-197	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-1001E	474	E	274.9-279.9	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-1002C	476	C	205.1-210.1	Sep-18	**0.7705**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-1002E	477	E	275.5-280.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-9501A	314	A	110-120	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-9501B	315	B	162.5-172.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-9501C	316	C	218.5-228.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
DBN-9501E	317	E	245.2-255.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELM-8901	216	A	145.5-165	Sep-18	**1.427**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELM-8907	220	A	130.3-150.3	Sep-18	**0.668**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELM-8908	221	A	125-145	Sep-18	**0.263**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELM-8909	222	A	135-155	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELM-9501	234	A	54-69	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-0801B	455	B	100-105	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-0801C	456	C	145.5-150.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-0801E	457	E	202.6-207.6	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-0802A	458	A	92.5-107.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-0802C	459	C	175.8-180.8	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1001B	460	B	91.1-96.1	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1001C	461	C	155.2-160.2	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Table 11
Groundwater Analytical Results
September 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C											
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,1-Dichloroethane**	**1,1-Dichloroethene**	**1,1,1-Trichloroethane**	**Bromodichloromethane**	**Carbon Disulfide**	**Carbon Tetrachloride**	**Chloroform**	**Chloromethane**	**Ethyl Ether**	**Tetrachloroethene**	**Trichloroethene**	**Nitrate, Total**
ELN-1001E	462	E	240.5-245.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1002A	463	A	55.3-70.3	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1002B	464	B	111.2-116.2	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1002B (dup)	464	B	111.2-116.2	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1002C	465	C	159.1-164.1	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1002E	466	E	231.5-236.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003A	467	A	16.2-31.2	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003B	468	B	91.5-96.5	Oct-18	**0.192**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003B (dup)	468	B	91.5-96.5	Oct-18	**0.171**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003C	469	C	155.1-160.1	Oct-18	**0.1327**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003E	470	E	255.6-230.6	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1502A	533	A	115.3-130.3	Sep-18	**0.627**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1502A (dup)	533	A	115.3-130.3	Sep-18	**0.801**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1502C	534	C	198-203	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1503A	535	A	73.7-88.7	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1503C	536	C	157.6-162.6	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1504B	537	B	34.8-39.8	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-8203A	210	A	147.5-157.5	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-8203B	211	B	164-166	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-8203C	212	C	174-176	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-8902B	224	B	173.5-178.5	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-9107A	227	A	116-126	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-9107B	228	B	135-145	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-9402AR	231	A	130-145	Oct-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
S1121	755	A	39.11-59.3	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
S1134R	236	A	136-151	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Table 11
Groundwater Analytical Results
September 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C											
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,1-Dichloroethane**	**1,1-Dichloroethene**	**1,1,1-Trichloroethane**	**Bromodichloromethane**	**Carbon Disulfide**	**Carbon Tetrachloride**	**Chloroform**	**Chloromethane**	**Ethyl Ether**	**Tetrachloroethene**	**Trichloroethene**	**Nitrate, Total**
NC PRODUCTION PLUME AREA WELLS																	
RIM-0703	440	A	98-113	Sep-18	**0.029 (J)**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
RIM-0705	442	A	91-106	Sep-18	**0.089**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
RIM-1002	478	A	95.2-110.2	Sep-18	**0.21**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
RIM-1002 (dup)	478	A	95.2-110.2	Sep-18	**0.22**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
RIN-1001A	480	A	91.8-106.8	Sep-18	**0.073**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
RIN-1001C	481	C	176.41-181.41	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
RIN-1007C	479	C	170.3-175.3	Sep-18	<0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
S1125	504	A	106.25-126.5	Sep-18	**0.0061(J)**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
PBG PLUME AREA WELLS																	
PBM-0001	367	A	109.5-134.5	Sep-18	**12.98**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.14 (J)**	<0.1	<0.1	<0.1	<0.1	**0.31**	**3.6**
PBM-0002	368	A	106.5-131.5	Sep-18	**2.33**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.29**	<0.1	<0.1	<0.1	<0.1	**0.69**	**3.4**
PBM-0006	372	A	99.5-124.5	Sep-18	**1.841**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.34**	<0.1	<0.1	<0.1	<0.1	**0.73**	**3.1**
PBM-0008	374	A	97-122	Sep-18	**1.603**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.19 (J)**	<0.1	<0.1	<0.1	<0.1	**0.41**	NT
PBM-1201	764	A	103.5-118.5	Sep-18	**23.66**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.25**	<0.1	<0.1	<0.1	<0.1	**0.65**	NT
PBM-1202	765	A	103.5-118.5	Sep-18	**3.45**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.34**	<0.1	<0.1	<0.1	<0.1	**0.8**	NT
PBM-1203	766	A	103.4-118.4	Sep-18	**0.201**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.25**	<0.1	<0.1	<0.1	<0.1	**0.32**	NT
PBM-8907	637	A	82.72-92.72	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.27**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBM-8909	639	A	104.4-124.4	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.18 (J)**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBM-9001D	981	D	200.5-210.5	Oct-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**15**	**1.4**	<0.1	<0.1	<0.1	**5.5**	NT
PBM-9801	360	A	108.5-123.5	Sep-18	**3.582**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.16 (J)**	<0.1	<0.1	<0.1	<0.1	**0.35**	NT
PBN-1001C	595	C	194.7-199.7	Sep-18	**0.038**	<0.1	<0.1	**0.49**	<0.1	<0.2	**0.86**	**0.65**	<0.1	<0.1	<0.1	<0.1	NT
PBN-1003C	592	C	184.6-189.6	Sep-18	<0.008	<0.1	<0.1	<0.1	**0.11 (J)**	<0.2	<0.1	**0.22**	<0.1	<0.1	<0.1	<0.1	NT
PBN-1302A	770	A	69.7-84.7	Sep-18	<0.008	<0.1	<0.1	**0.62**	<0.1	<0.2	**2.2**	**0.14 (J)**	<0.1	<0.1	<0.1	<0.1	NT
PBN-1302B	771	B	131.2-136.2	Sep-18	**0.011 (J)**	<0.1	<0.1	**0.55**	<0.1	<0.2	**2.5**	**0.14 (J)**	<0.1	<0.1	<0.1	<0.1	NT
PBN-1302C	772	C	182.6-187.6	Sep-18	**0.0087 (J)**	<0.1	**0.1 (J)**	**0.68**	<0.1	<0.2	**3.8**	**0.69**	<0.1	<0.1	<0.1	<0.1	NT

Table 11
Groundwater Analytical Results
September 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C											
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,1-Dichloroethane**	**1,1-Dichloroethene**	**1,1,1-Trichloroethane**	**Bromodichloromethane**	**Carbon Disulfide**	**Carbon Tetrachloride**	**Chloroform**	**Chloromethane**	**Ethyl Ether**	**Tetrachloroethene**	**Trichloroethene**	**Nitrate, Total**
PBN-1302D	773	D	240.1-245.1	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	**1.3**	<0.1	<0.1	NT
PBN-1303A	774	A	115.5-130.5	Sep-18	<0.008	<0.1	<0.1	**0.32**	<0.1	<0.2	**0.47**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1303B	775	B	171.5-176.5	Sep-18	<0.008	<0.1	<0.1	**0.51**	<0.1	<0.2	**0.83**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1303B (dup)	775	B	171.5-176.5	Sep-18	<0.008	<0.1	<0.1	**0.51**	<0.1	<0.2	**0.81**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1303C	776	C	227-232	Sep-18	<0.008	<0.1	<0.1	**0.77**	<0.1	<0.2	**1.4**	**0.31**	<0.1	<0.1	<0.1	<0.1	NT
PBN-1303D	777	D	282-287	Sep-18	<0.008	**0.13 (J)**	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1304A	778	A	101-116	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1304B	779	B	158.1-163.1	Sep-18	<0.008	<0.1	<0.1	**0.13 (J)**	<0.1	<0.2	**0.16 (J)**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1304C	780	C	213-218	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1304D	781	D	268-273	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.11 (J)**	**0.14 (J)**	<0.1	<0.1	<0.1	<0.1	NT
PBN-1401A	782	A	117.2-132.2	Sep-18	**0.742**	<0.1	<0.1	**0.14 (J)**	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	**0.16 (J)**	NT
PBN-1401B	783	B	158.7-163.7	Sep-18	**0.552**	<0.1	<0.1	**0.14 (J)**	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	**0.13 (J)**	NT
PBN-1401B (dup)	783	B	158.7-163.7	Sep-18	**0.47**	<0.1	<0.1	**0.12 (J)**	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	**0.13 (J)**	NT
PBN-1401C	784	C	198.3-203.3	Sep-18	**0.058**	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-1404B	791	B	174.5-179.5	Sep-18	<0.008	<0.1	<0.1	**0.19 (J)**	<0.1	<0.2	**2.8**	**0.97**	<0.1	<0.1	<0.1	**1**	NT
PBN-1404C	792	C	234.3-239.3	Sep-18	**0.0044 (J)**	<0.1	<0.1	**0.18 (J)**	**0.16 (J)**	<0.2	**0.73**	**0.84**	<0.1	<0.1	<0.1	**0.2**	NT
PBN-1404D	793	D	294.8-299.8	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	**480**	<0.1	<0.1	NT
PBN-1405F	794	F	314.7-319.7	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	**0.29 (J)**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-8202A	613	A	108.5-118.5	Sep-18	**116.42**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.28**	<0.1	<0.1	<0.1	<0.1	**0.8**	NT
PBN-8202A (dup)	613	A	108.5-118.5	Sep-18	**103.32**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.31**	<0.1	<0.1	<0.1	<0.1	**0.84**	NT
PBN-8202B	614	B	131-133	Sep-18	**14.612**	<0.1	<0.1	<0.1	<0.1	<0.2	**0.64**	<0.1	<0.1	<0.1	<0.1	**0.82**	NT
PBN-8202C	615	C	139.2-141.2	Sep-18	**0.77**	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	**0.14 (J)**	NT
PBN-8205A	622	A	102.5-112.5	Sep-18	**0.837**	<0.1	<0.1	**0.29**	<0.1	<0.2	**2.8**	<0.1	<0.1	<0.1	<0.1	**0.71**	NT
PBN-8205B	623	B	122.2-124.2	Sep-18	**0.962**	<0.1	<0.1	**0.29**	<0.1	<0.2	**3.1**	<0.1	<0.1	<0.1	<0.1	**0.76**	NT
PBN-8205C	624	C	131.5-133.5	Sep-18	**1.094**	<0.1	<0.1	**0.42**	<0.1	<0.2	**3.8**	<0.1	<0.1	<0.1	<0.1	**0.91**	NT
PBN-8502A	632	A	129-138	Sep-18	<0.008	<0.1	<0.1	**0.83**	<0.1	<0.2	**14**	**0.12 (J)**	<0.1	<0.1	<0.1	**2**	NT

Table 11
Groundwater Analytical Results
September 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C											
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,1-Dichloroethane**	**1,1-Dichloroethene**	**1,1,1-Trichloroethane**	**Bromodichloromethane**	**Carbon Disulfide**	**Carbon Tetrachloride**	**Chloroform**	**Chloromethane**	**Ethyl Ether**	**Tetrachloroethene**	**Trichloroethene**	**Nitrate, Total**
PBN-8503A	633	A	85.82-94.82	Sep-18	**0.068**	<0.1	<0.1	<0.1	<0.1	<0.2	**1.7**	<0.1	**0.14 (J)**	<0.1	<0.1	<0.1	NT
PBN-8902BR	795	B	155-160	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**1.6**	**0.31**	**0.12 (J)**	<0.1	<0.1	**0.96**	NT
PBN-8902C	645	C	188.1-193.3	Sep-18	**0.017 (J)**	<0.1	<0.1	**0.11 (J)**	<0.1	<0.2	**1.5**	<0.1	<0.1	<0.1	<0.1	**0.67**	NT
PBN-8903B	646	B	120-125	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.13 (J)**	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-8903C	647	C	155-160	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-8912A	654	A	83.4-103.4	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-8912B	655	B	133-138	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.66**	<0.1	<0.1	<0.1	**0.11 (J)**	**0.44**	NT
PBN-9101C	561	C	142.5-152.5	Oct-18	**0.08**	<0.1	<0.1	**0.16 (J)**	<0.1	<0.2	**19**	**1.7**	<0.1	<0.1	<0.1	**8.5**	NT
PBN-9112C	665	C	173.4-183.4	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.96**	**0.13 (J)**	<0.1	<0.1	<0.1	**0.33**	NT
PBN-9112D	666	D	221-231	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-9301B	668	B	150.5-160.5	Sep-18	<0.008	<0.1	<0.1	**0.31**	<0.1	<0.2	**3.1**	**0.37**	<0.1	<0.1	<0.1	**0.13 (J)**	NT
PBN-9301C	669	C	217.5-227.5	Sep-18	<0.008	<0.1	**0.1 (J)**	**1.1**	**0.15 (J)**	<0.2	**1.7**	**1.1**	<0.1	<0.1	<0.1	**0.34**	NT
PBN-9303B	673	B	83.5-93.5	Sep-18	<0.008	<0.1	<0.1	**0.75**	<0.1	<0.2	**2.4**	**0.16 (J)**	<0.1	<0.1	<0.1	**0.2**	NT
PBN-9303B (dup)	673	B	83.5-93.5	Sep-18	<0.008	<0.1	<0.1	**0.65**	<0.1	<0.2	**2.1**	**0.15 (J)**	<0.1	<0.1	<0.1	**0.18 (J)**	NT
PBN-9303C	674	C	154.5-164.5	Sep-18	<0.008	<0.1	**0.37**	**1.9**	<0.1	<0.2	**3.5**	**1.1**	<0.1	<0.1	<0.1	<0.1	NT
PBN-9303D	675	D	214.5-224.5	Sep-18	<0.008	**0.39**	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
PBN-9304D	687	D	200-210	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	**560**	<0.1	<0.1	NT
PBN-9902D	691	D	217.5-222.5	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	**0.26**	<0.1	<0.1	NT
PBN-9903A	692	A	61-76	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**1.5**	<0.1	<0.1	<0.1	<0.1	**0.12 (J)**	NT
PBN-9903B	693	B	107-112	Sep-18	<0.008	<0.1	<0.1	**0.27**	<0.1	<0.2	**5.2**	**0.28**	<0.1	<0.1	<0.1	**1.2**	NT
PBN-9903B (dup)	693	B	107-112	Sep-18	<0.008	<0.1	<0.1	**0.28**	<0.1	<0.2	**5.2**	**0.29**	<0.1	<0.1	<0.1	**1.2**	NT
PBN-9903C	694	C	158-163	Sep-18	**0.078**	<0.1	<0.1	**0.12 (J)**	<0.1	<0.2	**10**	**0.23**	<0.1	<0.1	<0.1	**1**	NT
PBN-9903D	695	D	203-208	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	**440**	<0.1	<0.1	NT
S1147	709	A	45.8-70.8	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
S1148	710	A	31.7-56.7	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
SPN-8903B	718	B	88.7-93.7	Sep-18	<0.008	<0.1	<0.1	**0.16 (J)**	<0.1	<0.2	**0.98**	**0.12 (J)**	**0.12 (J)**	<0.1	<0.1	**0.18 (J)**	NT

Table 11
Groundwater Analytical Results
September 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C											
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,1-Dichloroethane**	**1,1-Dichloroethene**	**1,1,1-Trichloroethane**	**Bromodichloromethane**	**Carbon Disulfide**	**Carbon Tetrachloride**	**Chloroform**	**Chloromethane**	**Ethyl Ether**	**Tetrachloroethene**	**Trichloroethene**	**Nitrate, Total**
SPN-8903C	719	C	122.7-127.7	Sep-18	<0.008	<0.1	**0.19 (J)**	**1.5**	<0.1	<0.2	**0.54**	<0.1	**0.11 (J)**	<0.1	<0.1	**0.92**	NT
SPN-8904B	720	B	70-75	Sep-18	**0.061**	<0.1	<0.1	**0.18 (J)**	<0.1	<0.2	**3.3**	**0.15 (J)**	<0.1	<0.1	<0.1	**1**	NT
SPN-8904C	721	C	101.5-106.5	Sep-18	<0.008	<0.1	<0.1	**0.24**	<0.1	<0.2	**4.5**	<0.1	<0.1	<0.1	<0.1	**0.37**	NT
SPN-9103D	725	D	190.5-200.5	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
SPN-9104D	726	D	196-206	Oct-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	**2,200**	<0.1	<0.1	NT
SWN-9102C	569	C	142.5-152.5	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
SWN-9102D	570	D	175-185	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
SWN-9103B	571	B	103.4-113.4	Sep-18	<0.008	<0.1	<0.1	**0.13 (J)**	<0.1	<0.2	**1.4**	**0.11 (J)**	<0.1	<0.1	<0.1	**0.18 (J)**	NT
SWN-9103B (dup)	571	B	103.4-113.4	Sep-18	<0.008	<0.1	<0.1	**0.14 (J)**	<0.1	<0.2	**1.9**	**0.13 (J)**	<0.1	<0.1	<0.1	**0.2**	NT
SWN-9103C	572	C	152.8-162.8	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.51**	**0.34**	<0.1	<0.1	<0.1	<0.1	NT
SWN-9103D	573	D	199.1-209.1	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**2.8**	**0.33**	<0.1	<0.1	<0.1	**0.32**	NT
SWN-9103E	574	E	227.9-237.9	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NT
SWN-9104C	575	C	154-164	Sep-18	<0.008	<0.1	<0.1	**0.12 (J)**	<0.1	<0.2	**3.8**	**0.5**	<0.1	<0.1	<0.1	<0.1	NT
SWN-9104D	576	D	187-197	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**5.1**	**0.79**	<0.1	<0.1	<0.1	<0.1	NT
SWN-9105B	577	B	102.5-112.5	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.1 (J)**	**0.2**	<0.1	<0.1	<0.1	<0.1	NT
SWN-9105C	578	C	137-147	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.19 (J)**	**0.65**	<0.1	<0.1	<0.1	<0.1	NT
SWN-9105D	579	D	190.5-200.5	Sep-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.2	**0.52**	**0.53**	<0.1	<0.1	<0.1	<0.1	NT
Chapter NR 140 Preventive Action Limit (PAL)					0.005	85	0.7	40	0.06	200	0.5	0.6	3	100	0.5	0.5	2
Chapter NR 140 Enforcement Standard (ES)					0.05	850	7	200	0.6	1000	5	6.0	30	1000	5	5	10

Notes:

The Sample Level references the typical well depth configuration
Dinitrotoluene, Total (DNT) & VOC results are expressed in micrograms per liter (µg/l)
Nitrate, Total results are expressed in milligrams per liter (mg/l)
Bold values are detected results
Wells listed with (dup) after the name were duplicate samples
Results for Dinitrotoluene, Total were analyzed by SW8270DSIM
J = Analytical result is between the Limit of Detection (LOD) and Limit of Quantitation (LOQ)
NT = Not Tested

A total of ten monitoring wells had NR 140 ES exceedances for 2,4-DNT during September 2018. 2,4-DNT was not detected in any residential wells that were sampled during August 2018.

A total of seventeen monitoring wells had NR 140 ES exceedances for 2,6-DNT during September 2018. In addition, eight monitoring wells had NR 140 PAL exceedances for 2,6-DNT during September 2018. 2,6-DNT was not detected in any residential wells that were sampled during August 2018.

A total of twenty-one monitoring wells had NR 140 ES exceedances for total DNT during September 2018. In addition, four monitoring wells had NR 140 PAL exceedances for total DNT during September 2018. Total DNT was not detected in any residential wells that were sampled during August 2018.

One monitoring well had a NR 140 ES exceedance for ethyl ether during September 2018. In addition, three monitoring wells had NR 140 PAL exceedances for ethyl ether during September 2018. One residential well had an ethyl ether detection that was below the NR 140 PAL during August 2018.

Three monitoring wells had NR 140 PAL exceedances for nitrate during September 2018. Residential wells are no longer being sampled for nitrate due to historically low detections.

A total of two monitoring wells had NR 140 ES exceedances for TCE during September 2018. In addition, seventeen monitoring wells had NR 140 PAL exceedances for TCE during September 2018. TCE was not detected in any residential wells that were sampled during August 2018.

4.5.1.1 *Carbon Tetrachloride*

The horizontal distribution of CTET is illustrated in Figure 22. The green shaded area displays where CTET was detected above the NR 140 PAL (0.5 µg/l). The blue shaded area displays where CTET was detected above the NR 140 ES (5 µg/l). These same color designations are also used in each CTET cross section. The highest concentration of CTET detected during September 2018 was 19 µg/l in PBN-9101C, which is located 2,300 feet upgradient of the Wisconsin River. The horizontal boundary of the CTET plume covers the largest area compared to ethyl ether, total DNT, and trichloroethene.

Figure 6 shows the orientation of the isoconcentration cross sections for CTET, which are illustrated in Figures 23, 24, 25, and 26. As shown in Figures 23 and 25, there is a dolomite/shale layer beneath the contamination plume that retards groundwater contamination from migrating into the lower Mt. Simon Formation (sandstone).

Figure 23 (A-A’) illustrates the estimated vertical extent of CTET, along the centerline of the PBG Plume, from the PBG (north) towards the Wisconsin River (south). The CTET concentrations are highest south of the BAAP boundary and in wells screened approximately 65 to 140 feet below the water table. The CTET plume extends north to south from the PBG to the

Wisconsin River with an average thickness of 90 feet beneath BAAP and 150 feet south of BAAP. The maximum depth of CTET is 150 feet below the water table at monitoring well PBM-9001D, which is screened in the gravel and sand just above the sandstone. Based on Figure 23, CTET has potentially entered the upper portion of the bedrock aquifer near PBM-9001D.

Based on the *Surface Waters Impact Investigation Report (BTS, LLC), November 2013*, CTET concentrations diminish as the PBG Plume migrates vertically and discharges into the Wisconsin River. CTET concentrations above the NR 140 ES were only identified in the sand aquifer; therefore, CTET does not migrate vertically into the bedrock. Isoconcentration sections for CTET (Figures 4 and 5) provided in the *Surface Waters Impact Investigation Report*, show the CTET plume boundaries in relation to the bedrock and Wisconsin River. More studies in this area would be helpful to further define the CTET concentrations above the bedrock.

CTET concentrations beneath the PBG (source area) are much lower than what is found downgradient of the PBG. The estimated boundary of the CTET plume is shown to approach the Wisconsin River. The groundwater mixes with the saturated sediment beneath the Wisconsin River. This zone is the groundwater/surface water interface. Dilution and volatilization of the CTET plume is expected to occur at the groundwater/surface water interface.

Figure 24 (B-B’) illustrates the width and depth of the CTET plume approximately 2,000 feet south of the PBG. Figure 25 (C-C’) illustrates the width and depth of the CTET plume approximately 6,600 feet south of the PBG and at the BAAP boundary. Figure 26 (D-D’) illustrates the width and depth of the CTET plume, but off-site and approximately 12,000 feet south of the PBG. The CTET plume in Figure 24 is estimated to be approximately 3,200 feet wide and a maximum depth of 135 feet below the water table at PBN-9301C. The CTET plume in Figure 25 is estimated to be approximately 2,800 feet wide and a maximum depth of 150 feet below the water table and below PBN-1302C. The CTET plume in Figure 26 is estimated to be approximately 2,500 feet wide and a maximum depth of 120 feet below the water table at monitoring well SWN-9103D.

The following residential wells are shown on either Figure 23 (A-A’) or Figure 26 (D-D’): Judd, Lins-K, Lins-R, Mueller-J, and Urban. These residential wells represent all the residential wells located near the PBG Plume. As shown in the figures, the Judd well is screened in the sand and gravel aquifer and the Lins-K, Lins-R, Mueller-J, and Urban wells are screened in the bedrock aquifer. There are several residential wells that were drilled through the CTET plume and then screened beneath the CTET plume.

4.5.1.2 *Ethyl Ether*

The horizontal distribution of ethyl ether (diethyl ether) is illustrated in Figure 27. The green shaded area displays where ethyl ether was detected above the NR 140 PAL (100 µg/l). The blue shaded area displays where ethyl ether was detected above the NR 140 ES (1,000 µg/l). These same color designations are also used in each ethyl ether cross section. The highest concentration of ethyl ether detected during September 2018 was 2,200 µg/l in SPN-9104D, which is located at the BAAP Boundary. The horizontal boundary of the ethyl ether plume covers the smallest area compared to CTET, total DNT, and trichloroethene. The ethyl ether plume is shown in two small areas downgradient of the PBG.

Figure 6 shows the orientation of the isoconcentration cross sections for ethyl ether, which are illustrated in Figures 28, 29, 30, and 31. Figure 28 (A-A') illustrates the estimated vertical extent of ethyl ether, along the centerline of the PBG Plume, from the PBG (north) towards the Wisconsin River (south). The ethyl ether concentrations are highest at the BAAP boundary and in wells screened approximately 170 feet below the water table. The ethyl ether plume is approximately 60 feet thick beneath BAAP. The maximum depth of ethyl ether is 190 feet below the water table and below PBN-9304D, which is screened just above the top of the bedrock. Figure 28 shows ethyl ether to only be detected in monitoring wells near the bottom of the sand aquifer. Based on Figure 28, ethyl ether has likely entered the upper portion of the bedrock aquifer near PBN-9304D and SPN-9104D. Ethyl ether was not detected in PBN-1405F, which was constructed 110 feet beneath PBN-9304D and below the dolomite/shale layer.

Figure 29 (B-B') illustrates the width and depth of the ethyl ether plume approximately 2,000 feet south of the PBG. Figure 30 (C-C') illustrates the width and depth of the ethyl ether plume approximately 6,600 feet south of the PBG and at the BAAP boundary. Figure 31 (D-D') illustrates the width and depth of the ethyl ether plume, but off-site and approximately 12,000 feet south of the PBG. There is no ethyl ether plume shown in Figure 29 because there were no detections above 100 µg/l. The ethyl ether plume in Figure 30 is estimated to be approximately 750 feet wide and a maximum depth of 190 feet below the water table and below PBN-9304D. There is no ethyl ether plume shown in Figure 31 because there were no detections above 100 µg/l.

The following residential wells are shown on either Figure 28 (A-A') or Figure 31 (D-D'): Judd, Lins-K, Lins-R, Mueller-J, and Urban. There are also five residential wells located over 1,400 feet east of the ethyl ether plume shown in Figure 27. The highest ethyl ether concentration in these five wells was only 0.16 µg/l.

4.5.1.3 *Trichloroethene*

The horizontal distribution of TCE is illustrated in Figure 32. The green shaded area displays where TCE was detected above the NR 140 PAL (0.5 µg/l). The blue shaded area displays where TCE was detected above the NR 140 ES (5 µg/l). These same color designations are also used in each TCE cross section. The highest concentration of TCE detected during September 2018 was 8.5 µg/l in PBN-9101C, which is located 2,300 feet upgradient of the Wisconsin River. The horizontal boundary of the TCE plume extends from the PBG to the Wisconsin River but is much narrower than the CTET plume.

Figure 6 shows the orientation of the isoconcentration cross sections for TCE, which are illustrated in Figures 33, 34, 35, and 36. Figure 33 (A-A') illustrates the estimated vertical extent of TCE, along the centerline of the PBG Plume, from the PBG (north) towards the Wisconsin River (south). The TCE concentrations are highest at the BAAP boundary, south of the BAAP boundary, and in wells screened approximately 65 to 140 feet below the water table. The TCE plume has an average thickness of 110 feet. The maximum depth of TCE is 145 feet below the water table and below PBM-9001D, which is screened just above the top of the bedrock. Based on Figure 33, TCE has likely entered the upper portion of the bedrock aquifer near PBM-9001D. TCE concentrations near the PBG (source area) are much lower than what is found downgradient of the PBG. The estimated boundary of the TCE plume is shown to approach the Wisconsin River.

Figure 34 (B-B’) illustrates the width and depth of the TCE plume approximately 2,000 feet south of the PBG. Figure 35 (C-C’) illustrates the width and depth of the TCE plume approximately 6,600 feet south of the PBG and at the BAAP boundary. Figure 36 (D-D’) illustrates the width and depth of the TCE plume, but off-site and approximately 12,000 feet south of the PBG. The TCE plume in Figure 34 is estimated to be approximately 1,200 feet wide and a maximum depth of 80 feet below the water table at PBN-8902C. The TCE plume in Figure 35 is estimated to be approximately 1,400 feet wide and a maximum depth of 85 feet below the water table and below SPN-8903C. There is no TCE plume shown in Figure 36 because there were no detections above 0.5 µg/l.

The following residential wells are shown on either Figure 33 (A-A’) or Figure 34 (D-D’): Judd, Lins-K, Lins-R, Mueller-J, and Urban. There are several residential wells that were drilled through the TCE plume and then screened beneath the TCE plume.

4.5.1.4 *Total Dinitrotoluene*

The horizontal distribution of total DNT is illustrated in Figure 37. The total DNT concentration is the sum of all six DNT isomers (2,3-DNT, 2,4-DNT, 2,5-DNT, 2,6-DNT, 3,4-DNT, and 3,5-DNT). The green shaded area displays where total DNT was detected above the NR 140 PAL (0.005 µg/l). The blue shaded area displays where total DNT was detected above the NR 140 ES (0.05 µg/l). The red shaded area displays where total DNT was detected above 1.0 µg/l. These same color designations are also used in each total DNT cross section. The highest concentration of total DNT detected during September 2018 was 116.42 µg/l in PBN-8202A, which is immediately downgradient of the PBG. The total DNT plume is shown in three separate areas, near the PBG, near the BAAP boundary, and farther downgradient of the PBG to the Wisconsin River. The separation of the total DNT plumes maybe related to the extensive groundwater pumping conducted by the MIRM treatment system.

Figure 6 shows the orientation of the isoconcentration cross sections for total DNT, which are illustrated in Figures 38, 39, 40, 41, and 42. Figure 38 (A-A’) illustrates the estimated vertical extent of total DNT, along the centerline of the PBG Plume, from the PBG (north) towards the Wisconsin River (south). The total DNT concentrations beneath the PBG (source area) are higher than what is found downgradient. The total DNT concentrations are much lower south of the BAAP boundary than what is found on BAAP. The total DNT concentrations are highest in wells screened approximately 0 to 30 feet below the water table. The total DNT plume has an average thickness of 100 feet. The maximum depth of total DNT is 100 feet below the water table at PBN-9903C, which is screened 40 feet above the top of the bedrock. Based on Figure 38, total DNT has not entered the bedrock aquifer beneath or downgradient of BAAP. The estimated boundary of the total DNT plume is shown to approach the Wisconsin River.

Figure 39 (A1-A1') illustrates the estimated vertical extent of total DNT beneath the capped PBG Waste Pits to the southeast corner of the Racetrack Area at PBN-8205A, B, C. The total DNT concentrations are highest in the shallow wells located beneath the PBG Waste Pits (source area). The highest concentrations of total DNT are shown in well nest PBN-8202A, B, C, which is downgradient of waste pit 2 (WP-2). The vertical depth of the total DNT plume beneath the PBG Waste Pits can only be estimated as there are no deeper monitoring wells.

Figure 40 (B-B') illustrates the width and depth of the total DNT plume approximately 2,000 feet south of the PBG. Figure 41 (C-C') illustrates the width and depth of the total DNT plume approximately 6,600 feet south of the PBG and at the BAAP boundary. Figure 42 (D-D') illustrates the width and depth of the total DNT plume, but off-site and approximately 12,000 feet south of the PBG. The total DNT plume in Figure 40 is estimated to be approximately 1,800 feet wide and a maximum depth of 100 feet below the water table at PBN-8902C. The total DNT plume in Figure 41 is estimated to be approximately 1,300 feet wide and a maximum depth of 130 feet below the water table and below PBN-1302C. There is no total DNT plume shown in Figure 42 because there were no detections above 0.005 µg/l.

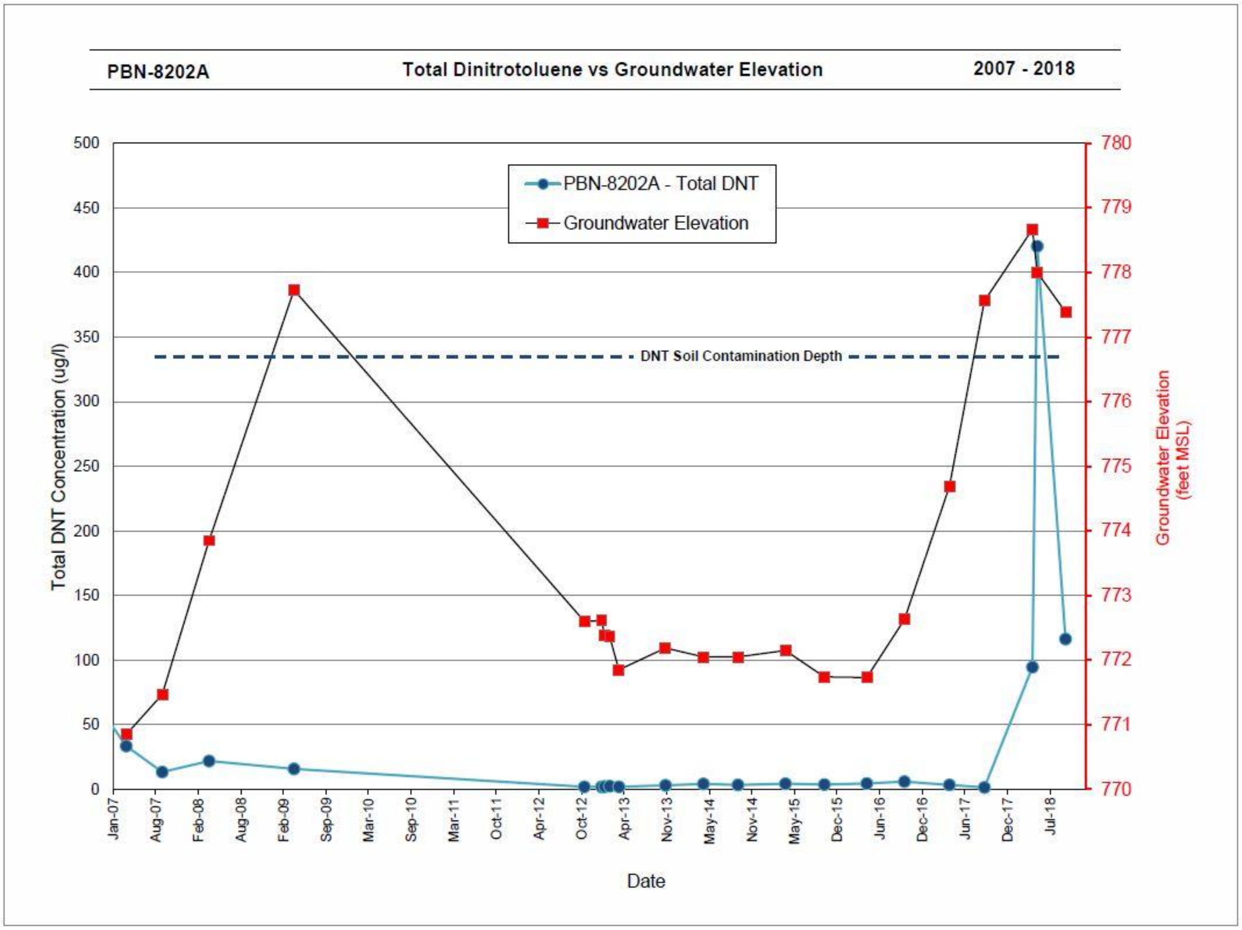
The following residential wells are shown on either Figure 38 (A-A') or Figure 42 (D-D'): Judd, Lins-K, Lins-R, Mueller-J, and Urban. There is one residential well that was drilled through the total DNT plume and then screened beneath the total DNT plume.

4.5.1.5 *Concentration Graphs*

To evaluate contaminant trend data for the PBG Plume, concentration over time graphs were prepared for select monitoring wells within the plume. Graphs showing PBG Plume contaminant concentration over time are presented in Appendix E. The primary COPCs used for trend analysis were CTET, chloroform, ethyl ether, TCE, and total DNT. In the source area, data from eight monitoring wells were graphed. Graphs were prepared for 17 on-site monitoring wells located downgradient of the PBG. Graphs were prepared for 17 off-site monitoring wells located downgradient of the PBG.

The source area wells PBM-0002, PBM-0008, and PBN-8202A show a large decrease in DNT concentrations after 2002. These sharp decreases are related to the operation of the BEST system from 2001 to 2005. During December 2012, the IRM ceased groundwater pumping directly downgradient of the PBG Waste Pits and PBM-0002. Between 2012 to 2017, the total DNT concentrations in the source area wells stabilized between 1 to 5 µg/l. During April 2018, a noticeable increase in total DNT concentration was identified in PBN-8202A. PBN-8202A is located directly south and downgradient of the PBG Waste Pits (see Figure 18). The total DNT concentration in PBN-8202A increased from 1.469 µg/l during September 2017 to 94.65 µg/l during April 2018 to 420.294 µg/l during May 2018 to 116.42 µg/l during September 2018.

Between April 2016 and April 2018, the groundwater table near the PBG Waste Pits rose 6.9 feet. Provided below is a graph depicting both the total DNT concentration and groundwater elevation in PBN-8202A from 2007 to 2018. The graph shows a peak in the groundwater elevation in 2009 but not an increase of total DNT. During 2009, the IRM was still operating a groundwater pumping well approximately 125 feet southwest of PBN-8202A. The graph shows another peak in groundwater elevation in 2018 along with a sharp increase of total DNT in PBN-8202A. During 2018, the groundwater elevation in PBN-8202A ranged from 777.4 to 778.5 feet MSL. Based on the 2005 soil investigation data presented in Appendix B (Table 5), soil boring PBB-0502 (Waste Pit 2) had detectable concentrations of both 2,4-DNT and 2,6-DNT at a depth of 105 feet or 776.80 feet MSL. The following graph displays the DNT soil contamination depth in relation to the groundwater elevation. During the 2005 soil investigation, the groundwater was at an elevation of 774.5 feet MSL, below the soil contamination. Based on the above information, the groundwater beneath the PBG Waste Pits has risen above the DNT contaminated soil. The recent increase in total DNT concentrations in PBN-8202A appears to be related to the recent rise in groundwater coming into contact with the soil contamination.



The VOC compounds of CTET, chloroform, and TCE have been declining near the source area since the 1980's. The VOC compounds have declined to levels at or below the NR 140 ES.

In the on-site portion of the plume, the VOC compounds of CTET, chloroform, and TCE show decreasing trends in both the shallow and deep wells. The exception is that chloroform in PBN-8502A had a peak during 2015 but declined in 2016, 2017, and 2018. The ethyl ether concentrations in PBN-1001C and PBN-9304D have been decreasing. The DNT concentrations in the wells downgradient of the PBG show either stable or decreasing trends.

As the plume extends off-site, the VOC compounds of CTET, chloroform, and TCE show either stable or decreasing trends in both the shallow and deep wells. There are several monitoring wells that have seen peaks followed by decreases.

- The CTET concentration in SWN-9103C had a sharp peak during 2010 (90.1 µg/l) followed by a sharp decrease below 5 µg/l by 2014. The CTET concentration in PBN-9101C had a peak during 2012 (44.8 µg/l) followed by a decrease to 19 µg/l during 2018. The CTET concentration in PBM-9001D had a peak (above 25 µg/l) during 2011 followed by a slight decrease to 15 µg/l during 2017. During 2018, the CTET concentration in PBM-9001D peaked again at 25 µg/l and then dropped back to 15 µg/l. The CTET concentration in SWN-9104C has increased from 2015 to 2018, reaching 3.8 µg/l during September 2018. The CTET concentration in SWN-9104D has increased from 2015 to 2018, reaching 5.1 µg/l during September 2018.

- The chloroform concentration in SWN-9103C had a peak during 2007 (above 7 µg/l) followed by a decrease to below 0.5 µg/l during 2018. The chloroform concentration in PBN-9101C had a peak during 2011 (above 6 µg/l) followed by a decrease to 1.7 µg/l during 2018. The chloroform concentration in PBM-9001D had a peak (above 3 µg/l) during 2011 followed by a decrease to 1.4 µg/l during 2018.

- The ethyl ether concentration in PBN-9903D peaked during 2014 (above 3,500 µg/l) but decreased during 2015 and has remained stable with a concentration of 440 µg/l during 2018. Ethyl ether is not detected in the off-site monitoring wells located south (downgradient) of PBN-9903D.

- The TCE concentration in SWN-9103B had a peak during 2000 (above 7 µg/l) followed by a steady decrease to below 0.5 µg/l by 2014. The TCE concentration in SWN-9103D had a peak during 2014 (near 5 µg/l) followed by a decrease to below 0.5 µg/l by 2018. The TCE concentration in PBN-9101C had a peak during 2011 (above 14 µg/l) followed by a decrease till 2017. Between 2017 and 2018, the TCE concentration in PBN-9101C increased from 6.5 to 8.8 µg/l. PBN-9101C was not sampled between 1999 to 2010; therefore, no data was available. The TCE concentration in PBM-9001D had a peak during 2011 (above 5 µg/l) followed by a decrease till 2015. Between 2015 and 2018, the TCE concentration in PBM-9001D has increased from 3.1 to 8.6 µg/l.

- The DNT concentrations in the off-site monitoring wells have been stable or decreasing. The exception is that PBN-9101C had a peak (above 0.1 µg/l) during 2013 followed by a slight decrease to 0.08 µg/l during 2018.

4.5.1.6 *Monitored Natural Attenuation*

An evaluation of existing site information and groundwater data was conducted to illustrate that monitored natural attenuation (MNA) of chlorinated solvents or VOCs has been occurring within the PBG Plume. Based on groundwater monitoring data collected between 2015 and 2018, the following VOCs have been detected above the NR 140 PAL or ES routinely in the PBG Plume: CTET, chloroform, ethyl ether, and TCE.

The *Draft Technical Report Natural Attenuation Screening Study for the Propellant Burning Ground* (Stone & Webster, August 1999) provided evidence that VOCs are naturally attenuating in the PBG Plume. The Stone & Webster report summarized that the concentrations of chlorinated solvents in the groundwater are declining over time, along the length of the plume, and decrease with separation from the source area. This indicates that, overall, the chlorinated solvents are leaving the groundwater by some natural attenuation mechanism. Stone & Webster documented that no chlorinated solvent degradation products or transformation products have been detected in the groundwater. Based on groundwater monitoring data over the past 30 years, the more toxic TCE degradation product, vinyl chloride, has not been detected.

During December 1998, Stone & Webster collected groundwater samples from 38 monitoring wells located within or near the PBG Plume. Monitoring wells were chosen upgradient of the source area, in the source area, and downgradient of the source area. The samples were laboratory analyzed for VOCs and semi-volatile organic compounds (SVOCs). The samples were also analyzed for the following geochemical parameters: chloride, dissolved oxygen, iron II, methane, nitrate, nitrite, oxidation reduction potential (ORP), pH, sulfate, sulfide, temperature, total dissolved solids, and total organic carbon. Based on this 1998 data, there is no evidence to suggest that reductive dechlorination has occurred in the PBG Plume. The PBG Plume is a well-oxygenated groundwater system (aerobic) with little or no organic matter.

Stone & Webster documented that CTET, chloroform, and TCE concentrations dropped between 1990 and 1998 in six monitoring wells that are located along the axis (centerline) of the PBG Plume (PBN-8910A, PBN-8205A, PBN-8501A, PBN-8504A, PBN-8912B, and SPN-8903B). A generalized summation of the Stone & Webster groundwater data findings is shown below.

Summary of 1990 - 1998 VOC Groundwater Data
Propellant Burning Ground Plume

Monitoring Well	Distance from Source Area (feet)	Date Sampled	Carbon Tetrachloride	Chloroform	Trichloroethene
PBN-8910A	700	Mar-90	31.0	5.6	103.0
		Dec-98	11.0	1.6	48.0
PBN-8205A	1,540	Mar-90	88.0	5.5	112.0
		Dec-98	42.0	2.6	41.0
PBN-8501A	2,520	Mar-90	43.0	14.0	30.0
		Dec-98	17.0	3.3	20.0
PBN-8504A	3,920	Mar-91	21.0	6.9	11.0
		Dec-98	0.8	<0.2	<0.2
PBN-8912B	5,600	Mar-90	51.0	7.8	20.0
		Dec-98	<0.4	<0.2	<0.2
SPN-8903B	7,000	Mar-90	130.0	11.0	<5.0
		Dec-98	24.0	2.1	1.3

Note: All results expressed in micrograms per liter (µg/l)

Shown on Figure 19 are locations of these six monitoring wells (shown above) in relation to the former IRM and MIRM extraction wells. Even though the four IRM wells (BCW-1, BCW-2, BCW-3, and SCW-1) were running from 1990 to 1998, they were only pumping a combined 350 gpm. Four of the six monitoring wells were isolated from the IRM wells and therefore not influenced by their pumping. The MIRM became operational in 1996 with six boundary extraction wells (EW-161, EW-162, EW-163, EW-164, EW-165, and EW-166) pumping a combined 3,000 gpm. Extraction wells EW-167, EW-168, EW-169, and EW-170 (EW-170R) were operational between 2006 and 2015. Five of the six monitoring wells were isolated (located far north) from the MIRM wells and therefore not influenced by their pumping. Shown in the above summary table are reductions in VOCs that clearly indicate that the PBG Plume was undergoing natural attenuation between 1990 and 1998.

Concentration over time graphs for monitoring well nests PBN-8205A, B, and C; PBN-8502A, PBN-8902BR, and PBN-8902C; and PBN-8912A, PBN-8912B, PBN-9112C, and PBN-9112D are provided in Appendix E. These 10 monitoring wells are located south of the former IRM wells and north of the original (1996) MIRM wells. These monitoring wells were not influenced by pumping operations until the MIRM was realigned in 2005. CTET, chloroform, and TCE concentrations for all 10 monitoring wells show decreasing trends. A more thorough discussion of concentration graphs for these 10 monitoring wells and 24 other monitoring wells associated with the PBG Plume is provided in Section 4.5.1.6. Ethyl ether concentrations in PBN-1001C, PBN-9304D, and PBN-9903D have been declining since 2013, graphs are provided in Appendix E.

Based on the historic groundwater data, MNA has a reasonable probability of bringing the VOCs in the PBG Plume into compliance with Chapter NR 140 groundwater quality standards within a reasonable period of time.

4.5.2 Deterrent Burning Ground Plume

The DBG Plume originates at the DBG and extends southeast beyond the BAAP boundary. East of BAAP, the plume continues southeast towards Weigand's Bay which is connected to the Wisconsin River. The DBG Plume shown in Figure 21 represents the area where groundwater concentrations exceed a NR 140 PAL or ES for 2,4-DNT, 2,6-DNT, or total DNT. All six DNT isomers (2,3-DNT, 2,4-DNT, 2,5-DNT, 2,6-DNT, 3,4-DNT, and 3,5-DNT) have been detected in the DBG Plume. Because total DNT encompasses all six DNT isomers, total DNT was used to map the DBG Plume boundaries. The DBG Plume boundaries shown in Figure 21 are approximate and based on total DNT groundwater data collected during 2018 from both monitoring wells and residential wells. Table 12 summarizes the groundwater analytical results from the April 2018 sampling event for the monitoring wells associated with the DBG Plume. The April 2018 sampling round includes results for total DNT, sulfate, and VOCs. Table 10 summarizes the groundwater analytical results from the August 2018 residential well sampling event. Table 11 summarizes the groundwater analytical results from the September 2018 monitoring well sampling event. Monitoring wells associated with the DBG Plume were not sampled for VOCs during September 2018. An isoconcentration map and two cross sections were prepared for total DNT. The isoconcentration map was prepared using all groundwater data collected during 2018. The isoconcentration cross sections were prepared using groundwater data collected during August and September 2018.

During 2015, 2016, 2017, and 2018, 2,4-DNT, 2,6-DNT, total DNT, sulfate, and 1,1,2-trichloroethane (1,1,2-TCA) have been COPCs in the DBG Plume. The DBG Plume groundwater results from the April, August, and September 2018 sampling events were evaluated for COPCs that exceeded a Chapter NR 140 PAL Groundwater Standard.

A total of three monitoring wells had NR 140 PAL exceedances for 2,4-DNT during April 2018. 2,4-DNT was not detected in any residential wells that were sampled during August 2018.

A total of two monitoring wells had NR 140 ES exceedances for 2,6-DNT during April 2018. In addition, eight monitoring wells had NR 140 PAL exceedances for 2,6-DNT during April 2018. One monitoring well had a NR 140 ES exceedance for 2,6-DNT during September 2018. In addition, eight monitoring wells had NR 140 PAL exceedances for 2,6-DNT during September 2018. 2,6-DNT was not detected in any residential wells that were sampled during August 2018.

Table 12
Groundwater Analytical Results
April 2018 (DBG Plume)
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C								
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,2-Dichloroethane**	**1,2-Dichloropropane**	**1,1,1-Trichloroethane**	**1,1,2-Trichloroethane**	**Dichlorodifluoromethane**	**Ethyl Ether**	**Tetrahydrofuran**	**Trichloroethene**	**Sulfate, Total**
DBG PLUME AREA WELLS														
DBM-8201	301	A	154.6-174.6	Apr-18	**2.216**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**18**
DBM-8202	302	A	137.3-157.3	Apr-18	**0.578**	<0.1	<0.1	**0.97**	<0.1	<0.1	<0.1	<1	<0.1	**31**
DBM-8903	306	A	113-133	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-1001B	472	B	154.5-159.5	Apr-18	**0.48**	<0.1	<0.1	**1.5**	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-1001C	473	C	192-197	Apr-18	**0.024 (J)**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-1001E	474	E	274.9-279.9	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-1002C	476	C	205.1-210.1	Apr-18	**0.772**	<0.1	<0.1	**0.23**	<0.1	<0.1	<0.1	<1	<0.1	**19**
DBN-1002E	477	E	275.5-280.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**18**
DBN-9501A	314	A	110-120	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-9501B	315	B	162.5-172.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-9501C	316	C	218.5-228.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
DBN-9501E	317	E	245.2-255.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELM-8901	216	A	145.5-165	Apr-18	**1.409**	<0.1	<0.1	**1.2**	<0.1	<0.1	<0.1	<1	<0.1	**76**
ELM-8907	220	A	130.3-150.3	Apr-18	**0.57**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**17**
ELM-8908	221	A	125-145	Apr-18	**0.345**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**15**
ELM-8909	222	A	135-155	Apr-18	<0.008	<0.1	<0.1	**0.76**	<0.1	<0.1	<0.1	<1	<0.1	**13**
ELM-9501	234	A	54-69	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-0801B	455	B	100-105	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-0801B (dup)	455	B	100-105	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-0801C	456	C	145.5-150.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-0801E	457	E	202.6-207.6	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT

Table 12
Groundwater Analytical Results
April 2018 (DBG Plume)
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C								
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,2-Dichloroethane**	**1,2-Dichloropropane**	**1,1,1-Trichloroethane**	**1,1,2-Trichloroethane**	**Dichlorodifluoromethane**	**Ethyl Ether**	**Tetrahydrofuran**	**Trichloroethene**	**Sulfate, Total**
ELN-1001B	460	B	91.1-96.1	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1001C	461	C	155.2-160.2	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1001E	462	E	240.5-245.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1002A	463	A	55.3-70.3	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1002B	464	B	111.2-116.2	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1002B (dup)	464	B	111.2-116.2	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1002C	465	C	159.1-164.1	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1002E	466	E	231.5-236.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1003A	467	A	16.2-31.2	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1003B	468	B	91.5-96.5	Apr-18	**0.232**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1003B (dup)	468	B	91.5-96.5	Apr-18	**0.225**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1003B	468	B	91.5-96.5	May-18	**0.186**	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003C	469	C	155.1-160.1	Apr-18	**0.074**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1003C	469	C	155.1-160.1	May-18	**0.108**	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1003E	470	E	255.6-230.6	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1502A	533	A	115.3-130.3	Apr-18	**0.594**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1502A (dup)	533	A	115.3-130.3	Apr-18	**0.537**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1502A	533	A	115.3-130.3	May-18	**0.69**	NT	NT	NT	NT	NT	NT	NT	NT	NT
ELN-1502C	534	C	198-203	Apr-18	**0.022 (J)**	<0.1	<0.1	**0.71**	<0.1	**0.14 (J)**	<0.1	<1	<0.1	NT
ELN-1503A	535	A	73.7-88.7	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1503C	536	C	157.6-162.6	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
ELN-1504B	537	B	34.8-39.8	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT

Table 12
Groundwater Analytical Results
April 2018 (DBG Plume)
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

						Volatile Organic Compounds (VOC) - SW8260C								
Well	**Well ID**	**Sample Level**	**Sample Depth (feet)**	**Sample Date**	**Dinitrotoluene, Total**	**1,2-Dichloroethane**	**1,2-Dichloropropane**	**1,1,1-Trichloroethane**	**1,1,2-Trichloroethane**	**Dichlorodifluoromethane**	**Ethyl Ether**	**Tetrahydrofuran**	**Trichloroethene**	**Sulfate, Total**
ELN-8203A	210	A	147.5-157.5	Apr-18	<0.008	<0.1	**0.28**	<0.1	**0.3**	**0.15 (J)**	**0.49**	<1	<0.1	**1100**
ELN-8203B	211	B	164-166	Apr-18	<0.008	<0.1	**0.36**	<0.1	**0.98**	**0.36**	**0.27**	<1	<0.1	**990**
ELN-8203B (dup)	211	B	164-166	Apr-18	<0.008	<0.1	**0.35**	**0.11 (J)**	**0.87**	**0.38**	**0.31**	<1	<0.1	**1000**
ELN-8203C	212	C	174-176	Apr-18	<0.008	<0.1	<0.1	<0.1	**0.38**	<0.1	<0.1	<1	<0.1	**55**
ELN-8902B	224	B	173.5-178.5	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**18**
ELN-9107A	227	A	116-126	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**21**
ELN-9107B	228	B	135-145	Apr-18	<0.008	<0.1	<0.1	<0.1	**0.25**	<0.1	<0.1	<1	<0.1	**34**
ELN-9402AR	231	A	130-145	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	**11**
S1121	755	A	39.11-59.3	Apr-18	<0.008	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	NT
S1134R	236	A	136-151	Apr-18	<0.008	<0.1	**0.11 (J)**	<0.1	**0.42**	<0.1	<0.1	<1	<0.1	**750**
Chapter NR 140 Preventive Action Limit (PAL)					0.005	0.5	0.5	40	0.5	200	100	10	0.5	125
Chapter NR 140 Enforcement Standard (ES)					0.05	5	5	200	5	1000	1000	50	5	250

Notes:

The Sample Level references the typical well depth configuration

Dinitrotoluene, Total (DNT) & VOC results are expressed in micrograms per liter (µg/l)

Sulfate, Total results are expressed in milligrams per liter (mg/l)

Bold values are detected results

Wells listed with (dup) after the name were duplicate samples

Results for Dinitrotoluene, Total were analyzed by SW8270DSIM

J = Analytical result is between the Limit of Detection (LOD) and Limit of Quantitation (LOQ)

NT = Not Tested

A total of ten monitoring wells had NR 140 ES exceedances for total DNT during April 2018. In addition, two monitoring wells had NR 140 PAL exceedances for total DNT during April 2018. A total of eleven monitoring wells had NR 140 ES exceedances for total DNT during September 2018. Total DNT was not detected in any residential wells that were sampled during August 2018.

Three monitoring wells had an NR 140 ES exceedance for sulfate during April 2018. Residential wells are no longer being sampled for sulfate due to historically low detections.

Two residential wells had NR 140 PAL exceedances for TCE during August 2018. No monitoring wells had a TCE detection during 2018. Historically, TCE has not been detected in monitoring wells associated with the DBG Plume. Because TCE can be a residential contaminant and the contamination related to past Army operations has not been present in this area, these residential wells are assumed to not be contaminated by the DBG Plume. Based on Army investigations, some residential wells pumps have been found to contain TCE.

One monitoring well had a NR 140 PAL exceedance for 1,1,2-TCA during April 2018. One residential well had a 1,1,2-TCA detection but below the NR 140 PAL during August 2018.

4.5.2.1 *Total Dinitrotoluene*

The horizontal distribution of total DNT is illustrated in Figure 43. The green shaded area displays where total DNT was detected above the NR 140 PAL (0.005 µg/l). The blue shaded area displays where total DNT was detected above the NR 140 ES (0.05 µg/l). The red shaded area displays where total DNT was detected above 1.0 µg/l. These same color designations are also used in each total DNT cross section. The highest concentration of total DNT detected during 2018 was 3.005 µg/l in DBM-8201, which is immediately downgradient of the DBG. The horizontal boundary of the DBG Plume extends from the DBG towards Weigand’s Bay but does not reach it. There are two wells shown in Figure 43 that are between the DBG Plume and Weigand’s Bay. Total DNT was not detected in these two wells (ELN-1504B and Purcell-D) during 2018. During April 2019, there was a detection of 3,4-DNT and total DNT in residential well Purcell-D that was above the NR 140 ES.

Figure 6 shows the orientation of the contaminant plume isoconcentration cross sections for total DNT, which are illustrated in Figures 44 and 45. Figure 44 (E-E’) illustrates the estimated vertical extent of total DNT, along the centerline of the DBG Plume, from the DBG (northwest) towards Weigand’s Bay (southeast). The total DNT concentrations adjacent to the DBG (source area) are higher than what is found downgradient. The highest total DNT concentrations are found in wells screened approximately 0 to 30 feet below the water table. The total DNT plume extends northwest to southeast approximately 6,700 feet with an average thickness of 80 feet. Figure 44 shows that the DNT plume is only present in the sand and gravel aquifer and has not migrated downward into the bedrock.

Figure 45 (F-F’) illustrates the width and depth of the total DNT plume between 200 to 1,200 feet south of the DBG. The total DNT plume is estimated to be approximately 1,000 feet wide and a maximum depth of 55 feet below the water table in Figure 45 (F-F'), which is close to the source area.

The Purcell-D residential well is shown on Figure 44 (E-E') at the leading edge of the DBG Plume. The Purcell-D residential well was chosen based on its location along the cross section. The Purcell-D residential well is 112 feet deep and screened in the sand and gravel aquifer. Most of the residential wells in the Weigand's Bay area (downgradient of the DBG Plume) are screened in the sand and gravel aquifer along with a few bedrock wells. Based on the depth and location in relation to the DBG Plume and the historic groundwater monitoring data results, the DBG Plume containing total DNT is migrating toward the residential wells. Results from the August 2018 sampling of 23 residential wells located east and southeast of the DBG Plume did not detect total DNT (see Table 10). However, during April 2019 there was a detection of 3,4-DNT and total DNT in residential well Purcell-D that was above the NR 140 ES.

4.5.2.2 *Sulfate*

The horizontal distribution of sulfate is illustrated in Figure 46. The sulfate isoconcentrations are interpreted from the April 2018 groundwater data. Annually during April, 16 monitoring wells are sampled for sulfate. Table 12 summarizes the sulfate groundwater analytical results from the April 2018 sampling event. Since 2013, residential wells are no longer sampled for sulfate due to the historically low detections and the stability of the sulfate near Landfill #5. The green shaded area displays where sulfate was detected above the NR 140 PAL [125 milligrams per liter (mg/l)]. The blue shaded area displays where sulfate was detected above the NR 140 ES (250 mg/l). The highest concentration of sulfate detected during April 2018 was 1,100 mg/l in ELN-8203A, which is immediately downgradient of Landfill #5. The limits of the sulfate isoconcentrations are approximately 500 by 850 feet. Due to the limited extent of sulfate detections, cross sections were not prepared. Wisconsin has a "secondary" NR 140 Public Welfare Groundwater Quality Standard for sulfate. The sulfate Chapter NR 140 Groundwater Standard is based on a taste threshold and not based on risk to human health.

4.5.2.3 *1,1,2-Trichloroethane*

Concentrations of 1,1,2-trichloroethane (1,1,2-TCA) exceeded the NR 140 PAL in monitoring well ELN-8203B, which is downgradient of Landfill #5 (see Figure 21). Table 12 summarizes the 1,1,2-TCA groundwater analytical results from the April 2018 sampling event. The April 2018 concentration of 1,1,2-TCA in ELN-8203B was 0.98 µg/l. 1,1,2-TCA is detected in several other monitoring wells but below the NR 140 PAL (0.5 µg/l). 1,1,2-TCA is routinely detected (below the PAL) in the Spear residential well, which is located 2,600 feet southeast of ELN-8203B. Due to the limited extent of 1,1,2-TCA detections, an isoconcentration map or cross section were not prepared.

4.5.2.4 *Trichloroethene*

The groundwater results from the August 2018 sampling event show that TCE was detected in three residential wells (Anderson-R, Hendershot, and Wenger). Two of those residential wells had TCE detections above the NR 140 PAL (0.5 µg/l). All three residential wells are located in the Weigand's Bay area (downgradient of the DBG Plume), see Figure 20. All three residential wells are screened in the sand aquifer, see Table 5. TCE has routinely been detected in the Anderson-R and Hendershot residential wells since 2007 and the Wenger residential well since 2010. The maximum concentration of TCE (4.7 µg/l) was detected in the Hendershot residential well during August 2016. This TCE concentration is below the federal MCL and the NR 140 ES of 5 µg/l for drinking water. The TCE concentration in the Hendershot residential well during August 2018 was 2.0 µg/l.

Table 12 summarizes the TCE groundwater analytical results from the April 2018 monitoring well sampling event. No monitoring wells had a TCE detection during April 2018. Historically, TCE has not been detected in monitoring wells associated with the DBG Plume. There has been no source of TCE identified at BAAP that is upgradient of the Weigand's Bay area. A potential source of TCE is the shallow well jet pump at each residence. During 2012, the Army investigated TCE contamination in the Goelz residential well adjacent to Gruber's Grove Bay. The investigation determined that the well jet pump was the source of TCE contamination in the shallow residential well. Due to the absence of TCE in monitoring wells, TCE is not a COPC in the DBG Plume; therefore, an isoconcentration map or cross section was not prepared.

4.5.2.5 *Concentration Graphs*

To evaluate contaminant trend data for the DBG Plume, concentration over time graphs were prepared for select monitoring wells within the plume. Graphs showing DBG Plume contaminant concentration over time are presented in Appendix E. The primary COPC in the DBG Plume is total DNT; therefore, concentrations of total DNT were evaluated for trends. In the source area, data from wells DBM-8201, DBM-8202, and DBN-1001B, C, E were graphed. DBM-8201 shows a generally stable trend with some periods of elevated concentrations. DBM-8202 shows a spike in 2003 followed by a stable to decreasing trend. DBN-1001B shows a decreasing trend from 2014 till 2017. Between 2017 and 2018, the total DNT concentration in DBN-1001B has increased from 0.162 to 0.5978 µg/l. At the center of the DBG Plume, data from wells ELM-8901, ELM-8907, ELM-8908, and ELN-1502A, C were graphed. ELM-8901 shows a steep decreasing trend since 2009. ELM-8907 showed a generally stable trend followed by an increase between 2008 and 2011 then a steadily decreasing trend. ELM-8908 showed some variability then noticeable increases in 2008 and 2013 followed by a decreasing trend since 2014. Data from four wells (ELM-9501 and ELN-0801B, C, E) were used to evaluate the downgradient portion of the plume. All four wells have shown either stable or decreasing trends since 2009. During 2018, total DNT was not detected in ELM-9501 and ELN-0801B, C, E.

ELN-1502A and ELN-1502C were installed in 2015 to provide additional definition of the center of the DBG Plume near the BAAP boundary (see Figure 21). The total DNT concentration in ELN-1502A has been steadily increasing from 0.0087 µg/l during December 2015 to 0.801 µg/l during September 2018. Data from a nest of wells (ELN-1003A, B, C, E) located at the leading edge of the plume indicates a steady increase of total DNT in ELN-1003B and ELN-1003C. The total DNT concentration in ELN-1003B increased from 0.051 µg/l during April 2017 to 0.32 µg/l during November 2018. The total DNT concentration in ELN-1003C increased from 0.0085 µg/l during April 2017 to 0.278 µg/l during November 2018.

4.5.3 Central Plume

The source of the Central Plume is suspected to be related to production waste water, which was discharged to open ditches in the rocket paste and rocket propellant areas. The soil in this area has been thoroughly investigated and remediated. No groundwater contamination source was clearly identified. The Central Plume shown in Figure 21 represents the area where groundwater concentrations exceed a NR 140 PAL for 2,6-DNT or total DNT. 2,6-DNT has been routinely detected in either monitoring wells or residential wells in the Central Plume. Because total DNT encompasses all six DNT isomers, total DNT was used to map the Central Plume boundary. The Central Plume boundary shown in Figure 21 is approximate and based on total DNT groundwater data collected during 2018 from both monitoring wells and residential wells. Total DNT has been detected at shallow depths in the sand and gravel aquifer. Table 13 summarizes the groundwater analytical results from the June 2018 monitoring well sampling event. Table 10 summarizes the groundwater analytical results from the August 2018 residential well sampling event. An isoconcentration map and cross section were prepared for total DNT. The isoconcentration map was prepared using all groundwater data collected during 2018. The isoconcentration cross section was prepared using groundwater data collected only during June and August 2018. Since there has been no historical NR 140 ES exceedances for chloroform, an isoconcentration map or cross section were not prepared.

During 2015, 2016, 2017, and 2018, 2,6-DNT, total DNT, and chloroform have been COPCs in the Central Plume. The Central Plume groundwater results from the June and August 2018 sampling events were evaluated for COPCs that exceeded a Chapter NR 140 PAL Groundwater Standard. Six monitoring wells and one residential well had NR 140 ES exceedances for both 2,6-DNT and total DNT during 2018. Three monitoring wells and two residential wells had NR 140 PAL exceedances for chloroform during 2018.

Table 13
Groundwater Analytical Results - June 2018
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Well	Well ID	Sample Level	Sample Depth (feet)	Sample Date	Dinitrotoluene, Total	Chloroform
DBG PLUME AREA WELLS						
ELN-1003B	468	B	91.5-96.5	Jun-18	**0.179**	NT
ELN-1003C	469	C	155.1-160.1	Jun-18	<0.008	NT
ELN-1003C (dup)	469	C	155.1-160.1	Jun-18	<0.008	NT
ELN-1504B	537	B	34.8-39.8	Jun-18	<0.008	NT
CENTRAL PLUME AREA WELLS						
NLN-1001A	331	A	96-111.5	Jun-18	**0.209**	NT
NLN-1001C	332	C	149-154.5	Jun-18	**0.203**	NT
NLN-8203A	258	A	105.5-115.5	Jun-18	<0.008	NT
NLN-8203B	259	B	125.5-127.5	Jun-18	<0.008	NT
NLN-8203B (dup)	259	B	125.5-127.5	Jun-18	<0.008	NT
NLN-8203C	260	C	136.5-138.5	Jun-18	<0.008	NT
NPM-8901	506	A	80-100	Jun-18	<0.008	NT
RIM-1003	491	A	99.3-114.3	Jun-18	<0.008	NT
RIM-1004	494	A	55.5-70.5	Jun-18	<0.008	NT
RIN-0701C	443	C	175-180	Jun-18	<0.008	NT
RIN-0702C	444	C	196-201	Jun-18	<0.008	NT
RIN-0703C	445	C	202-207	Jun-18	<0.008	NT
RIN-1002A	492	A	77.2-92.2	Jun-18	<0.008	NT
RIN-1002C	493	C	174.8-179.8	Jun-18	**0.062**	NT
RIN-1003A	495	A	75.5-90.5	Jun-18	<0.008	NT
RIN-1004B	498	B	141.7-146.7	Jun-18	**0.066**	NT
RIN-1004B (dup)	498	B	141.7-146.7	Jun-18	**0.066**	NT
RIN-1005A	496	A	45.5-60.5	Jun-18	<0.008	NT
RIN-1005C	497	C	142-147	Jun-18	**0.063**	NT
RIN-1501B	538	B	113.5-123.5	Jun-18	<0.008	NT
RIN-1501C	539	C	160.2-165.2	Jun-18	<0.008	NT
RIN-1501D	540	D	232.8-237.8	Jun-18	<0.008	NT
RIN-1502B	541	B	98.4-103.4	Jun-18	<0.008	NT
RIN-1502C	542	C	138.1-143.1	Jun-18	<0.008	NT
RIN-1502D	543	D	208.3-213.3	Jun-18	<0.008	NT
RPM-8901	507	A	104.8-124.3	Jun-18	<0.008	NT
S1111	751	A	78.75-99	Jun-18	<0.008	NT
SEN-0501A	580	A	17-32	Jun-18	<0.008	**0.17 (J)**
SEN-0501B	581	B	77-87	Jun-18	<0.008	**0.46**
SEN-0501D	582	D	180-190	Jun-18	<0.008	**0.91**
SEN-0502A	583	A	18-33	Jun-18	<0.008	<0.1
SEN-0502D	584	D	177-187	Jun-18	<0.008	**0.63**
SEN-0503A	585	A	40.5-55.5	Jun-18	<0.008	<0.1
SEN-0503B	586	B	100-110	Jun-18	**0.065**	<0.1
SEN-0503B (dup)	586	B	100-110	Jun-18	**0.064**	<0.1
SEN-0503D	587	D	203-213	Jun-18	<0.008	**1.2**
Chapter NR 140 Preventive Action Limit (PAL)					0.005	0.6
Chapter NR 140 Enforcement Standard (ES)					0.05	6

Notes:

The Sample Level references the typical well depth configuration
All results are expressed in micrograms per liter (µg/l)
Bold values are detected results
Wells listed with (dup) after the name were duplicate samples
Results for Dinitrotoluene, Total were analyzed by SW8270DSIM
J = Analytical result is between the Limit of Detection (LOD) and Limit of Quantitation (LOQ)

NE = Not Established
NT = Not Tested

4.5.3.1 *Total Dinitrotoluene*

The horizontal distribution of total DNT is illustrated in Figure 47. The green shaded area displays where total DNT was detected above the NR 140 PAL (0.005 µg/l). The blue shaded area displays where total DNT was detected above the NR 140 ES (0.05 µg/l). These same color designations are used in the total DNT cross section. The highest concentration of total DNT detected during June or August 2018 was 0.209 µg/l in NLN-1001A, which is located in northeast corner of the Central Plume (see Figure 21). Figure 47 shows that total DNT in the northern section of the Central Plume, near the source area, has been depleted. Prior to 2017, the Central Plume encompassed a larger area that stretched up to the source area (NPM-8901) and further west towards RIM-1003 and RPM-8901.

Figure 6 shows the orientation of the contaminant plume isoconcentration cross section for total DNT, which is illustrated in Figure 48. Figure 48 (G-G') illustrates the estimated vertical extent of total DNT, along the centerline of the Central Plume, as it migrates towards Gruber's Grove Bay. The total DNT concentrations are highest in the northern portion of the Central Plume and in wells screened within 60 feet below the water table. The total DNT plume extends from the north to the south with an average thickness of 100 feet in the northern and southern sections. The total DNT plume is thinner, 60 feet, within the middle section. Figure 48 indicates that the DNT plume is only present in the sand and gravel aquifer and has not migrated downward into the bedrock.

The WE-UK125 residential well is shown on Figure 48 (G-G'). The WE-UK125 residential well was chosen based on its location along the cross section. The WE-UK125 residential well is screened in the bedrock aquifer, but the majority of the residential wells in the Water's Edge Subdivision are screened in the sand and gravel aquifer. Many of the residential wells located in the Water's Edge Subdivision are screened at the same depth (60 feet below the water table) that the DNT plume occurs. The DNT plume encompasses a portion of the residential wells located in the Water's Edge Subdivision.

4.5.3.2 *Benzene*

The groundwater results from the June 2017 sampling event indicated that benzene was detected in SEN-0503B at a concentration of 10 µg/l, which is above the NR 140 ES of 5 µg/l. SEN-0503B is located in the Water's Edge Subdivision (see Figure 21). None of the other seven monitoring wells or 16 residential wells in the Water's Edge Subdivision had detections of benzene during 2017. Between 2005 and 2016, benzene had not been detected in SEN-0503B. Since June 2017, SEN-0503B has been sampled twice during 2017 and twice during 2018 with no benzene detections. Benzene was also not detected in any monitoring wells or residential wells that were sampled during 2018. The source of the benzene is unknown. However, there is no evidence to suggest that these past benzene detections are attributable to the Army. Therefore, benzene is not considered to be a COPC.

4.5.3.3 *Concentration Graphs*

To evaluate contaminant trend data for the Central Plume, concentration over time graphs were prepared for select monitoring wells within the plume. Concentration over time graphs are provided in Appendix E. The primary COPC in the Central Plume is total DNT; therefore, concentrations of total DNT were evaluated. Seventeen of the 23 wells selected showed stable to decreasing trends throughout the plume. The other six wells (NLN-1001A, NLN-1001C, RIN-1002C, RIN-1005C, RIN-1004B, and SEN-0503B) have shown increasing total DNT concentrations. The total DNT concentrations in these six wells increased from below the NR 140 ES during June 2017 to above the NR 140 ES during June 2018.

4.5.4 Nitrocellulose Production Area Plume

The source of the NC Area Plume is believed to be from various nitrocellulose production buildings in the northwest section of BAAP. The NC Area Plume shown in Figure 21 represents the area where groundwater concentrations exceed a NR 140 PAL or ES for 2,6-DNT or total DNT. 2,6-DNT has been routinely detected in monitoring wells in the NC Area Plume. Because total DNT encompasses all six DNT isomers, total DNT was used to map the NC Area Plume boundary. The NC Area Plume boundary shown in Figure 21 is approximate and based on total DNT groundwater data collected during 2018 from only monitoring wells. There are no residential wells located near the NC Area Plume. Total DNT has only been detected at shallow depths in the sand and gravel aquifer. Table 11 summarizes the groundwater analytical results from the September 2018 monitoring well sampling event. An isoconcentration map and cross section were prepared for total DNT. The isoconcentration map was prepared using all groundwater data collected during 2018. The isoconcentration cross section was prepared using groundwater data collected during September 2018.

During 2015, 2016, 2017, and 2018, 2,6-DNT and total DNT have been COPCs in the NC Area Plume. The NC Area Plume groundwater results from the September 2018 sampling event were evaluated for COPCs that exceeded a Chapter NR 140 PAL Groundwater Standard. Three monitoring wells had an NR 140 ES exceedance for both 2,6-DNT and total DNT. In addition, two monitoring wells had a NR 140 PAL exceedance for both 2,6-DNT and total DNT.

4.5.4.1 *Total Dinitrotoluene*

The horizontal distribution of total DNT is illustrated in Figure 49. The green shaded area displays where total DNT was detected above the NR 140 PAL (0.005 µg/l). The blue shaded area displays where total DNT was detected above the NR 140 ES (0.05 µg/l). This same color designation is used in the total DNT cross section. The highest concentration of total DNT detected during September 2018 was 0.22 µg/l in RIM-1002, which is located in the northern section of the NC Area Plume.

Figure 6 shows the orientation of the contaminant plume isoconcentration cross section for total DNT, which is illustrated in Figure 50. Figure 50 (H-H’) illustrates the estimated vertical extent of total DNT, along the centerline of the NC Area Plume, as it migrates south. The total DNT concentrations are highest in wells screened at the water table. The total DNT plume extends from the north to the south with an average thickness of 30 feet. Figure 50 indicates that DNT has not migrated vertically into the monitoring wells screened 80 feet below the water table.

4.5.4.2 *Concentration Graphs*

To evaluate contaminant trend data for the NC Area Plume, concentration over time graphs were prepared for select monitoring wells within the plume. Concentration over time graphs are provided in Appendix E. The primary COPC in the NC Area Plume is total DNT; therefore, concentrations of total DNT were evaluated. The total DNT concentration in RIM-1002 has increased from 0.045 µg/l during September 2016 to 0.22 µg/l during September 2018. Four of the five wells selected showed stable to decreasing trends throughout the plume. These four wells are located downgradient of RIM-1002. There are no residential wells located near the NC Area Plume.

4.6 Residential Well Replacement

4.6.1 Propellant Burning Ground Plume

The Army has replaced three residential wells due to impacts from chlorinated solvents. All three residential wells were located in the southern portion of the PBG Plume (see Figure 20). CTET was detected above the NR 140 ES in the Kirner (former Gruber-South) residential well during April 1990. The Kirner (former Gruber-South) replacement residential well, located on Hwy 78, was installed by the Army in 1990. CTET was detected above the NR 140 ES in the Mueller-J residential well during April 1990. The Mueller-J replacement residential well, located on Hwy 78, was installed by the Army in 1990. CTET and chloroform were detected above the NR 140 ES in the Lins-K residential well during April 1990. The Lins-K replacement residential well, located on County Road Z, was installed by the Army in 1996. Prior to well replacement, bottled water had been provided to the affected residences.

4.6.2 Deterrent Burning Ground Plume

The Army has replaced one residential well due to impacts from total DNT. The Purcell-D residential well is located at the southeastern extent of the DBG Plume (shown in Inset A on Figure 20). The Purcell-D residential well, located on Hwy 78, was replaced by the Army in July 2019. During April 2019, 3,4-DNT and total DNT were detected at 0.056 µg/l in the Purcell-D residential well. This total DNT concentration was above the NR 140 ES. The contaminated residential well was screened in the sand aquifer down to 112 feet deep. The replacement well was drilled into the lower bedrock aquifer, sealing off the upper sand aquifer with a grouted steel casing. Prior to well replacement, bottled water was being provided to the affected residence.

4.6.3 Central Plume

The Army has replaced three residential wells due to impacts from 2,6-DNT. All three residential wells were located in the southern portion of the Central Plume and in the Water's Edge Subdivision (see Inset B on Figure 20). During 2004, the 2,6-DNT and total DNT concentrations in two residential wells exceeded the NR 140 ES. In 2005, the Army replaced the WE-RM385 and WE-RR541 residential wells with WE-SQ017 and WE-SQ001, respectively. The original residential wells were screened in the sand and gravel aquifer down to 100 feet deep. The replacement residential wells were also screened in the sand and gravel aquifer but at 180 feet deep. During June 2018, the 2,6-DNT and total DNT concentrations in the WE-UK124 residential well exceeded the NR 140 ES. In 2018, the Army replaced the WE-UK124 residential well with WE-ZE512. The original residential well (WE-UK124) was screened in the sand and gravel aquifer down to 100 feet deep. The replacement well (WE-ZE512) was drilled into the lower bedrock aquifer, sealing off the upper sand aquifer with a grouted steel casing. Prior to well replacement, bottled water had been provided to the affected residences.

5.0 GROUNDWATER HUMAN HEALTH RISK ASSESSMENT

A groundwater human health risk assessment (HHRA) was performed to determine and document whether groundwater contamination originating from BAAP posed a potential current or hypothetical future risk to human health. Because the RI only pertains to groundwater contamination, the focus of the HHRA was only groundwater. Soil remedial actions conducted by the Army and property restrictions have minimized the potential exposure of soil contamination to human health based on the anticipated future land use at the former BAAP.

Source areas and associated contaminant plumes for BAAP are shown on Figure 1. This HHRA provides risk managers information for determining whether unacceptable human health risks (cancer and non-cancer health hazards) might be caused by exposure to contaminants in the groundwater such that additional evaluation or action is necessary. The HHRA addresses human exposure pathways related to groundwater including the potential for vapor intrusion and for potable use or other domestic purposes. The Army will use the HHRA results in determining the scope of any response action(s) undertaken to address contaminants in the groundwater caused by past Army activities at BAAP.

5.1 Risk Assessment Overview

A HHRA is required to be completed as part of a remedial investigation/feasibility study under CERCLA to evaluate the potential human health risks associated with chemical exposure to environmental media (e.g., groundwater). This HHRA was conducted using standard USEPA risk assessment guidance, exposure assumptions, and toxicity factors. The USEPA HHRA process uses conservative assumptions about exposure to chemicals and their toxicity so that risks reported within this HHRA will not be underestimated. In all circumstances, priority is given to evaluating the potential human health risk regardless of the impact.

Risk assessments generally make risk estimates for defined groups or populations. The term receptor is often used to designate people who may be exposed to an environmental hazard and to whom the HHRA would be directed. Identification of receptor location and pathways by which they might be exposed is an integral part of any HHRA.

The focus of this HHRA is related to groundwater and the risk it may pose to humans. The HHRA does not address any potential risks associated with the direct exposure to contaminated soil or ecological receptors. For some media such as soil, the potential for exposure does not currently exist.

A screening level groundwater risk evaluation was conducted for each of the four plumes using USEPA human health risk assessment methods (USEPA 1989, 1991). The screening risk evaluation was conducted in two steps. First, site chemical concentrations were compared to health-based screening levels to identify chemicals of potential concern (COPCs). Second, risk estimates were calculated for COPCs that exceeded screening levels. The risk estimates were then compared to risk management criteria to put the magnitude of the risks into perspective.

The following four sections provide plume-specific screening level groundwater risk evaluations for each of the four plume areas. The risks for all four plume areas are assessed for the on-site portion of the plume and the off-site portion of the plume.

5.2 Identification of Exposure Pathways

As defined in the Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A (USEPA 1989), an exposure pathway is composed of the following elements:

- A source and mechanism of chemical release to the environment
- An environment transportation medium (e.g. groundwater) for the released chemical and/or mechanism to transfer the chemical from one medium to another
- A point of potential contact by humans with contaminated medium
- A route of exposure (i.e., ingestion, inhalation or dermal)

The exposure routes associated with domestic use of water include ingestion, inhalation, and dermal exposure.

- **Ingestion** – Potential chemical exposure because of groundwater use for potable purposes for drinking water and preparing food.
- **Inhalation** – Potential exposure due to groundwater use for domestic purposes resulting in inhalation of the contaminants during activities such as bathing, food preparation, and dishwashing.
- **Dermal** – Potential use of groundwater resulting in chemical absorption through skin during activities such as washing hands and bathing.

5.3 Screening Level Groundwater Risk Evaluation

A Screening Level Groundwater Risk Evaluation (Draft) was conducted by Exponent, see Appendix G. The objectives of the risk evaluation were to estimate current and hypothetical future risks using groundwater quality data from existing residential and off-site monitoring wells (current risk) and on-site groundwater monitoring wells (hypothetical future risk). Exponent’s screening level groundwater risk evaluation was conducted using standard USEPA risk assessment methods. The conservative calculations for this risk screening overestimate the actual risk. The maximum concentrations of analytes associated with each plume for current (residential wells and off-site monitoring wells) and hypothetical future (on-site monitoring wells) scenarios were used to estimate the risks.

5.3.1 Data Collection and Evaluation

Groundwater quality data for residential wells and off-site monitoring wells monitored by the Army from the past four years (2015, 2016, 2017, and 2018) were used to evaluate current groundwater exposure and risk. To evaluate hypothetical future groundwater exposure and risk, on-site monitoring well data collected over the past four years (same period) were used. The past four years of groundwater quality data was selected to best represent current groundwater quality conditions.

The maximum concentrations of contaminants in the wells associated with each plume were used to estimate the risks. In other words, the highest concentrations of each chemical in each plume (i.e., many wells) were evaluated as if they had occurred in any one well. Consequently, the risks represented should be viewed as upper bound estimates of potential groundwater risks within a specific plume area.

5.3.2 Chemicals of Potential Concern Selection Process

The first step in the screening level groundwater risk evaluation is to select those chemicals that exceed screening levels for groundwater. Both USEPA’s tapwater RSLs and Wisconsin NR 140 Groundwater Standards (ES and PAL) were used to screen chemicals. A comprehensive summary of the groundwater screening levels is provided in the Screening Level Groundwater Risk Evaluation (Draft) included in Appendix G. The determination of which groundwater standard was used to screen each chemical is further defined in Table 1 of Appendix G. A Total Hazard Quotient (THQ) Table THQ = 0.1 was used for screening as it is recommended by the USEPA for sites with multiple chemicals. Chemicals or analytes that exceeded the lowest available groundwater screening value are referred to as the COPCs. The maximum concentration of the chemicals detected in each plume were compared to the lowest of the groundwater screening values. These COPCs were retained for further risk evaluation and calculations.

5.3.3 Exposure Assessment and Assumption

USEPA’s tapwater RSLs are risk-based concentrations developed using specific generic exposure assumptions that represent reasonable maximum exposure (RME) to groundwater. Exposure to chemicals in groundwater are incorporated into the tapwater RSLs for both ingestion and dermal contact with the water, as well as inhalation of the portion of the chemicals in groundwater that are volatilized from the water as it is used (e.g., for bathing). Tapwater RSLs based on non-cancer effects are also developed separately for adults and children, and then the lower of the two RSLs is selected for evaluating risks to people. RSLs based on cancer incorporate exposure during both childhood and adulthood. For this reason, the tapwater RSLs are considered a conservative risk-based benchmark on which to estimate risk associated with groundwater chemical exposure.

The groundwater risk evaluation was performed using tapwater RSLs that incorporate RME factors that characterize how adults and children are assumed to be exposed to groundwater. Some of the key exposure assumptions used to develop the tapwater RSLs are listed below.

USEPA Tapwater Regional Screening Levels (RSLs) Exposure Assumptions

Assumption	Adult	Child
Exposure Duration (cancer effects)	20 years	6 years
Exposure Duration (non-cancer effects)	26 years	6 years
Exposure Frequency	350 days/year	350 days/year
Water Ingestion Rate	2.5 liters/day	0.78 liter/day
Hours/day Air Inhaled	24 hours/day	24 hours/day
Body Weight	80 kilograms	15 kilograms
Averaging Time (cancer effects) [averaging of exposure is integrated over a person's lifetime]	25,550 days (i.e., 365 days/year x 70 years)	
Averaging Time (non-cancer effects) [averaging occurs over the adult or child's exposure duration]	9,490 days (i.e., 365 days/year x 26 years)	2,190 days (i.e., 365 days/year x 6 years)

5.3.3.1 *Cancer Risk Characterization*

Cancer risks were estimated for each COPC related to each plume. The cancer risk is the probability that an individual will develop cancer due to chemical exposure in the groundwater over their lifetime. This probability of contracting cancer due to chemical exposure represents the incremental increase in the probability of developing cancer during one's lifetime above and beyond the background probability of developing cancer. For example, $1x10^{-6}$ represents a one in a million chance of contracting cancer. This cancer risk is in addition to the general background level risk of contracting cancer of any kind during one's lifetime unrelated to groundwater chemical exposure. Based on the USEPA's National Contingency Plan, cumulative carcinogenic risk below $1x10^{-6}$ are generally considered to represent a negligible risk, cumulative risks between $1x10^{-6}$ and $1x10^{-4}$ are within a range considered acceptable under most conditions and cumulative cancer risk above $1x10^{-4}$ indicate unacceptable levels of risk where potential action or further evaluation needs to be considered.

In off-site areas, where the Army does not have control over the use of the groundwater as a drinking water source, a cumulative cancer risk greater than $1x10^{-6}$ is cause for potential action or additional evaluation. For areas within the BAAP property, where the Army has control over the use of groundwater as a drinking source, a cumulative cancer risk greater than $1x10^{-4}$ is cause for potential action or additional evaluation.

5.3.3.2 *Non-Cancer Risk Characterization*

Non-cancer risks were estimated for each COPC related to each plume. For non-cancer effects, the likelihood that a receptor will develop an adverse effect other than cancer (e.g., kidney disease) is estimated by comparing the predicted level of exposure for a chemical with the highest level of exposure that is considered protective. The chemical-specific non-cancer risk is represented by a hazard quotient (HQ) value, which is derived by comparing the groundwater chemical concentrations to the chemical-specific tapwater RSLs. If an HQ value is less than or equal to one, then adverse health effects associated with exposure to that chemical in the groundwater are unlikely to occur even among sensitive individuals (e.g., children). An HQ greater than one indicates that there is the potential for a health effect and that additional analysis is necessary. The sum of all non-cancer risks (i.e., each HQ for each COPC) within an area or plume is referred to as the hazard index (HI). An HI greater than one indicates a level of exposure that needs to be evaluated further to determine if a health concern exists.

5.3.3.3 *Risk Calculations*

The default tapwater RSL values provided in the USEPA's RSL Resident Tapwater Generic Table (November 2018) were used to calculate the risks. Groundwater risk estimates were calculated for each plume using a simple scaling method developed by the USEPA. For each COPC, the calculations described below were used to estimate potential cancer and non-cancer risks.

Cancer Risk: (Groundwater Concentration x Target Cancer Risk)/RSL for Tapwater
Non-cancer HQ: (Groundwater Concentration x Target Hazard Quotient)/RSL for Tapwater

The target cancer risk that the RSL is based upon is $1x10^{-6}$ and the target hazard quotient is 0.1 as recommended by USEPA since multiple contaminants are present at the site.

5.3.3.4 *Risk Evaluation Results*

A comprehensive summary of the groundwater risk calculations is provided in the Screening Level Groundwater Risk Evaluation (Draft) included in Appendix G. The total DNT concentration represents the sum of all isomers of DNT detected in the water sample. The risk associated with DNT was evaluated for both total DNT and individual isomers. The higher of the two risk estimates (i.e., based on total or the sum of the individual isomers) were used in calculating the total risk for each plume area.

5.4 Propellant Burning Ground Plume

5.4.1 Characterization of Exposure Settings

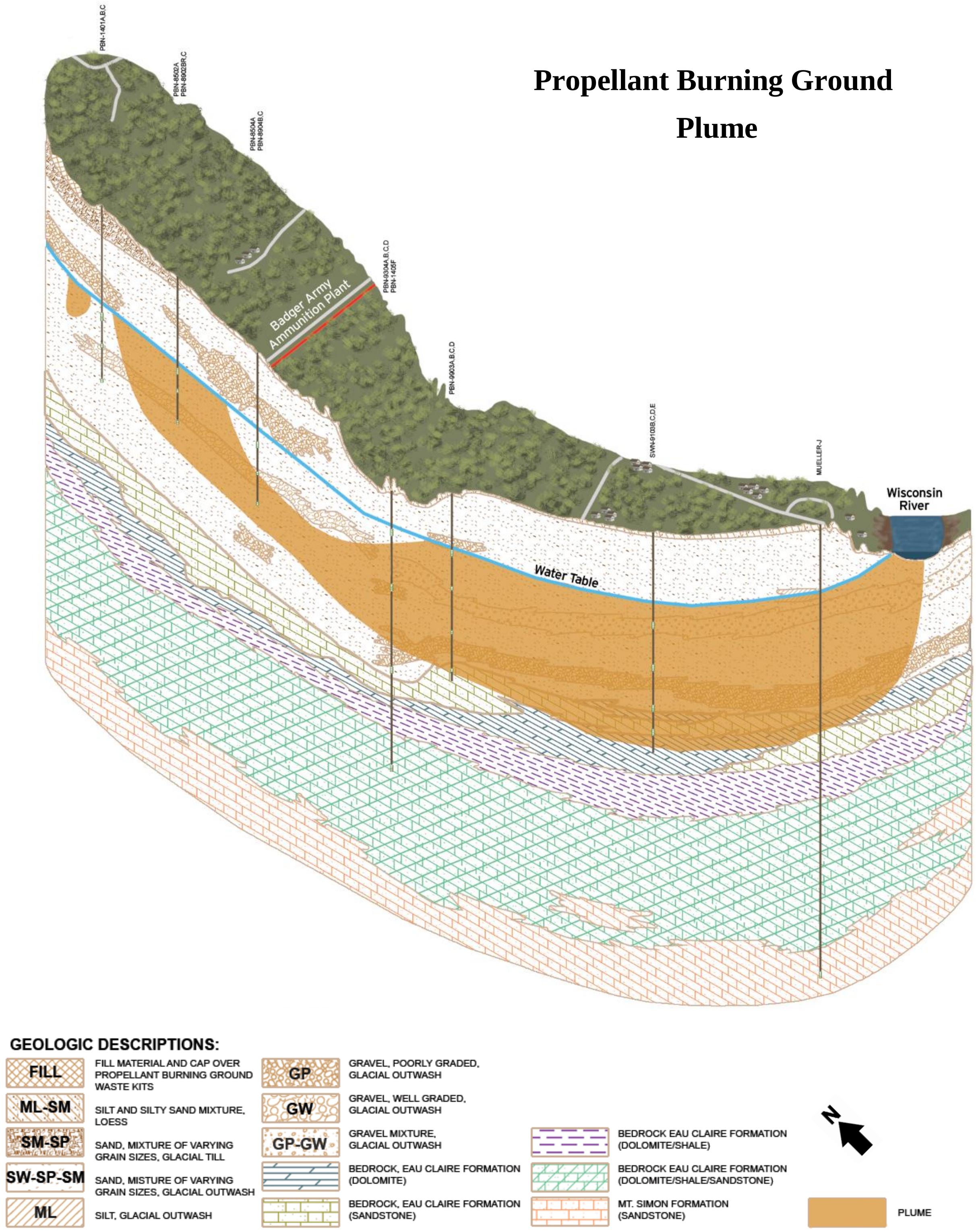
The sources of the PBG Plume are in the southwestern portion of BAAP, see Figure 1. The PBG sources are comprised of the PBG Waste Pits, 1949 Pit, Racetrack Area, and Landfill #1. The Army has covered each of the PBG source areas with either an engineered cap or soil cover to inhibit the movement of contaminants in the soil to the groundwater. The PBG Waste Pits and 1949 Pit became active sometime between 1942 and 1949 and were last used in 1983. A clay and geomembrane barrier cap was installed over the 1949 Pit in 1998 and the PBG Waste Pits in 2008. The Racetrack Area consisted of a series of burning pads, plates and pits that were used from 1949 to 1994. In 1995, three-fourths of the Racetrack Area was covered with soil to prevent contact with residual lead in the soil. Contaminated soil was removed from the remaining portion of the Racetrack Area in 1997. Landfill #1 is a closed demolition debris disposal facility located east of the PBG Waste Pits that was used between 1942 and 1959. A composite cap (two feet of clay and geomembrane barrier) was installed over Landfill #1 in 1997. Section 3.1 provides additional details on remediation activities of the source areas.

DNT and volatile organic solvents (e.g. carbon tetrachloride, chloroform, and trichloroethene) are known to have been disposed of at the PBG through open burning and burial during production periods. Contamination from these disposal and open burning activities migrated through the soil and into the groundwater. Groundwater beneath the PBG source areas is approximately 105 feet deep. The contaminated groundwater in the PBG Plume has migrated south to southeast (off-site) and then discharges into the Wisconsin River, see Figure 1. As the PBG Plume migrates away from the source area, it sinks lower into the sand aquifer. The off-site portion of the PBG Plume sinks deeper into the sand aquifer. Groundwater in the PBG Plume travels approximately 306 feet per year. Contaminants in the PBG Plume are expected to travel at the same speed as groundwater. Groundwater beneath the off-site residential areas is approximately 80 feet deep. Contaminated groundwater (above the NR 140 ES) in the off-site portion of the PBG Plume has been identified within the sand aquifer at depths between 80 and 210 feet. The sand aquifer extends down to 210 feet. The three residential wells located within the areal extent of the PBG Plume range in depth from 240 to 534 feet and are screened in the bedrock. These bedrock residential wells draw their groundwater from beneath the contaminated portion of the PBG Plume. The residential wells located outside the areal extent of the PBG Plume range in depth from 122 to 310 feet and average 250 feet deep. Over half the residential wells located outside of the PBG Plume are screened in the bedrock. Both DNT and VOCs have been detected in monitoring wells located in the PBG Plume. Sections 4.4 and 4.5 provide additional details on groundwater properties and groundwater contaminants.

The Army has performed various soil remediation activities at the PBG source areas (bioremediation, soil excavation, and soil vapor extraction). The Army performed groundwater remediation using a groundwater pump and treat system from 1990 to 2015 at the source areas and downgradient of the source areas. The pump and treat system influenced the groundwater flow in the PBG Plume by drawing groundwater downward within the area of pumping influence. The pump and treat system also reduced the off-site migration of the PBG Plume when it was operational. Since pumping was stopped in 2015, the portion of the PBG Plume near the BAAP boundary has shifted eastward toward residential wells. Over the past 24 months, the groundwater table beneath the PBG source areas has risen six feet. This rise in groundwater has resulted in an increase of DNT concentrations directly downgradient (south) of the source areas. Sections 4.4 and 4.5 provide additional details on groundwater properties and groundwater contaminants.

A graphical depiction of the PBG Plume in relationship to the local geology, monitoring wells, residential wells, site features, and groundwater plume boundaries is shown on the subsequent page. The groundwater flow direction is from the upper left (north) towards the right (southeast). The groundwater contaminant plume is shown below the water table and migrates into the Wisconsin River. The groundwater contaminant plume is shown to have traveled past the BAAP property and beneath a residential area.

Propellant Burning Ground Plume



A groundwater conceptual site model (CSM) for the PBG Plume is provided in Appendix H. The CSM shows the relationship between the sources of contamination, how the contamination is transported, type of media exposure, the route of exposure, and who may be exposed. The contaminants infiltrated through the soil (leaching) below the waste disposal areas until they reached the groundwater. The contaminants within the groundwater have been transported with the directional flow of groundwater into the Wisconsin River to the south-southeast. Contaminated groundwater has the potential to reach residential wells which may be used for domestic or potable purposes. Residential well users can be exposed to contaminated groundwater through ingestion or drinking of water, inhalation of vapor during bathing or dishwashing, and dermal contact while bathing.

The exposure routes associated with domestic use of water, as shown on the CSM (Appendix H), include ingestion, inhalation, and dermal exposure. The off-site residential use pathways are potentially complete under current land use conditions and warrant further evaluation. The on-site hypothetical future residential use pathways are incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future on-site groundwater usage.

The exposure route associated with vapor intrusion, as shown on the CSM, includes only inhalation of indoor vapors. Both the off-site and on-site residential use vapor intrusion exposure pathways are incomplete or considered insignificant based on past vapor intrusion investigations and so no further evaluation is warranted. Section 5.4.2 discusses the potential vapor intrusion exposure into buildings.

5.4.2 Exposure Quantification – Vapor Intrusion Pathway Analysis

An evaluation was conducted to determine whether vapors from PBG Plume of groundwater contamination pose a current or hypothetical future risk to human health. Vapor intrusion occurs when there is a migration of vapor-forming chemicals from a subsurface source (i.e., contaminated groundwater) into an overlying building. The exposure route evaluated was the inhalation of contaminants from indoor air.

The subsurface contaminants that have the greatest potential to pose a health concern via vapor intrusion, based upon their volatility, and potential hazards is provided in the USEPA's OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air [OSWER Publication 9200.2-154, June 2015]. The USEPA's OSWER Technical Guide specifies that a chemical generally is "volatile" if: 1) vapor pressure is greater than 1 millimeter of mercury (mm Hg), or 2) Henry's law constant (ratio of a chemical's vapor pressure in air to its solubility in water) is greater than 10^{-5} atmosphere-meter cubed per mole (atm m^3 mol^{-1}). Common vapor-forming chemicals are VOCs, such as carbon tetrachloride, gasoline compounds, and trichloroethene. Other compounds such as the six DNT isomers (2,3-, 2,4-, 2,5-, 2,6-, 3,4-, and 3,5-) are not as volatile and are semi-volatile organic compounds (SVOCs).

The USEPA's OSWER specifications were compared to the chemical properties of the six DNT isomers. The vapor pressures for all six DNT isomers are well below 1 mm Hg. Also, Henry's law constants for all DNT isomers are well below 10^{-5} atm m^3 mol^{-1}. Therefore DNT is not likely to volatilize from the groundwater into soil and therefore does not pose a vapor pathway risk. Based on this information, DNT does not contribute to vapor intrusion risk related to human health. In addition to DNT, the PBG Plume contains VOCs that could be considered a vapor intrusion risk; therefore, further evaluation of VOC vapor intrusion was conducted.

During 2012, the Army conducted two vapor intrusion pathway analysis investigations associated with the PBG Plume. Copies of these investigation reports are enclosed in Appendix F. The goal of the vapor intrusion pathway analysis was to evaluate if VOCs in the groundwater could vertically migrate through the subsurface and into buildings. Vapor sampling was conducted at eight locations south of BAAP, within/near the PBG Plume. The off-site locations were also positioned near current residential properties. Vapor samples were collected using the post-run tubing vapor sampling technique in accordance with WDNR vapor intrusion guidance, Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin, PUB-RR-800, December 2010. The vapor samples were collected through soil borings drilled approximately 40 feet below ground surface. The groundwater depth for the sampling locations was approximately 80 feet below ground surface. The vapor samples were laboratory analyzed for chloroform, carbon tetrachloride, and trichloroethene by the Wisconsin State Laboratory of Hygiene. Based on groundwater samples collected from monitoring wells located within the off-site portion of the PBG Plume, only chloroform, carbon tetrachloride, and trichloroethene were detected. Evaluation or laboratory analysis of other VOCs was not warranted during the 2012 vapor intrusion pathway analysis investigations.

Analytical results of soil gas samples collected off-site did not exceed the 2011 WDNR Vapor Regional Screening Levels (RSLs) for Deep Soil Gas. The 2012 vapor intrusion pathway analysis reports concluded that the PBG Plume does not present a risk to human health via vapor intrusion off-site of BAAP. Because the vapor sample analysis results for chloroform, carbon tetrachloride, and trichloroethene did not exceed the RSLs, additional investigation (e.g., sub-slab, indoor air) of the vapor pathway was not warranted.

Based on the vapor intrusion pathway analysis investigations conducted during 2012, inhalation exposure due to soil gas vapor intrusion from the PBG Plume does not pose a current or potential future risk to area residents.

5.4.3 Exposure Quantification – Groundwater Pathway Analysis

5.4.3.1 *Current and Potential Future Uses of Groundwater*

Groundwater located in the PBG Plume within the boundary of BAAP is not used for human consumption. The land that was transferred from the Army to other property owners includes a deed restriction on the use of groundwater and so restricts the potential exposure to groundwater within the boundary of BAAP. These groundwater access restrictions state that the property owner “shall not access or use groundwater underlying the property for any purpose without the prior written approval of the Army and the WDNR”.

Residential wells located outside of BAAP use groundwater for potable water and domestic purposes. The potential future use of groundwater adjacent to and downgradient of BAAP is expected to be for potable water and domestic purposes.

Residential well users can be exposed to contaminated groundwater through ingestion or drinking of water, inhalation of vapor during showering or dishwashing, and dermal contact while bathing. Groundwater contaminants from BAAP impacted three residential wells located in the PBG Plume. The Army replaced these three residential wells due to impacts from VOCs (carbon tetrachloride and/or chloroform). Section 4.6 provides additional details on the residential well replacements conducted by the Army.

5.4.4 Risk Evaluation Summary

5.4.4.1 *Hypothetical Future On-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to hypothetical future on-site risks associated with the PBG Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > $1x10^{-4}$ or HI > 1).

Summary of Hypothetical Future Risk – Propellant Burning Ground Plume (On-Site Monitoring Well Data)

Location	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
On-Site (Hypothetical Future Risk)	**$6x10^{-3}$**	**53**	2,6-DNT Ethyl Ether Trichloroethene

Risks calculated using the simple scaling method for a hypothetical future residential scenario, along with the maximum observed concentration of each COPC, yielded cumulative cancer risk estimates above the risk management criterion for the on-site portion of the PBG Plume. The cumulative cancer risk ($6x10^{-3}$) for the PBG Plume was above the risk management criterion ($1x10^{-4}$). The contaminant of concern that contributed to the cumulative cancer risk for the PBG Plume was 2,6-DNT.

The calculated non-cancer HI of 53 was above the risk management criterion (HI > 1) in the on-site portion of the PBG Plume. The contaminants of concern that contributed to the HI > 1 in the PBG Plume were 2,6-DNT, ethyl ether and trichloroethene.

Based on the maximum risk scenario, the on-site portion of the PBG Plume represents an area that, if groundwater migrated off-site would be associated with cumulative groundwater risks above the risk management criteria (cumulative cancer risk above $1x10^{-4}$ and non-cancer HI above 1). The on-site portion of the PBG Plume has the potential to migrate off-site, thus impacting downgradient residential wells. Further evaluation of the risks is provided in Section 8.0 Remedial Alternative Development Process.

5.4.4.2 *Current Off-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to current off-site groundwater risks associated with the PBG Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > $1x10^{-6}$ or HI > 1).

Summary of Current Risk – Propellant Burning Ground Plume
(Residential Well and Off-Site Monitoring Well Data)

Location	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
Off-Site (Current Risk)	**$1x10^{-4}$**	**5**	2,6-DNT Carbon Tetrachloride Chloroform Trichloroethene

Risks calculated using the simple scaling method for a current residential scenario, along with the maximum observed concentration of COPC, yielded cumulative cancer risk estimates above the risk management criterion for the off-site portion of the PBG Plume. The cumulative cancer risk ($1x10^{-4}$) for the PBG Plume was above the risk management criterion ($1x10^{-6}$). The contaminants of concern that contributed to the cumulative cancer risk for the PBG Plume were 2,6-DNT, carbon tetrachloride, chloroform, and trichloroethene.

The calculated non-cancer HI of 5 was above the risk management criterion (HI > 1) in the off-site portion of the PBG Plume. The contaminant of concern that contributed to the HI > 1 in the PBG Plume was trichloroethene.

Based on the maximum risk scenario, the off-site portion of the PBG Plume is associated with cumulative groundwater risks above the risk management criteria (cumulative cancer risk above $1x10^{-6}$ and non-cancer HI above 1). Further evaluation of the risks is provided in Section 8.0 Remedial Alternative Development Process.

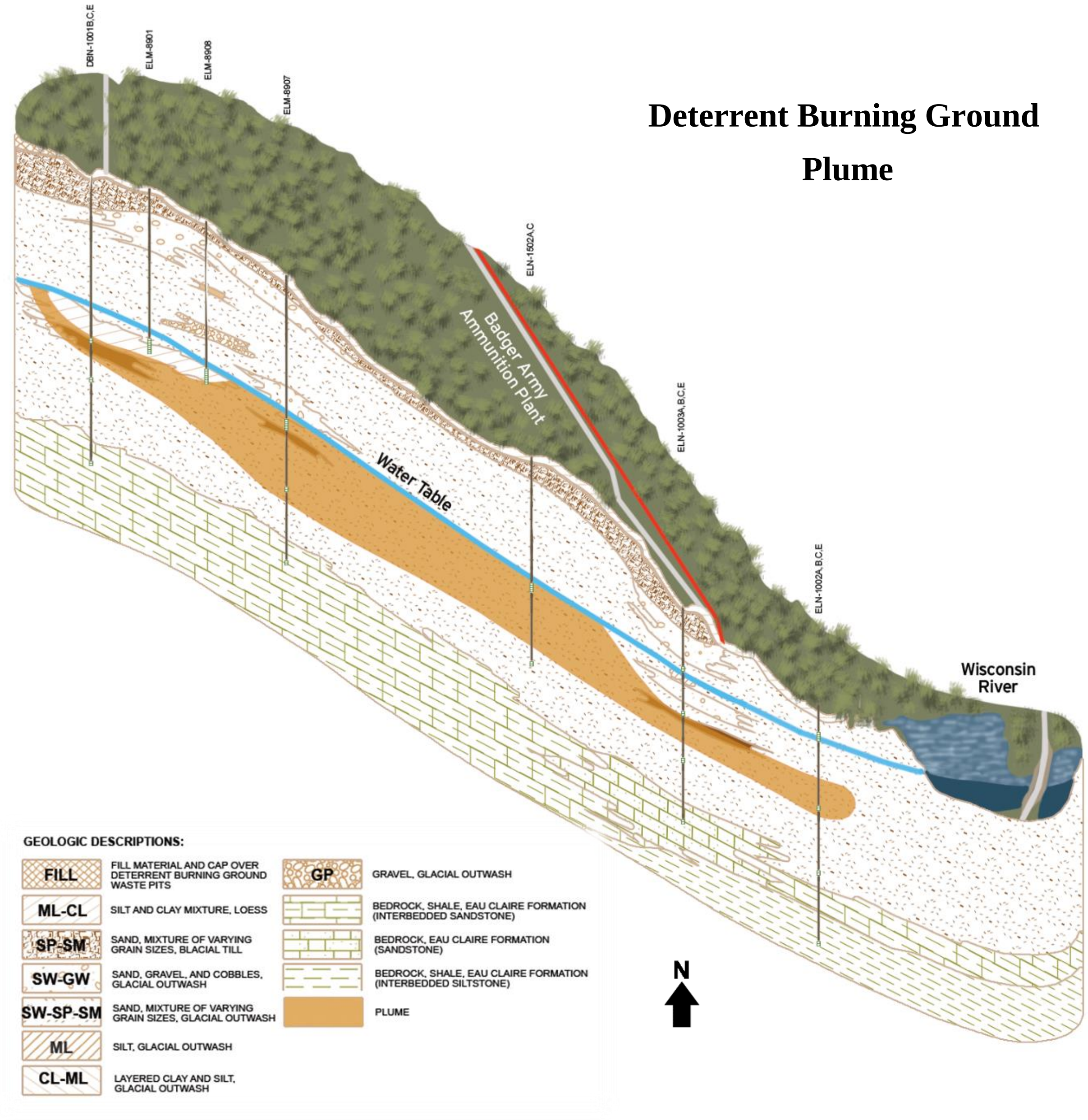
5.5 Deterrent Burning Ground Plume

5.5.1 Characterization of Exposure Settings

The sources of the DBG Plume are in the northeastern portion of BAAP, see Figure 1. The DBG sources are comprised of the DBG (waste pits), Landfill #3, and Landfill #5. From the 1940s to the 1970s, liquid deterrent, comprised mostly of DNT, is known to have been burned and disposed of at the DBG. During the same period, coal ash from the power plant, construction debris, trash, and burned garbage were disposed of in Landfill #3. In 2003, a geosynthetic clay and geomembrane barrier were installed above the DBG and Landfill #3 as one contiguous cap. In addition, an enhanced biodegradation system was operated at this site from 2003 to 2008. From 1979 to 1988, solid waste including office and laboratory waste, demolition debris, and coal ash were disposed of in Landfill #5. In 1988, Landfill #5 was closed with a clay barrier cap. The Army has covered each of the DBG source areas with an engineered cap to inhibit the movement of contaminants in the soil to the groundwater. The Army has performed various soil remediation activities at the DBG (bioremediation and soil excavation). The Army has not performed any groundwater remediation in the DBG Plume. Section 3.2 provides additional details on remediation activities of the source areas.

Contamination from these disposal and open burning activities migrated through the soil and into the groundwater. Groundwater beneath the DBG source areas is approximately 130 feet deep. The contaminated groundwater in the DBG Plume has migrated southeast (off-site) towards the Wisconsin River (Weigand’s Bay), see Figure 1. As the DBG Plume migrates away from the source area, it sinks lower into the sand aquifer. The off-site portion of the DBG Plume sinks below the groundwater surface and deeper into the sand aquifer. Groundwater in the DBG Plume travels approximately 109 feet per year. Contaminants in the DBG Plume are expected to travel at the same speed as groundwater. Groundwater beneath the off-site residential areas is approximately 25 feet deep. Contaminated groundwater (above the NR 140 ES) in the off-site portion of the DBG Plume has been identified within the sand aquifer at depths between 50 and 180 feet. The sand aquifer extends down to 216 feet. The residential wells located outside the areal extent of the DBG Plume range in depth from 20 to 260 feet and average 100 feet deep. Most of the residential wells located outside the areal extent of the DBG Plume are screened in the sand. Total DNT has been detected in monitoring wells located both on-site and off-site in the DBG Plume. Over the past three years, the total DNT concentrations in off-site monitoring wells (ELN-1003B and ELN-1003C) have been increasing. These increases indicate that the DBG Plume is migrating off-site (southeast) towards residential wells located near Weigand's Bay. During April 2019, total DNT was detected in a residential well above the NR 140 ES. During July 2019, the Army replaced one residential well associated with the DBG Plume that was impacted by total DNT. Sections 4.4 and 4.5 provide additional details on groundwater properties and groundwater contaminants. Section 4.6 provides additional details on the residential well replacement conducted by the Army.

A graphical depiction of the DBG Plume in relationship to the local geology, monitoring wells, site features, and groundwater plume boundaries is shown on the subsequent page. The groundwater contaminant plume is shown below the water table and migrating towards the Wisconsin River. The groundwater contaminant plume is shown to have traveled past the BAAP property.



A groundwater CSM for the DBG Plume is provided in Appendix H. The CSM shows the relationship between the sources of contamination, how the contamination is transported, type of media exposure, the route of exposure, and who may be exposed. The contaminants infiltrated through the soil (leaching) below the waste disposal areas until they reached the groundwater. The contaminants within the groundwater have been transported with the directional flow of groundwater towards the Wisconsin River (Weigand’s Bay) to the southeast. Contaminated groundwater has the potential to reach residential wells which may be used for domestic or potable purposes. Residential well users can be exposed to contaminated groundwater through ingestion or drinking of water, inhalation of vapor during bathing or dishwashing, and dermal contact while bathing.

The exposure routes associated with domestic use of water, as shown on the CSM (Appendix H), include ingestion, inhalation, and dermal exposure. The off-site residential use pathways are potentially complete under current land use conditions and warrant further evaluation. The on-site hypothetical future residential use pathways are incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future on-site groundwater usage.

The exposure route associated with vapor intrusion, as shown on the CSM, includes only inhalation of indoor vapors. Both the off-site and on-site residential use vapor intrusion exposure pathways are incomplete or considered insignificant based on past vapor intrusion investigations and so no further evaluation is warranted. Section 5.5.2 discusses the potential vapor intrusion exposure into buildings.

5.5.2 Exposure Quantification – Vapor Intrusion Pathway Analysis

An evaluation was conducted to determine whether vapors from the DBG Plume of groundwater contamination pose a current or hypothetical future risk to human health. Vapor intrusion occurs when there is a migration of vapor-forming chemicals from a subsurface source (i.e., contaminated groundwater) into an overlying building. The exposure route evaluated was the inhalation of contaminants from indoor air.

The Army did not conduct a vapor intrusion pathway analysis investigation specifically in the DBG Plume. Section 5.4.2 discussed the 2012 vapor intrusion pathway analysis investigations conducted by the Army in the PBG Plume. The PBG Plume represents the worst-case scenario for volatile-forming chemicals present in the groundwater and thus provides a conservative representation of vapor conditions associated with the DBG Plume. The 2012 vapor intrusion pathway analysis reports concluded that VOCs in the PBG Plume do not present a risk to human health via vapor intrusion.

Based on the information in Section 5.4.2, inhalation exposure due to soil gas vapor intrusion from the DBG Plume does not pose a current or potential future risk to area residents.

5.5.3 Exposure Quantification - Groundwater Pathway Analysis

5.5.3.1 *Current and Potential Future Uses of Groundwater*

Groundwater located in the DBG Plume within the boundary of BAAP is not used for human consumption. The land that was transferred from the Army to other property owners includes a deed restriction on the use of groundwater and so restricts the potential exposure to groundwater within the boundary of BAAP. These groundwater access restrictions state that the property owner “shall not access or use groundwater underlying the property for any purpose without the prior written approval of the Army and the WDNR”.

Currently, residential wells located outside of BAAP use groundwater for potable water and domestic purposes. The potential future use of groundwater adjacent to and downgradient of BAAP is expected to be for potable water and domestic purposes.

Residential well users can be exposed to contaminated groundwater through ingestion or drinking of water, inhalation of vapor during showering or dishwashing, and dermal contact while bathing. Groundwater contaminants from BAAP have resulted in groundwater impacts in one residential well located in the DBG Plume. The Army replaced one residential well associated with the DBG Plume that has been impacted by total DNT. Section 4.6 provides additional details on the residential well replacement conducted by the Army.

5.5.4 Risk Assessment Summary

5.5.4.1 *Hypothetical Future On-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to hypothetical future on-site risks associated with the DBG Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > 1×10^{-4} or HI > 1).

Summary of Hypothetical Future Risks – Deterrent Burning Ground Plume (On-Site Monitoring Well Data)

Location	**Cumulative Cancer Risk**	**Non-cancer Hazard Index (HI)**	**Contaminants of Concern**
On-Site (Hypothetical Future Risk)	9×10^{-5}	**3**	1,1,2-Trichloroethane

Risks calculated using the simple scaling method for a hypothetical future residential scenario, along with the maximum observed concentration of each COPC, yielded cumulative cancer risk estimates below the risk management criterion (1×10^{-4}) for the on-site portion of the DBG Plume.

The calculated non-cancer HI of 3 was above the risk management criterion (HI > 1) in the on-site portion of the DBG Plume. The contaminant of concern that contributed to the HI > 1 in the DBG Plume was 1,1,2-trichloroethane.

Based on the maximum risk scenario, the on-site portion of the DBG Plume represents an area that, if future residential development occurred, would be associated with cumulative non-cancer risk above the risk management criterion (HI above 1). The on-site portion of the DBG Plume has the potential to migrate off-site, thus impacting downgradient residential wells. Further evaluation of the risks is provided in Section 8.0 Remedial Alternative Development Process.

5.5.4.2 *Current Off-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to current off-site groundwater risks associated with the DBG Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > $1x10^{-6}$ or HI > 1).

Summary of Current Risk – Deterrent Burning Ground Plume
(Residential Well and Off-Site Monitoring Well Data)

Location	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
Off-Site (Current Risk)	**$2x10^{-5}$**	**2**	Chloroform Total DNT Trichloroethene

Risks calculated using the simple scaling method for a current residential scenario, along with the maximum observed concentration of COPC, yielded cumulative cancer risk estimates above the risk management criterion for the off-site portion of the DBG Plume. The cumulative cancer risk ($2x10^{-5}$) for the DBG Plume area was above the risk management criterion ($1x10^{-6}$). The contaminants of concern that contributed to the cumulative cancer risk for the DBG Plume were chloroform, total DNT, and trichloroethene.

The calculated non-cancer HI of 2 was above the risk management criterion (HI > 1) in the off-site portion of the DBG Plume. The contaminant of concern that contributed to the HI > 1 in the DBG Plume was trichloroethene.

Based on the maximum risk scenario, the off-site portion of the DBG Plume represents an area that would be associated with cumulative groundwater risks above the risk management criteria (cumulative cancer risk above $1x10^{-6}$ and non-cancer HI above 1). Further evaluation of the risks is provided in Section 8.0 Remedial Alternative Development Process.

5.6 Central Plume

5.6.1 Characterization of Exposure Settings

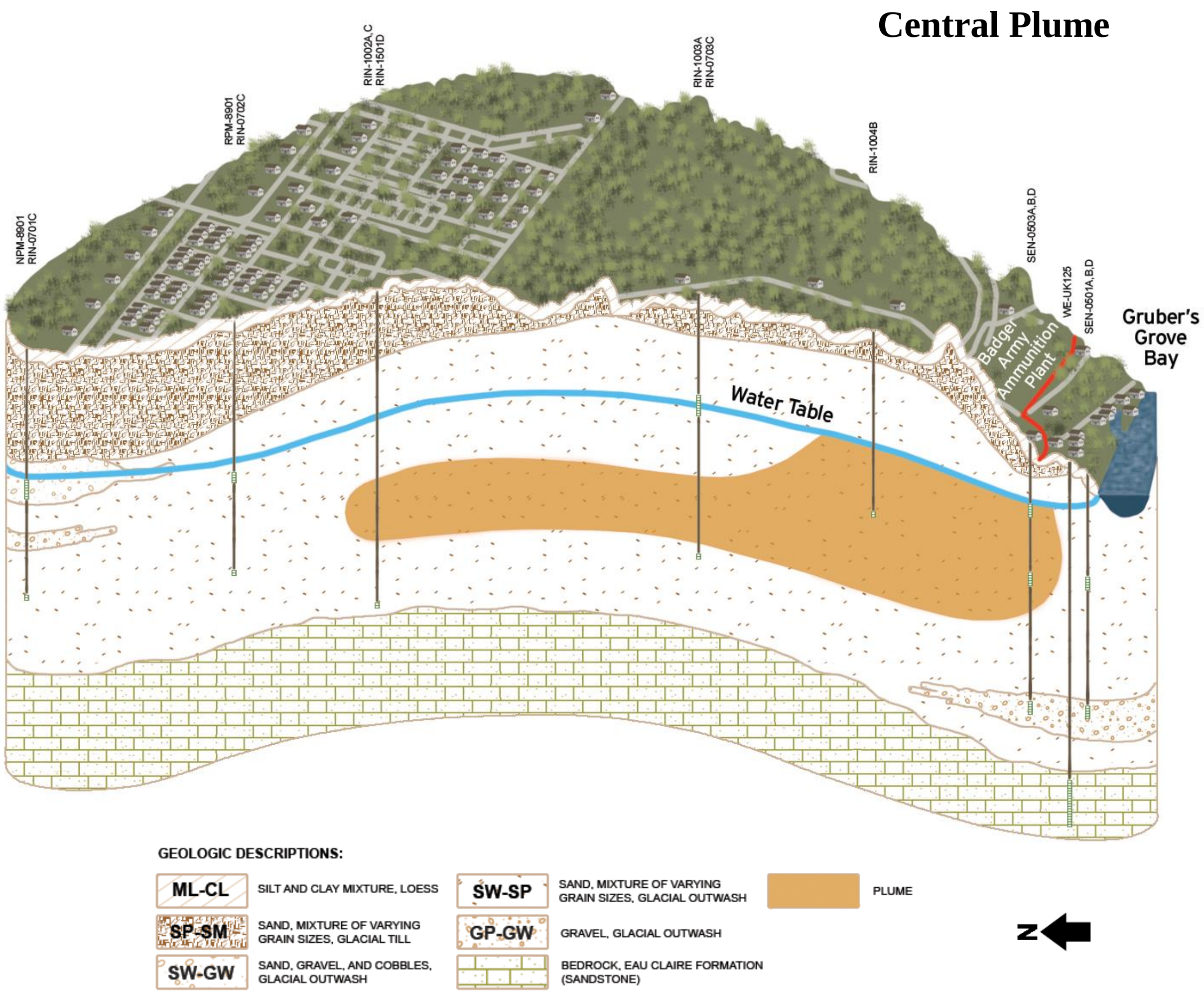
The source of the Central Plume is in the north-central portion of BAAP where nitroglycerin, rocket paste, and rocket propellant were produced, see Figure 1. Within the production area, containers of production chemicals, which contained DNT, were transported by rail to each Pre-Mix House from the Bag Loading House. Nitrocellulose and nitroglycerin were added to the chemical mixture in each Pre-Mix House. The resulting slurry was then pumped to the Final Mix Houses. The Rocket Paste production area was not connected to the main industrial sewer network, so production related wash waters were discharged to open ditches. It is believed that the broad production area may have caused the DNT impacted groundwater. The primary source of contaminated soil originated in former production areas. The Army has performed numerous soil excavations in ditches and ponds, sewer pipe removals, and building demolition throughout the Central Plume source area. The Army has not performed any groundwater remediation in the Central Plume.

The contaminated groundwater in the Central Plume has migrated south and off-site towards the Wisconsin River (Gruber's Grove Bay), see Figure 1. Based on current groundwater monitoring data, there is no evidence to suggest that the Central Plume is discharging into the Wisconsin River. As the Central Plume migrates south, it vertically sinks into the sand aquifer. The thickness of Central Plume narrows as it moves off-site and towards the Wisconsin River. Groundwater in the Central Plume travels approximately 143 feet per year. Contaminants in the Central Plume are expected to travel at the same speed as groundwater. Groundwater beneath the Central Plume source area is approximately 105 feet deep. Contaminated groundwater (above the NR 140 ES) in the Central Plume has only been identified within the sand aquifer at depths between 85 and 130 feet. Groundwater beneath the off-site residential areas is approximately 20 feet deep. Section 3.3 provides additional details on source investigation and remediation. Sections 4.4 and 4.5 provide additional details on groundwater properties and groundwater contaminants.

The seven residential wells located within the areal extent of the Central Plume range in depth from 80 to 324 feet. Two of those seven residential wells are screened in the bedrock and draw their groundwater from beneath the contaminated portion of the Central Plume. Three of those seven residential wells are screened in the sand but draw their groundwater from beneath the contaminated portion of the Central Plume. Two of those seven residential wells are screened in the sand and at the same depth as the contaminated portion of the Central Plume. DNT has been detected in these two residential wells below the NR 140 ES.

The residential wells located outside the areal extent of the Central Plume range in depth from 80 to 575 feet. Most of the residential wells located outside of the Central Plume are screened in the sand and average 120 feet deep. DNT has been detected in monitoring wells located both on-site and off-site in the Central Plume. The Army has replaced three residential wells, screened in the sand, located in the southern extent of the Central Plume. Section 4.6 provides additional details on the residential well replacements conducted by the Army.

A graphical depiction of the Central Plume in relationship to the local geology, monitoring wells, residential wells, site features, and groundwater plume boundaries is shown below. The groundwater flow direction is from the left (north) towards the right (south). The groundwater contaminant plume is shown below the water table and migrating towards Gruber's Grove Bay. The groundwater contaminant plume is shown to have traveled past the BAAP property and beneath a residential area.



A groundwater CSM for the Central Plume is provided in Appendix H. The CSM shows the relationship between the sources of contamination, how the contamination is transported, type of media exposure, the route of exposure, and who may be exposed. The contaminants infiltrated through the soil (leaching) beneath production areas (i.e., buildings, ditches, ponds or sewers) until they reached the groundwater. The contaminants within the groundwater have been transported with the directional flow of groundwater towards the Wisconsin River (Gruber's Grove Bay) to the south. Contaminated groundwater has the potential to reach residential wells which may be used for domestic or potable purposes. Residential well users can be exposed to contaminated groundwater through ingestion or drinking of water, inhalation of vapor during bathing or dishwashing, and dermal contact while bathing.

The exposure routes associated with domestic use of water, as shown on the CSM (Appendix H), include ingestion, inhalation, and dermal exposure. The off-site residential use pathways are potentially complete under current land use conditions and warrant further evaluation. The on-site hypothetical future residential use pathways are incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future on-site groundwater usage.

The exposure route associated with vapor intrusion, as shown on the CSM, includes only inhalation of indoor vapors. Both the off-site and on-site residential use vapor intrusion exposure pathways are incomplete or considered insignificant based on past vapor intrusion investigations and so no further evaluation is warranted. Section 5.6.2 discusses the potential vapor intrusion exposure into buildings.

5.6.2 Exposure Quantification – Vapor Intrusion Pathway Analysis

An evaluation was conducted to determine whether vapors from the Central Plume of groundwater contamination pose a current or hypothetical future risk to human health. Vapor intrusion occurs when there is a migration of vapor-forming chemicals from a subsurface source (i.e., contaminated groundwater) into an overlying building. The exposure route evaluated was the inhalation of contaminants from indoor air.

The Army did not conduct a vapor intrusion pathway analysis investigation specifically in the Central Plume. Section 5.2.3 discussed the 2012 vapor intrusion pathway analysis investigations conducted by the Army in the PBG Plume. The PBG Plume represents the worst-case scenario for volatile-forming chemicals present in the groundwater and thus provides a conservative representation of vapor conditions associated with the Central Plume. The 2012 vapor intrusion pathway analysis reports concluded that VOCs in the PBG Plume do not present a risk to human health via vapor intrusion.

Based on the above information in Section 5.2.3, inhalation exposure due to soil gas vapor intrusion from the Central Plume does not pose a current or potential future risk to area residents.

5.6.3 Exposure Quantification - Groundwater Pathway Analysis

5.6.3.1 *Current and Potential Future Uses of Groundwater*

Groundwater located in the Central Plume found within the boundary of BAAP is not used for human consumption. The land that was transferred from the Army to other property owners includes a deed restriction on the use of groundwater and so restricts the potential exposure to groundwater within the boundary of BAAP. These groundwater access restrictions state that the property owner “shall not access or use groundwater underlying the property for any purpose without the prior written approval of the Army and the WDNR”.

Currently, residential wells located outside of BAAP use groundwater for potable water and domestic purposes. The potential future use of groundwater adjacent to and downgradient of BAAP is expected to be for potable water and domestic purposes.

Residential well users can be exposed to contaminated groundwater through ingestion or drinking of water, inhalation of vapor during showering or dishwashing, and dermal contact while bathing. Groundwater contaminants from BAAP have resulted in groundwater impacts in three residential wells located in the Central Plume. The Army has replaced three residential wells due to impacts from DNT. Section 4.6 provides additional details on the residential well replacements conducted by the Army.

5.6.4 Risk Assessment Summary

5.6.4.1 *Hypothetical Future On-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to hypothetical future on-site risks associated with the Central Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > $1x10^{-4}$ or HI > 1).

Summary of Hypothetical Future Risks – Central Plume
(Monitoring Well Data)

Location	**Cumulative Cancer Risk**	**Non-cancer Hazard Index (HI)**	**Contaminants of Concern**
On-Site (Hypothetical Future Risk)	$3x10^{-6}$	0.02	None

Risks calculated using the simple scaling method for a hypothetical future residential scenario, along with the maximum observed concentration of each COPC, yielded cumulative cancer risk estimates below the risk management criterion ($1x10^{-4}$) for the on-site portion of the Central Plume.

The non-cancer HI risk calculations were below the risk management criterion ($HI \leq 1$) in the on-site portion of the Central Plume.

Based on the maximum risk scenario, the on-site portion of the Central Plume represents an area where cumulative risk estimates are below the risk management criteria, and so no contaminants of concern were identified. Further evaluation of the risks is provided in Section 8.0 Remedial Alternative Development Process.

5.6.4.2 *Current Off-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to current off-site groundwater risks associated with the Central Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > $1x10^{-6}$ or HI > 1).

Summary of Current Risk – Central Plume
(Residential Well and Off-Site Monitoring Well Data)

Location	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
Off-Site (Current Risk)	**$4x10^{-5}$**	0.4	1,2-Dichloroethane 2,6-DNT Benzene Chloroform

Risks calculated using the simple scaling method for a current residential scenario, along with the maximum observed concentration of COPC, yielded cumulative cancer risk estimates above the risk management criterion for the off-site portion of the Central Plume. The cumulative cancer risk ($4x10^{-5}$) for the Central Plume was above the risk management criterion ($1x10^{-6}$). The contaminants of concern that contributed to the cumulative cancer risk for the Central Plume were 1,2-dichloroethane, 2,6-DNT, benzene, and chloroform.

The non-cancer HI risk calculations were below the risk management criterion ($HI \leq 1$) in the off-site portion of the Central Plume.

Based on the maximum risk scenario, the off-site portion of the Central Plume represents an area that would be associated with a cumulative cancer risk above the risk management criterion (above $1x10^{-6}$). Further evaluation of the risks is provided in Section 8.0 Remedial Alternative Development Process.

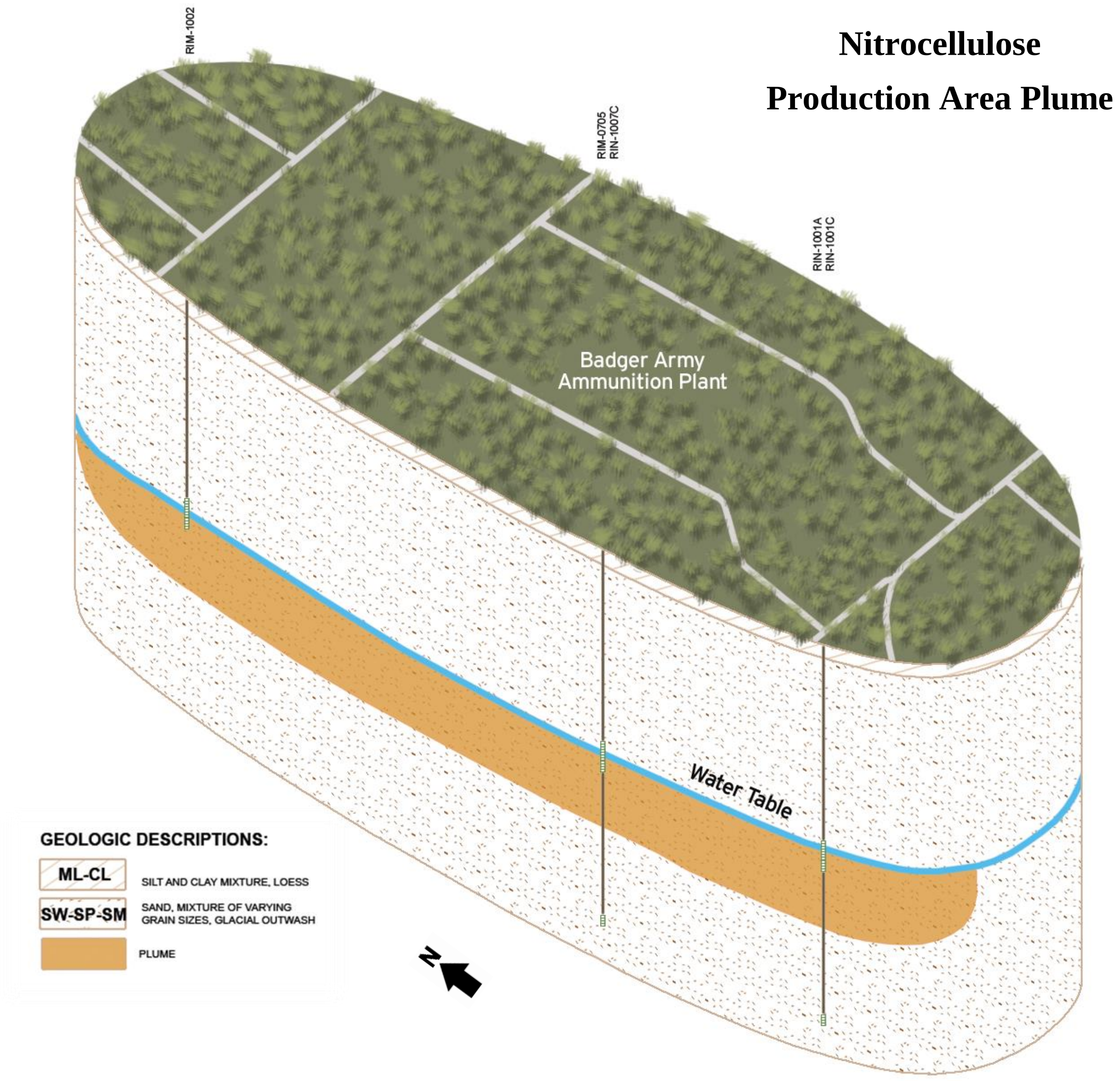
5.7 Nitrocellulose Production Area Plume

5.7.1 Characterization of Exposure Settings

The source of the NC Area Plume is in the northwestern portion of BAAP where nitrocellulose was produced (see Figure 1). Completed nitrocellulose was used to manufacture single-base propellants such as smokeless powder or double-base propellants such as rocket grains or Ball Powder. DNT was added to the manufacturing process in various production buildings. The broad production area contained numerous production buildings and process water disposal sewer piping that caused the DNT impacted groundwater. The sources of the DNT contamination have been removed. The Army has performed numerous soil excavations, sewer pipe removals, and building demolition throughout the NC Area Plume.

As the NC Area Plume migrates south, it remains near the groundwater surface and doesn’t sink vertically. Groundwater in the NC Area travels approximately 132 feet per year. Contaminants in the NC Area Plume are expected to travel at the same speed as groundwater. Groundwater beneath the NC Area Plume is approximately 100 feet deep. Contaminated groundwater (above the NR 140 ES) in the NC Area Plume has only been identified within the sand aquifer at depths between 100 and 120 feet. The contaminated groundwater in the NC Area Plume has migrated south but remains on-site, see Figure 1. The Army has not performed any groundwater remediation in the NC Area Plume. Based on the direction of groundwater flow, the NC Area Plume is migrating towards the PBG Plume. In the future, the NC Area Plume could comingle with the PBG Plume while on BAAP property. There are no residential wells located within 2 miles downgradient (south) of the NC Area Plume. Sections 4.4 and 4.5 provide additional details on groundwater properties and groundwater contaminants.

A graphical depiction of the NC Area Plume in relationship to the local geology, monitoring wells, site features, and groundwater plume boundaries is shown below. The groundwater flow direction is from the upper left (north) towards the lower right (south). The groundwater contaminant plume is shown below the water table. The groundwater contaminant plume is contained on the BAAP property.



A groundwater CSM for the NC Area Plume is provided in Appendix H. The CSM shows the relationship between the sources of contamination, how the contamination is transported, type of media exposure, the route of exposure, and who may be exposed. The contaminants infiltrated through the soil (leaching) beneath production areas (i.e., buildings or sewers) until they reached the groundwater. The contaminants within the groundwater have been transported with the directional flow of groundwater but have remained on-site.

The exposure routes associated with domestic use of water, as shown on the CSM (Appendix H), include ingestion, inhalation, and dermal exposure. The off-site residential use pathways are considered incomplete since the NC Area Plume has not migrated off-site. The on-site hypothetical future residential use pathways are incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future on-site groundwater usage.

The exposure route associated with vapor intrusion, as shown on the CSM, includes only inhalation of indoor vapors. Both the off-site and on-site residential use vapor intrusion exposure pathways are incomplete or considered insignificant based on past vapor intrusion investigations and so no further evaluation is warranted. Section 5.7.2 discusses the potential vapor intrusion exposure into buildings.

5.7.2 Exposure Quantification - Vapor Intrusion Pathway Analysis

Contaminated groundwater from the NC Area Plume has not migrated off-site. There are no on-site buildings located over the NC Area Plume. Based on these factors, there is no vapor intrusion exposure pathway from groundwater associated with the NC Area Plume and there is no current or potential future risk to area residents.

5.7.3 Exposure Quantification - Groundwater Pathway Analysis

5.7.3.1 *Current and Potential Future Uses of Groundwater*

Groundwater located in the NC Area Plume is only found within the boundary of BAAP and is not used for human consumption. The land that was transferred from the Army to other property owners includes a deed restriction on the use of groundwater and so restricts the potential exposure to groundwater within the boundary of BAAP. These groundwater access restrictions state that the property owner “shall not access or use groundwater underlying the property for any purpose without the prior written approval of the Army and the WDNR”. It should be noted that there are no residential wells located within 2 miles downgradient (south) of the NC Area Plume. In addition, there are no off-site monitoring wells associated with the NC Area Plume.

5.7.4 Risk Assessment Summary

5.7.4.1 *Hypothetical Future On-Site Groundwater Risks*

The cumulative cancer risk, non-cancer HI and contaminants of concern related to hypothetical future on-site groundwater risks associated with the NC Area Plume are summarized below. Contaminants of concern are analytes found to significantly contribute to the cumulative risk in an area where risk was estimated to be above the risk management criteria (cumulative cancer risk > $1x10^{-4}$ or HI > 1).

Summary of Hypothetical Future Well Risks – NC Area Plume
(On-Site Monitoring Well Data)

Location	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
On-Site (Hypothetical Future Risk)	$4x10^{-6}$	0.04	None

Risks calculated using the simple scaling method for a hypothetical future residential scenario, along with the maximum observed concentration of each COPC, yielded cumulative cancer risk estimates below the risk management criterion ($1x10^{-4}$) for the NC Area Plume.

The non-cancer HI risk calculations were below the risk management criterion (HI ≤ 1) in the NC Area Plume.

Based on the maximum risk scenario, the NC Area Plume represents an area where cumulative risk estimates are below the risk management criteria, and so no contaminants of concern were identified.

5.7.4.2 *Current Off-Site Groundwater Risks*

There are no off-site monitoring wells associated with the NC Area Plume. In addition, there are no residential wells located within 2 miles downgradient (south) of the NC Area Plume; therefore, current groundwater risks were not evaluated.

6.0 REGULATORY REQUIREMENTS

CERCLA requires that on-site remedial actions attain or waive federal environmental applicable and relevant and appropriate requirements (ARARs), or more stringent state environmental ARARs, upon completion of the remedial action. The USEPAs 1994 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) also requires compliance with ARARs during removal and remedial actions to the extent practicable. These ARARs, in conjunction with the overall protection to human health and the environment criterion, help form the criteria to evaluate remedial alternatives. Under CERCLA, remedial actions must be protective of human health and the environment. Additionally, CERCLA remedial actions must meet a level and standard of control that attains standards, requirements, limitations, or criteria that are “applicable or relevant and appropriate” under the circumstances of the release. Information that is “to be considered” (TBC) federal and state criteria, advisories, and guidance may also be considered/evaluated along with ARARs as a part of a risk assessment conducted at a CERCLA site to help set clean-up level targets.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. In other words, an applicable requirement is one with which a private party would have to comply by law if the same action was being undertaken apart from CERCLA authority.

If a requirement is not applicable, it still may be relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

“Applicability” is a legal and jurisdictional determination, while the determination of “relevant and appropriate” relies on professional judgment, considering environmental and technical factors at the site.

USEPA identifies three basic types of ARARs:

- Chemical-specific ARARs are generally health- or risk-based values which, when applied to site-specific conditions, result in numerical values. These values establish the acceptable concentration of a chemical that may be found in, or discharged to, the ambient environment.

- Location-specific ARARs are restrictions placed upon removal activities of hazardous substances solely because they are occurring in a particular place.

- Action-specific ARARs are general technology or activity-based requirements on actions taken with respect to hazardous substances. These requirements are triggered by the particular activities that are selected to accomplish a remedy. Thus, action-specific requirements do not in themselves determine the removal alternative; rather, they indicate how the selected alternative must be achieved.

TBCs are non-promulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs; however, TBCs may be considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of clean-up for protection of health and the environment.

Potential State and Federal ARARs and TBCs to be used in the groundwater remedial alternatives evaluation are presented in Table 14.

Table 14
Potential State and Federal Applicable or Relevant and Appropriate Requirements
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR)
Chemical-Specific ARARs and TBCs			
Groundwater Quality	Wisconsin Administrative Code, Chapter NR 140.26	Chemical-specific groundwater Enforcement Standard (ES).	ARAR – Establishes applicable groundwater quality standards.
National Primary Drinking Water Regulations: Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels	40 CFR Part 141 Subpart G	Chemical-specific drinking water quality standards.	ARAR – Establishes relevant and appropriate groundwater quality standards.
National Secondary Drinking Water Regulations	40 CFR Part 143	Chemical-specific drinking water quality standards related to aesthetics.	TBC – Recommended drinking water quality guidelines.
Regional Screening Level (RSL) Resident Tapwater Table	USEPA – November 2017	Screening level guidance for human health risk from exposure to groundwater.	TBC – Recommended groundwater quality screening levels.
Location-Specific ARARs			
No Location-Specific ARARs were identified.			
Action-Specific ARARs			
Well Construction and Pump Installation	Wisconsin Administrative Code, Chapter NR 812 excluding subsections 812.05, 25, 38, 39, 40, 42, 43, 44 and 45.	Establishes requirements for installing water supply wells and extracting groundwater.	ARAR – Applicable to alternatives that would replace a contaminated residential well or active remediation activities that pump groundwater.

Note: Table 16 lists the groundwater cleanup level & regulatory concentration for each contaminant of concern.

7.0 CONTAMINANTS OF CONCERN

This section presents the contaminants of concern (COC) for the groundwater contamination associated with four groundwater contamination plumes at BAAP. The COCs are based on the results of the HHRA detailed in Section 5.0. Table 15 summarizes the groundwater COCs for the BAAP. Table 15 provides a breakdown of which risk-based COCs were identified as having a cancer risk and/or non-cancer risk. Table 15 also shows which risk-based COC was identified as an on-site or off-site risk above the risk management criteria.

Table 16 provides the groundwater cleanup levels for each risk-based COC related to the PBG Plume, DBG Plume, Central Plume, and NC Area Plume. The groundwater cleanup level for each risk-based COC is based on the lower of either the MCLs (National Primary Drinking Water Regulations per 40 CFR Part 141) or the Wisconsin NR 140 ES.

7.1 Propellant Burning Ground Plume

The risk-based COCs identified in the PBG Plume were chloroform, CTET, ethyl ether, TCE, and 2,6-DNT.

- Chloroform was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, chloroform concentrations were not identified above the groundwater cleanup level listed in Table 16. Therefore, remedial alternatives are not being considered for chloroform.
- CTET was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, CTET concentrations were identified above the groundwater cleanup level listed in Table 16.
- Ethyl ether was identified as having an on-site non-cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, ethyl ether concentrations were identified above the groundwater cleanup level listed in Table 16.
- TCE was identified as having both an off-site cancer risk and an on-site and off-site non-cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, TCE concentrations were identified above the groundwater cleanup level listed in Table 16.
- 2,6-DNT was identified as having an on-site and off-site cancer risk plus an on-site non-cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, 2,6-DNT concentrations were identified above the groundwater cleanup level listed in Table 16.

Based on the above information, CTET, ethyl ether, TCE, and 2,6-DNT will be the COCs considered in the FS for the development of remedial alternatives in the PBG Plume.

Table 15
Groundwater Contaminants of Concern
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Groundwater Plume	Contaminant of Concern (COC) - HHRA					
	Cancer Risk (1)			Non-Cancer Risk (2)		
	COC	On-Site	Off-Site	COC	On-Site	Off-Site
Propellant Burning Ground	Carbon Tetrachloride		X			
	Chloroform		X			
				Ethyl Ether	X	
	Trichloroethene		X	Trichloroethene	X	X
	2,6-Dinitrotoluene	X	X	2,6-Dinitrotoluene	X	
Deterrent Burning Ground	Chloroform		X			
				1,1,2-Trichloroethane	X	
	Trichloroethene (3)		X	Trichloroethene (3)		X
	Dinitrotoluene, Total *		X			
Central	Benzene (4)		X	none		
	Chloroform		X			
	1,2-Dichloroethane		X			
	2,6-Dinitrotoluene		X			
Nitrocellulose Production Area	none			none		

Notes:

Based on analytical lab results from residential and groundwater monitoring well samples for 2015, 2016, 2017, and 2018.

HHRA - Human Health Risk Assessment

(1) Contaminants found to contribute to a cumulative human cancer risk above the risk management criteria.

(2) Contaminants found to contribute to a cumulative human non-cancer risk above the risk management criteria.

(3) Trichloroethene (TCE) is not considered a COC in the Detererent Burning Ground Plume.
The source of TCE is not attributable to the Army and has been found in residential well jet pumps.

(4) Benzene is not considered a COC in the Central Plume. The source of benzene is not attributable to the Army.

* Total Dinitrotoluene (DNT) Isomers (2,3-DNT; 2,4-DNT; 2,5-DNT ; 2,6-DNT; 3,4-DNT; 3,5-DNT) - NR 140.10

Table 16 lists the groundwater cleanup level & regulatory concentration for each contaminant of concern.

Table 16
Groundwater Cleanup Levels
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Groundwater Plume	Contaminants of Concern (COC)	State	Federal	Groundwater Cleanup Level [1]
		NR 140 ES	40 CFR Part 141 MCLs	
Propellant Burning Ground	Carbon Tetrachloride	5	5	5
	Chloroform	6	80 (2)	6
	2,6-Dinitrotoluene	0.05	none	0.05
	Ethyl Ether	1000	none	1000
	Trichloroethene	5	5	5
Deterrent Burning Ground	Chloroform	6	80 (2)	6
	Total Dinitrotoluene	0.05	none	0.05
	1,1,2-Trichlorethane	5	5	5
	Trichloroethene (3)	5	5	5
Central	Benzene (4)	5	5	5
	Chloroform	6	80 (2)	6
	1,2-Dichloroethane	5	5	5
	2,6-Dinitrotoluene	0.05	none	0.05
Nitrocellulose Production Area	none	none	none	none

Notes:

(1) Cleanup Level is the lowest value of either the NR 140 ES or Federal MCL.

(2) The Chloroform MCL is for Total Trihalomethanes (sum of bromodichloromethane, bromoform, dibromochloromethane, & chloroform)

(3) Trichloroethene is not considered a COC in the Detererent Burning Ground Plume. The source of trichloroethene is not attributable to the Army. Trichloroethene has been found in residential well jet pumps.

(4) Benzene is not considered a COC in the Central Plume. The source of benzene is not attributable to the Army.

All concentration values are expresed in micrograms-per-liter (µg/l)

ES = Enforcement Standard

40 CFR Part 141 - National Primary Drinking Water Regulations: Maximum Contaminant Levels (MCLs)

Total Dinitrotoluene (DNT) consists of isomers (2,3-DNT; 2,4-DNT; 2,5-DNT ; 2,6-DNT; 3,4-DNT; 3,5-DNT)

7.2 Deterrent Burning Ground Plume

The risk-based COCs identified in the DBG Plume were chloroform, 1,1,2-TCA, TCE, and total DNT.

- Chloroform was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, chloroform concentrations were not identified above the groundwater cleanup level listed in Table 16. Therefore, remedial alternatives are not being considered for chloroform.
- 1,1,2-TCA was identified as having an on-site non-cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, 1,1,2-TCA concentrations were not identified above the groundwater cleanup level listed in Table 16. Therefore, remedial alternatives are not being considered for 1,1,2-TCA.
- TCE was identified as having both an off-site cancer and non-cancer risk above the risk management criteria. TCE has not been detected in monitoring wells nor is there a known source associated with the DBG Plume. The source of TCE is not attributable to the Army and has been found in residential well jet pumps. Therefore, remedial alternatives are not being considered for TCE.
- Total DNT was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, total DNT concentrations were identified above the groundwater cleanup level listed in Table 16.

Based on the above information, total DNT will be the only COC considered in the FS for the development of remedial alternatives in the DBG Plume.

7.3 Central Plume

The risk-based COCs identified in the Central Plume were benzene, chloroform, 1,2-dichloroethane, and 2,6-DNT.

- Benzene was identified as having an off-site cancer risk above the risk management criteria. Benzene has not been detected in monitoring wells located on-site (upgradient) nor is there a known source associated with the Central Plume. The source of benzene is not attributable to the Army. Benzene was also not detected in any monitoring wells or residential wells that were sampled during 2018. Therefore, remedial alternatives are not being considered for benzene.
- Chloroform was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, chloroform concentrations were not identified above the groundwater cleanup level listed in Table 16. Therefore, remedial alternatives are not being considered for chloroform.
- 1,2-Dichloroethane was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, 1,2-dichloroethane concentrations were not identified above the groundwater cleanup level

listed in Table 16. Therefore, remedial alternatives are not being considered for 1,2-dichloroethane.

- 2,6-DNT was identified as having an off-site cancer risk above the risk management criteria. Based on the groundwater monitoring data from 2015 to 2018, 2,6-DNT concentrations were identified above the groundwater cleanup level listed in Table 16.

Based on the above information, 2,6-DNT will be the only COC considered in the FS for the development of remedial alternatives in the Central Plume.

7.4 Nitrocellulose Production Area Plume

The HHRA did not identify any human health risk related COCs for the NC Area Plume; therefore, no remedial alternatives will be developed for the NC Area Plume in the FS.

8.0 REMEDIAL ALTERNATIVE DEVELOPMENT PROCESS

As described in Section 5.0, a HHRA was completed as it relates to current and hypothetical future risks for the groundwater contaminant plumes as appropriate. Based on groundwater monitoring results for 2015, 2016, 2017 and 2018, the HHRA found unacceptable risk related to groundwater from BAAP and identified a completed exposure pathway for the PBG, DBG, and Central Plumes. Based on these factors (cleanup level exceedances, risk identified above the risk management criteria and completed exposure pathway identification), the Army is evaluating the feasibility of groundwater remedial actions to reduce, control, or mitigate exposure to be protective of human health and the environment for the PBG, DBG, and Central Plumes. Section 7.0 identifies the COCs for each plume and the groundwater cleanup levels for each COC.

The HHRA did not identify risk above the risk management criteria for the NC Area Plume. Therefore, groundwater remedial alternatives are not being considered by the Army for the NC Area Plume and groundwater sampling of the monitoring wells is not part of the CERCLA remedy for the NC Area Plume.

For ease of review, clarity and appropriateness, the remedial alternative development process was completed for each individual plume. As each contaminant plume has a specific set of circumstances including but not limited to size, location, geology, hydrogeology and contaminants of concern, plume-specific alternatives were developed. This process allows plume-specific alternatives to be tailored to the circumstances associated with each individual plume.

8.1 Previous Soil Remedial Activities

Soil remedial activities have been conducted at the source areas of the four groundwater contaminant plumes, PBG Plume, DBG Plume, Central Plume, and NC Area Plume. These soil remedial activities are summarized in Sections 3.1, 3.2, 3.3, and 3.4. Source areas with contaminated soil have been addressed at BAAP either with removal, in-situ treatment, vapor extraction, soil covers, or engineered barriers. These remedial activities have minimized the potential exposure to contaminated soil at BAAP. The Army has received site closure from the WDNR on all soil related investigations and remedial actions at BAAP.

8.2 Previous Groundwater Remedial Activities

Groundwater remedial activities were first conducted at the PBG Plume starting in 1990 with the construction and operation of the IRM. The IRM ultimately consisted of two source control wells, three boundary control wells, a treatment process building and a discharge pipeline to the Wisconsin River. These wells extracted and treated approximately 310 gpm of groundwater until the IRM’s operational termination in 2012. The IRM was augmented by the construction of the MIRM in 1996. This system ultimately consisted of five extraction wells, a treatment process building and discharge pipeline to the Wisconsin River. These wells extracted and treated approximately 2,400 gpm of groundwater until the MIRM’s operational termination in 2015. Biochemical treatment of groundwater at the PBG Waste Pits began in 2001 and was operational until 2005. These groundwater remedial activities are summarized in Section 3.1.

Groundwater remedial activities have not been conducted at the Central Plume, DBG Plume, or NC Area Plume.

8.3 Groundwater Remedial Action Objectives

Groundwater remedial action objectives (RAOs) provide a general description of what the cleanup will accomplish, serve as the basis for evaluating each remedial alternative, and provide an understanding of how the unacceptable risks will be addressed by each remedial alternative. Groundwater RAOs require the remedy to protect human health by preventing exposure to contaminated groundwater, to restore groundwater to the extent practicable, and minimize the impact of the contaminant plumes on the environment. Specifically, the RAOs for any individual plume are achieved when the risk-based groundwater COCs listed in Table 15 are below the groundwater cleanup levels provided in Table 16. The groundwater cleanup levels shown in Table 16 are based on either the NR 140 ES or federal MCL.

8.4 General Response Actions

The General Response Actions (GRAs) are general actions that would satisfy the RAOs. The potential applicability of GRAs and associated technologies were evaluated based on site specific constraints. The applicable GRAs and a brief description for the BAAP groundwater are listed below.

- **Land Use Controls** – Administrative actions such as land use restrictions to protect public health and the environment.
- **Development of New Water Resources** – Provision of bottled water well replacement and alternate water supply systems.
- **Groundwater Treatment** – Removal, treatment and disposal of contaminated groundwater.
- **Groundwater Containment** – Isolation of groundwater using subsurface barriers.

8.5 Identification and Screening of Potentially Applicable Technologies

This section identifies the appropriate plume specific remedial technologies and process options for each GRA for groundwater at BAAP. Process options refer to a specific process within each technology type. For example, the vertical barrier technology category could include process options such as a slurry wall, sheet pile wall or deep soil mixing. For each GRA, several broad technology types may be identified and within each remedial technology, several process options may be applicable.

During this screening step, process options and entire technology types are eliminated from further consideration based on technical implementability. This is completed by using readily available information from site conditions, contaminant types and concentrations and site-specific circumstances. Based on this evaluation, some remedial technologies and process options were eliminated from further consideration. The technology screening process and subsequent process option evaluation for each plume meeting the qualifying criteria (cleanup level exceedances, risk identified above the risk management criteria and completed exposure pathway identification) is shown in Table 17.

8.6 Process Option Screening Criteria

This section contains the description of process options screening criteria for each technology which provides the basis for developing remedial alternatives. For technologies with more than one process option, each option was evaluated. Each process option is evaluated according to the following criteria:

- **Effectiveness** – which includes evaluating the following:
  - Potential effectiveness in handling the estimated area or volumes of media.
  - Potential in meeting the RAOs.
  - Potential impacts to human health and the environment during the construction and implementation phase.
  - Demonstrated reliability of the process with respect to the contaminants and site conditions.

- **Implementability** – which includes technical and administrative feasibility of implementing a process option:
  - Technologies passing the initial screen of applicability are screened based on technical feasibility. This criterion means feasibility under site specific conditions. This evaluation may indicate that although a technology may be generally applicable for the COCs, the specific technology may be limited due to site-specific conditions.
  - Institutional feasibility emphasizing the institutional aspects of implementability such as the ability to obtain necessary permits for off-site actions.

- **Cost** – Plays a limited role in the screening process and is used only when two alternatives are found to be equally protective. Cost analyses are based on engineering judgement and evaluated as to whether costs are high, moderate or low in relation to other process options.

Following the selection of the most appropriate process options for each technology type, the process options are combined to form remedial alternatives. Remedial alternatives are discussed in Sections 9.0 for the PBG Plume, 10.0 for the DBG Plume, and 11.0 for the Central Plume.

8.7 Evaluation and Selection of Representative Process Options

This section evaluates the process options using the criteria listed in Section 8.6: effectiveness, implementability and cost. Only the most applicable process options, as identified in Table 17, were carried forward and are included in the development of remedial alternatives.

Table 17
Technology Screening
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

General Response Action	Remedial Technology	Process Option	Description/Comments	Retained for Further Consideration
Land Use Controls	Access Restrictions	Deed Restrictions - On-site	Deed would restrict on-site water use only.	Yes
Development of New Water Resources	Alternate Water Supply	Provision of Bottled Water	Provide bottled water to residential well owners with impacts above the Enforcement Standards.	Yes
		Impacted Well Replacement	Replacement of residential wells impacted above the Enforcement Standards.	Yes
		Well Replacement - Plume Areas	Replacement of residential wells within plume boundaries.	Yes
		Municipal Water Supply - New System	Construct new municipal water system for residential well owners south and east of BAAP. Army does not have authority.	No
Groundwater Treatment	Groundwater Removal	Extraction Wells	Series of wells to extract contaminated groundwater.	Yes
		Subsurface Drains	Perforated pipe in trenches backfilled with porous media to collect contaminated groundwater. Not feasible due to depth of necessary trenches.	No
	In-Situ Treatment	Biochemical Injection	Injection of treatment agent into groundwater.	Yes
		Permeable Reactive Barrier	Reactive barrier allows contaminated groundwater to pass through with passive treatment. Not feasible due to depth of contamination.	No
		Monitored Natural Attenuation	Allowing natural processes (dilution, dispersion and sorption) to slowly degradation contamination.	Yes
	Ex-Situ - On-site Treatment	Mobile Treatment Facility	Utilize mobile treatment units to treat contaminated water.	Yes
		On-site Treatment Facility	Construct on-site facility to treat contaminated water. Army no longer owns property.	No
		Bluffview Sanitary District (BSD)	Utilize BSD wastewater treatment plant. Not feasible due to flow limitations.	No
	Ex-Situ - Off-site	Publicly Owned Treatment Works (POTW)	Haul extracted groundwater to POTW. Not feasible due to anticipated volume.	No
	Groundwater Disposal	On-site Discharge - Injection	Treated water discharged to deep well injection system. Not feasible due to anticipated volume.	No
		On-site Discharge - Infiltration Gallery	Treated water discharged to an on-site infiltration gallery. Not feasible due to anticipate volume.	No
		Pipeline to Wisconsin River	Treated water discharged into the Wisconsin River.	Yes
Groundwater Containment	Vertical Barriers	Slurry Wall	Trench around impacted area is filled with a soil/cement/bentonite mix. Not feasible due to depth of contamination.	No
		Sheet Pile Wall	Sheet pile wall around impacted areas. Not feasible due to depth of contamination.	No
		Deep Soil Mixing	Mixing of bentonite in soil through augers. Not feasible due to depth of contamination.	No

8.7.1 Land Use Controls

Access Restrictions - On-site Deed Restrictions - Groundwater access restrictions for the BAAP property are already in place and restricts property owners from accessing groundwater as part of the property transfer agreement. Specifically, the Groundwater Restrictions state, "The Grantee, its successors and assigns, shall not access or use groundwater underlying the Property for any purpose without the prior written approval of the Army and the WDNR. For the purpose of this restriction, "groundwater" shall have the same meaning as Section 101(12) of CERCLA."

- **Effectiveness** – Access restrictions are effective in controlling human activities such as potable well construction on the BAAP property.
- **Implementability** – These deed restrictions are currently implemented as a result of parcel transfer agreements.
- **Cost** – Low

Land Use Controls are carried forward as a process option which can be combined with other process options to meet the RAO.

8.7.2 Development of New Water Resources

Alternate Water Supply - Provision of Bottled Water and Well Replacement - For areas impacted by groundwater contamination off the BAAP property, the Army currently has an environmental monitoring and health protection program in place that is protective of the residential water well users. If a Chapter NR 140 ES is exceeded in a residential well once, bottled water is made available to the occupant. If the exceedance occurs a second, consecutive time, well replacement is offered to the owner. Bottled water would be made available to the occupant until the well is replaced, operational and water quality verified (typically 3 months and based on driller availability). If the NR 140 ES exceedance is not detected for two consecutive rounds after the first NR 140 ES exceedance detection, bottled water would be discontinued. To date, the Army has replaced seven shallow residential wells with deeper aquifer residential wells.

- **Effectiveness** – The alternate water supply has been effective in conjunction with groundwater monitoring to replace residential wells.
- **Implementability** – These options can be readily implemented.
- **Cost** – Low

Alternate Water Supply – Provision of Bottled Water and Well Replacement is carried forward as a process option which can be combined with other process options to meet the RAO.

Alternate Water Supply – Well Replacement within the Plume Areas - This process option would involve replacing individual residential shallow wells with a deeper aquifer well for existing residents. If sampling results indicate an increasing trend for a plume's COC in three consecutive rounds and that the plume is migrating toward a residential well, the Army will evaluate if well replacement is necessary. This process option would provide a safe, clean and reliable water source for potentially affected residential well owners downgradient of BAAP. The Army currently monitors 54 residential wells.

- **Effectiveness** – This process option would eliminate receptors from potential exposure to groundwater contamination within the plume areas by proactively providing a deeper aquifer well. This process option would rely on natural processes such as dilution, dispersion and sorption to degrade the contaminant plume over time.
- **Implementability** – This process option could be implemented by replacing individual shallow wells, meeting the criteria, with an individual deeper aquifer well.
- **Cost** – Low to Moderate depending upon replacement frequency.

Alternate Water Supply – Well Replacement within the Plume Area is carried forward as a process option which can be combined with other process options to meet the RAO.

Alternate Water Supply – Municipal Water System - This process option would involve construction of a new municipal water system servicing residents located east and south of the BAAP with the potential of being impacted by the contaminant plumes. In 2011, the Army submitted a Revised Alternative Feasibility Study, Groundwater Remedial Strategy report to the WDNR. The selected groundwater remedy was Monitored Natural Attenuation (MNA). Due to the relatively long remedial timeframe for the MNA remedy to achieve the proposed cleanup levels, the proposed remedy included construction and operation of a municipal drinking water system that would provide residents in the communities surrounding the BAAP with drinking water while groundwater contamination continued to diminish over time. During an evaluation by the Army's Office of General Counsel it was determined the Army did not have the legal or funding authority to procure and operate a municipal water system as identified in the 2011 Revised Alternative Feasibility Study, so this option was not carried forward in the Feasibility Study.

While a draft Decision Document (DD) for Site-Wide Groundwater was being prepared in 2012, the Army identified several areas where the draft DD did not meet both legal and policy requirements. Specifically, a human health risk assessment was not prepared, incorrect legal standards were identified for the selected groundwater remedy and key components of the proposed response action were outside the Army's authority. For these reasons, this process option was not carried forward.

8.7.3 Groundwater Treatment

Groundwater Removal - Extraction Wells - Vertical extraction wells are installed to collect and extract contaminated groundwater to reduce concentrations and/or contain a contaminant plume.

- **Effectiveness** – This process option is commonly used as an effective groundwater removal technology. Proper well location is necessary for effective source reduction and plume control. This process has been used at BAAP and based on previous experience, additional study and design may be needed to maximize source reduction and plume control.
- **Implementability** – This process option has been used at BAAP and is commonly used in the industry to remove groundwater. This process option would require utilities to be

extended to the site of the extraction well network. Groundwater extraction wells are relatively easy to install. This process option would also require coordination from existing property owners on- and off-site as the land in which the extraction wells would be located is owned and/or managed by other entities.
- **Cost** – Moderate cost due to site infrastructure improvements necessary for site specific conditions.

Groundwater Removal – Extraction Wells is carried forward as a process option which can be combined with other process options to meet the RAO.

Groundwater Removal – Subsurface Drains - This process option utilizes horizontal interceptor trenches filled with porous media to convey impacted water to extraction points. This application is typically used in shallow applications. Based on the depth of the contaminant plumes, this process option was not carried forward.

Groundwater Treatment - In-situ Biochemical Injection - Vertical injection points are installed within the contaminant plume, in areas where COCs exceed groundwater cleanup levels, and injected with a biochemical selected for the ability to degrade specific chemicals into harmless by-products through anaerobic biodegradation.

- **Effectiveness** – The procedures and applications of biochemical injection are applicable to numerous anaerobically biodegradable contaminants including but not limited to chlorinated solvents, energetics, and nitrates.
- **Implementability** – Equipment and expertise would be readily available; however, a field-scale pilot test would be necessary. This process option would also require coordination from existing property owners on- and off-site as the land in which the injection points would be located is owned and/or managed by other entities.
- **Cost** – Moderate to high cost depending upon the amount and corresponding cost of biochemical necessary to treat the plume.

Groundwater Treatment - In-situ Biochemical Injection is carried forward as a process option which can be combined with other process options to meet the RAO.

Groundwater Treatment - Permeable Reactive Barrier - This process option utilizes reactive media constructed across the path of a contaminant plume to treat groundwater. A permeable reactive barrier is generally limited to shallow applications and its effectiveness is a concern based on the longevity of the reactive media. Due to the depth of the contaminant plumes and concerns about the lifespan of the reactive media, this process option was not carried forward.

Groundwater Treatment - Monitored Natural Attenuation - MNA is a passive remedial process that utilizes groundwater sampling results to monitor the reduction in groundwater contaminants. Natural processes such as dilution, dispersion and sorption would be monitored over time to confirm contaminant reduction.

These natural attenuation processes include a variety of physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These in-situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. Natural attenuation processes may reduce the potential risk posed by site contaminants in three ways: (1) transformation of contaminant(s) to a less toxic form through destructive processes such as biodegradation or abiotic transformations; (2) reduction of contaminant concentrations whereby potential exposure levels may be reduced; and (3) reduction of contaminant mobility and bioavailability through sorption onto the soil or rock matrix.

Under CERCLA, MNA is considered to be a remedy like any other remedy. According to the USEPA (Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P), MNA can be an alternative means of achieving the RAO that may be appropriate for specific site circumstances where its use meets the applicable statutory and regulatory requirements. MNA can be used in conjunction with other remedies as a follow-up measure that will be monitored and compared with expectations. The USEPA expects that MNA will be most appropriate when used in conjunction with other remedial methods (e.g., source control, groundwater extraction), or as a follow-up to active remedial methods that have already been implemented. Both the USEPA and WDNR recognize MNA may be an appropriate remedial method for contaminated groundwater under certain circumstances.

- **Effectiveness** – This process option is an effective long-term solution as groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process.
- **Implementability** – This process option is easily implemented as monitoring well and residential well sampling and analytical testing are currently being conducted in accordance with the most recent regulatory approval.
- **Cost** – Low

Groundwater Treatment - Monitored Natural Attenuation is carried forward as a process option which can be combined with other process options to meet the RAO.

Groundwater Treatment – Mobile Treatment - Pressurized, mobile, tractor-trailer mounted treatment tanks utilizing activated carbon to treat extracted groundwater water in areas where COCs exceed groundwater cleanup levels.

- **Effectiveness** – Activated carbon has been previously used at BAAP to successfully treat DNT.
- **Implementability** – These units are capable of supporting treatment at flow rates up to 500 gpm. A separate mobile treatment unit would be required to support each well. This process option would require utilities to be extended to the site of the mobile treatment facility. This process option would also require coordination from existing property owners on- and off-site as the land on which the treatment units would be located is owned and/or managed by other entities. These mobile treatment units could be used in cold weather months with appropriate heating and insulation provisions.
- **Cost** – Moderate

Groundwater Treatment – Mobile Treatment is carried forward as a process option which can be combined with other process options to meet the RAO.

Groundwater Treatment - On-site Treatment Facility - A treatment facility for the extracted groundwater in areas where COCs exceed groundwater cleanup levels would be located on the BAAP property. It is anticipated that the treatment system would require a structure (treatment facility) equipped with supporting utilities including gas, electric, water, sewer and communication. Utilities would need to be extended to the site in addition to other site improvements. At the treatment facility, activated carbon is the treatment media expected to be utilized to treat the impacted groundwater. This process option has been utilized at the BAAP previously. The Army no longer owns the land in or around the contaminant plumes, for which they would require, for facility construction. For this reason, this process option was not carried forward.

Groundwater Treatment – Bluffview Sanitary District - This process option would involve pumping extracted groundwater to the Bluffview Sanitary District Wastewater Treatment Plant. The maximum daily capacity of this facility is 45,000 gallons per day which will not accommodate the flow rates anticipated for a pump and treat system. Each extraction well is expected to pump 720,000 gallons per day. For this reason, this process option was not carried forward.

Groundwater Treatment at Publicly Owned Treatment Works - This process option would involve pumping extracted groundwater in areas where COCs exceed groundwater cleanup levels to a holding tank and utilizing tanker trucks to transport the extracted groundwater to a publicly owned treatment works. Based on the anticipated flow rates needed for source removal and plume control (720,000 gallons per day per extraction well), the number of tanker trucks necessary to transport the impacted water would be not practicable. For this reason, this process option was not carried forward.

Groundwater Disposal - On-site Discharge - This process option would discharge treated groundwater on-site to either groundwater injection points or to an infiltration gallery. The areas near the contaminant plumes are on property owned and/or managed by other entities. Based on the anticipated flow rates needed for source removal and plume control, the size of the area necessary to facilitate injection or infiltration would be not practicable. Base on the anticipated discharge rates (720,000 gallons per day per extraction well) and subsequent size of the injection or infiltration area necessary for disposal, on-site discharge was not carried forward as a process option or remediation technology.

Off-site Discharge Pipeline to the Wisconsin River - This process option would discharge treated groundwater into the Wisconsin River. This would require pumping and a piping network to convey treated groundwater to the surface water discharge point.

- **Effectiveness** – This process option is an effective method for discharge water disposal provided that permit requirements could be met. This process option has been previously utilized at the BAAP.

- **Implementability** – This process option can be implemented as equipment and materials required for construction are readily available. This process option would require additional studies to design the discharge system to meet site specific requirements and constraints. This process option would also require coordination from existing property owners as the land in which the discharge piping would be located is owned and/or managed by other entities.
- **Cost** – Moderate cost depending upon discharge system design.

Off-site Discharge Disposal to the Wisconsin River is carried forward as a process option which can be combined with other process options to meet the RAO.

8.7.4 Groundwater Containment

Vertical Barriers - Vertical barriers including slurry and sheet pile walls and deep soil mixing would be installed around the contaminant plumes to provide horizontal containment. These walls are typically “keyed” into a relatively impervious formation, providing horizontal and vertical containment. However, there are some of these walls that are constructed to “hang” when the contaminant plume is at shallow elevations effectively stagnating the plume. Based on site geology and depth of the contaminant plumes, vertical barriers were not carried forward as a process option or remediation technology.

8.7.5 Summary of Process Options for Groundwater

The following process options remain after screening:

- Land Use Controls including on-site groundwater access restrictions
- Development of New Water Resources including provision of bottled water and residential well replacement within the plume areas
- Groundwater Treatment including removal through extraction wells, treatment through biochemical injection, monitored natural attenuation, and mobile treatment units and discharge through pipeline to the Wisconsin River

8.8 Alternatives Analysis Process

The NCP (40 CFR 300.430) states that the primary objective of the FS is to “ensure that appropriate remedial alternatives are developed and evaluated,” and that “the number and type of alternatives to be analyzed shall be determined at each site, considering the scope characteristics and complexity of the site problem that is being addressed.”

Nine evaluation criteria have been developed to serve as the basis for conducting a detailed analysis of the remedial alternatives. The evaluation criteria with the associated statutory considerations are:

1. Overall Protection of Human Health and the Environment
2. Compliance with the ARARs
3. Long-Term Effectiveness and Permanence
4. Reduction in Toxicity, Mobility and Volume through Treatment

5. Short-Term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance

A process to evaluate remedial alternatives has been developed based on statutory requirements. The nine criteria are categorized into three groups and include threshold criteria, primary balancing criteria and modifying criteria.

Evaluation against two criteria relate directly to statutory findings that must ultimately be made in the remedy. Therefore, these are categorized as threshold criteria in that each alternative must meet them. These two criteria are briefly described below:

- **Overall Protection of Human Health and the Environment** – The assessment against this criterion describes how the alternative achieves and maintains protection of human health and the environment.

- **Compliance with ARARs** – The assessment against this criterion describes how the alternative complies with ARARs. The assessment also addresses other information from advisories, criteria and guidance.

The five criteria listed below represent the primary balancing criteria upon which the analysis is based.

- **Long-Term Effectiveness and Permanence** – The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met.

- **Reduction of Toxicity Mobility and Volume through Treatment** – The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternate may employ.

- **Short-Term Effectiveness –** The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met.

- **Implementability –** This assessment evaluates the technical and administrative feasibility of alternatives and the availability of require goods and services.

- **Cost –** This assessment evaluates the capital and operation and maintenance cost of each alternative.

The final two modifying criteria are briefly described below.

- **State Acceptance –** This assessment reflects that State's apparent preferences among or concerns about the remedy. State acceptance of an alternative will be evaluated in the Proposed Plan issued for public comment. Therefore, this criterion is not considered in this FS.

- **Community Acceptance –** This assessment reflects the community's apparent preferences among or concerns about alternatives. Community acceptance of each alternative will be evaluated after a Proposed Plan is issued for public comment. Therefore, this criterion is not considered in this FS.

The sections below present the detailed analysis of alternatives based on criteria 1 through 7 from the NCP (40 CFR 300.4309(e)(9)), as listed above.

9.0 REMEDIAL ALTERNATIVES – PBG PLUME

As identified in Section 7.1, CTET, ethyl ether, TCE, and 2,6-DNT were the only risk-related COCs considered for the development of remedial alternatives in the PBG Plume. The RAO for the PBG Plume requires the remedy to protect human health by preventing exposure to contaminated groundwater, to minimize the impact of the contaminants on the environment, and to restore groundwater to the extent practicable. The RAO for the PBG Plume will be achieved when groundwater concentrations of CTET, ethyl ether, TCE, and 2,6-DNT are below the groundwater cleanup level listed in Table 16.

Based on site conditions and the screening of process options, six remedial alternatives were developed to address the presence of CTET, ethyl ether, TCE, and 2,6-DNT in the PBG Plume. Monitored Natural Attenuation (MNA) is expected to reduce the concentrations of the following VOCs by natural processes: CTET, chloroform, ethyl ether, and TCE. Active remedial alternatives were developed specifically for elevated concentrations of 2,6-DNT for the PBG Plume. Alternative 1 - No Action, provides a baseline to evaluate the other alternatives.

Alternative 1: No Action

The No Action Alternative is a mandatory evaluation that provides a baseline to evaluate the other alternatives. This alternative would have no impact on the contaminant plume and would not require groundwater monitoring of residential wells or monitoring wells. This alternative would include on-site groundwater access restrictions.

Alternative 2: Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation and Alternate Water Supply Alternative would continue the current remedial action approach and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement

Alternative 3: Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would target removing and treating impacted groundwater with elevated 2,6-DNT concentrations and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater removal through the installation of four groundwater extraction wells
- Groundwater treatment through the use of four mobile treatment units
- Groundwater disposal through the construction of piping leading to the Wisconsin River

Alternative 4: Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would target treating impacted groundwater with elevated 2,6-DNT concentrations and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater treatment through in-situ biochemical injection at nine permanent injection well locations directly downgradient of the source area
- Groundwater treatment through in-situ biochemical injection at 150 temporary locations (on-site and off-site)

Alternative 5: Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer wells (meeting qualifying criteria) within the PBG Plume area with deeper aquifer wells and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Replacement of as many as 47 existing residential wells

Alternative 6: Source Area Treatment

The Source Area Treatment Alternative would target treating impacted groundwater with elevated 2,6-DNT concentrations directly downgradient of the source area and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater treatment through in-situ biochemical injection at nine permanent injection well locations directly downgradient of the source area

9.1 Alternative 1 – No Action

The No Action Alternative would have no impact on any of the contaminant plumes and would not require groundwater monitoring of residential wells or monitoring wells. There would be no contaminant removal, treatment, containment or monitoring related to this alternative. As a condition of the Army’s property transfer, groundwater access restrictions would continue for areas within the BAAP boundary.

Overall Protection of Human Health and the Environment

Groundwater access is restricted within the BAAP boundary based on conditions of property transfer documentation. The groundwater access restrictions would require Army and WDNR authorization prior to well installation within the BAAP boundary; however, there are no groundwater access restrictions outside the BAAP boundary. This alternative would not provide any protection of human health or the environment beyond the groundwater access restrictions within the BAAP boundary. This alternative would result in the Army terminating the residential and monitoring well sampling program.

Compliance with ARARs

The residential and monitoring well sampling program is being conducted in accordance with the most recent regulatory approval. This alternative would result in the Army terminating the residential and monitoring well sampling program. This alternative would not comply with ARARs.

Long-Term Effectiveness and Permanence

This alternative would not provide an effective or permanent long-term solution. In this alternative, groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process (dilution, dispersion, and sorption). This alternative would result in the Army terminating the residential and monitoring well sampling program. Consequently, the degradation process would not be evaluated under this alternative.

Reduction of Toxicity, Mobility, and Volume through Treatment

Limited reductions in toxicity, mobility, and volume would occur through natural degradation processes only. This alternative would discontinue the residential and monitoring well sampling program. Consequently, the degradation process would not be evaluated.

Short-Term Effectiveness

There would be no action taken for this alternative. Since groundwater monitoring would be discontinued, any groundwater exceedances would go unidentified. Therefore, this alternative has no short-term effects.

Implementability

This alternative is inherently implementable as no remedial action would be taken.

Cost

There is no cost associated with the No Action Alternative.

9.2 Alternative 2 – Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation and Alternate Water Supply Alternative would include MNA for the PBG Plume, on-site groundwater access restrictions and a provision for an alternate water supply condition for residential wells. This alternative would also continue residential and monitoring well sampling of the PBG Plume as previously specified in Section 4.2 and Appendix D.

MNA relies on natural attenuation processes to achieve the RAO within a time frame that is reasonable compared to that offered by other more active remedial methods. MNA is expected to reduce the concentrations of the COCs that were carried forward in the development of remedial alternatives (see Section 7.1), which include CTET, ethyl ether, TCE, and 2,6-DNT. These natural attenuation processes include a variety of physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These in-situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

The Army currently has an environmental monitoring and health protection program in place that is protective of the residential water well users, “alternate water supply”. If a Chapter NR 140 ES is exceeded in a residential well once, bottled water is made available to the occupant. If the exceedance occurs a second, consecutive time, well replacement is offered to the owner. Bottled water would be made available to the occupant until the well is replaced, operational and water quality verified (typically 3 months and based on driller availability). If the NR 140 ES exceedance is not detected for two consecutive rounds after the first NR 140 ES exceedance detection, bottled water would be discontinued. To date, the Army has replaced three shallow residential wells within the PBG Plume.

Overall Protection of Human Health and the Environment

This alternative would provide protection of human health and the environment due to groundwater access restrictions within the BAAP boundary and the provision of an alternate water supply condition for residential wells. The groundwater sampling program would monitor the groundwater concentrations for compliance and contaminant reduction.

Compliance with ARARs

The residential and monitoring well sampling program is being conducted in accordance with the most recent regulatory approval. This alternative would continue the residential and groundwater monitoring program and comply with ARARs over time though natural degradation processes only.

Long-Term Effectiveness and Permanence

This alternative offers a long-term solution as groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process (dilution, dispersion, and sorption). This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition would address concerns associated with residential well impacts. Groundwater impacts are expected to remain and the groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

Limited reductions in toxicity, mobility, and volume is expected to occur through natural degradation processes only. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

This alternative offers a short-term solution as it is currently being applied and no additional work associated with implementation would be required. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition would address concerns associated with residential wells. If the alternate water supply provision is necessary, state licensed well drillers would be utilized for well replacement. The well drillers would be appropriately trained and would maintain applicable certifications to install any replacement well necessary.

Implementability

This alternative would be easily implementable as this action is currently being applied to the site. No remedial activities other than sampling under the MNA program would be performed. Groundwater access restrictions are already in place within BAAP.

Cost

The estimated total cumulative costs for Alternative 2 are shown below. See Appendix I for a summary of the costs for Alternative 2.

<u>Alternative 2 – Monitored Natural Attenuation and Alternate Water Supply</u>

Direct Capital Cost:	$	0
Indirect Capital Cost:	$	0
30 Years of Annual O&M:	$	4,913,113
Total Present Worth:	**$**	**4,913,113**

* Total costs use current rates and do not include inflation

9.3 Alternative 3 – Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would include groundwater extraction and treatment with mobile treatment units and continued groundwater monitoring of residential and monitoring wells. This alternative would also include on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 9.0, active remedial alternatives are only being developed for 2,6-DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the extraction wells would be strategically located to target elevated 2,6-DNT concentrations. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for 2,6-DNT.

It is anticipated that four extraction wells and four mobile treatment units (one treatment unit per extraction well) would be necessary for source area reduction and plume migration control. Four extraction wells were selected based on previous performance (capture zone) of extraction wells in this area. Generally, three of the extraction wells would be located on-site, south of the source area. The northern-most well would be located directly downgradient of the source area for source area reduction. The other two on-site extraction wells would be located in the southern portion of the on-site plume for migration control. One additional well would be located off-site, just south of the BAAP southern boundary, for migration control. Proposed pumping well locations and target pumping capture zones are shown on Drawing PBG-ALT 3 in Appendix J. The remainder of the PBG Plume located by Highway 78 would be allowed to degrade through natural processes, as no at-risk residential wells have been identified in this area.

Each extraction well is expected to pump at approximately 500 gpm. Similarly, each mobile treatment unit would be designed to treat 500 gpm. Based on previous experience with pump and treat systems in this area, groundwater flow velocities of 306 ft/yr (see Table 8) and assuming no additional source area contribution, the individual extraction wells and mobile treatment units are expected to operate continuously for various durations. The two extraction wells located in the southern on-site portion of the plume are expected to operate for at least 8 years. The extraction well located off-site is expected to operate for at least 6 years. The extraction well located closest to the source area is expected to operate for at least 2 years. The mobile treatment units are expected to use activated carbon as the primary treatment media as activated carbon has successfully treated DNT at BAAP. Site improvements including mobile treatment trailer staging area construction, electrical utility provision and site security would be necessary at each one of the extraction well/mobile treatment trailer areas.

A network of piping and appurtenances would be necessary to route extracted water from the extraction wells to the mobile treatment units and treated water from the mobile treatment units to a discharge location. Treated groundwater would ultimately discharge to the Wisconsin River. It is anticipated that the pump and treat system would require the services of an environmental technician to monitor and maintain the extraction wells and mobile treatment units.

Overall Protection of Human Health and the Environment

This alternative would be designed to control and limit the migration of and treat the groundwater with elevated 2,6-DNT concentrations. The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Compliance with ARARs

This alternative would be designed to comply with ARARs. The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

This alternative would be designed to reduce contaminant concentrations to comply with regulatory standards in groundwater through recovery and treatment of the portion of the PBG Plume with elevated 2,6-DNT concentrations. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. The previous pump and treat effort (MIRM) at the PBG showed effective DNT concentration reduction.

Based on previous experience, the groundwater pump and treat system's individual extraction wells and mobile treatment units are expected to operate continuously for various durations for up to eight years. The groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative is expected to result in reductions in toxicity, mobility, and volume through treatment of the PBG Plume with elevated 2,6-DNT concentrations. It is assumed that there would be no additional contribution of 2,6-DNT from the source areas into the groundwater. The previous pump and treat effort (MIRM) at the PBG showed effective 2,6-DNT concentration reduction. The groundwater contamination would also continue to decrease due to natural attenuation processes.

Short-Term Effectiveness

For this alternative, there would be some short-term effects to workers, residents and the environment during implementation. As described above, this alternative would require three on-site and one off-site extraction wells coupled with a mobile treatment unit for each extraction well. These locations would require construction of a staging area for the well and mobile treatment unit, security and electricity for the site for operations and lighting.

It is anticipated that from each extraction well to the mobile treatment unit and from the mobile treatment unit to a discharge location, a discharge pipe would be constructed. Treated water is expected to be discharged to the Wisconsin River.

There is some risk associated with the operation of heavy equipment for site preparation, well drilling, excavation, piping installation and backfilling; however, proper training and equipment would be required to mitigate these risks. Utility crossing, near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

To maximize contaminant reduction and plume migration control, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately one year. Construction and implementation of this alternative including well installation, piping construction, treatment area preparation and utility extension is expected to be completed in approximately one year.

Implementability

Equipment and materials required for construction of this alternative are readily available. However, extraction well and mobile treatment unit locations would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the PBG Plume. In addition, utilities to support the extraction wells and mobile treatment facility would need to be extended to the site, since none currently exist. The discharge line location would need to be determined and appropriate piping and appurtenance construction competed. The previous pump and treat discharge location to the Wisconsin River was identified during winter months with a high-visibility buoy system. This identified open water as a safety precaution to those who utilize the Wisconsin River in the winter for recreational activities such as ice fishing and snowmobiling. It is expected that a similar buoy system would be installed during the winter months and subsequently removed in the spring. This process of installation and decommissioning the buoy system would need to be repeated each winter and spring, respectively, as long as the system continued operation.

Cost

The estimated total cumulative costs for Alternative 3 are shown below. See Appendix I for a summary of the costs for Alternative 3.

Alternative 3 – Active Groundwater Remediation – Pump and Treat

Direct Capital Cost:	$ 3,633,573
Indirect Capital Cost:	$ 1,635,108
30 Years of Annual O&M:	$ 7,433,131
Total Cost:	**$ 12,701,812**

* Total costs use current rates and do not include inflation

9.4 Alternative 4 – Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would include in-situ anaerobic biodegradation targeting elevated concentrations of 2,6-DNT in groundwater and continued groundwater monitoring of residential and monitoring wells. This alternative would also include on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 9.0, active remedial alternatives are only being developed for 2,6-DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the in-situ biochemical injection locations would be strategically located to target elevated 2,6-DNT concentrations. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for 2,6-DNT.

For this alternative, a nutrient-enriched emulsified vegetable oil (EVO) is being proposed as the injection product. EVO has been used to stimulate in-situ anaerobic biodegradation of groundwater contaminants at commercial, industrial, and military sites. The procedures and applications of EVO are applicable to numerous anaerobically biodegradable contaminants including but not limited to chlorinated solvents, energetics, and nitrates.

The primary objective of injecting EVO into the groundwater is to stimulate the anaerobic biodegradation of the target contaminants. Groundwater aquifers are complex ecosystems populated by a broad and diverse array of microbial communities. The composition and activity of these microbial communities' changes continuously as their environment changes. Alterations in aquifer geochemistry and the availability of substrates and nutrients that can be used to generate energy and support growth and reproduction significantly affect microbial activity.

EVO would be distributed in the aquifer as an oil-in-water emulsion (mixture). In this approach, an oil-in-water emulsion would be first prepared using a food-grade oil, food-grade surfactants, and water. The emulsion would have small uniform droplets to allow transport in the aquifer. The emulsion would be injected into the aquifer (through injection wells or DPT) with additional water to distribute the oil droplets. The oil droplets would be distributed through the aquifer pore spaces and adhere to soil particles. The soil particle surfaces would gradually become coated with a thin layer of oil droplets that provide a carbon source for long-term anaerobic biodegradation. The oil droplets remain in the aquifer as a viable carbon source for approximately two years. Soluble substrates and nutrients (e.g., lactate, yeast extract, vitamins) can be added to the mixture prior to injection to stimulate rapid growth of desired bacteria. When the contaminated groundwater naturally flows toward and through the distributed EVO, the groundwater contaminants interact with the carbon source and break-down into less harmful byproducts.

It is anticipated that 159 injection points (both on-site and off-site and at varying stratigraphic depths) would be required to treat the plume. These injection points would be arranged in a series of eight treatment lines and consist of both permanent injection wells (nine) and temporary injection points (150). The nine permanent wells would be arranged in one treatment line located just downgradient of the source area. It is assumed that the source area would no longer contribute to the groundwater contamination. However, should this occur, the permanent wells could be utilized for additional injections. The other seven treatment lines consisting of temporary injection points would be located both on-site and off-site within the plume. Anticipated treatment line locations are shown on Drawing PBG-ALT 4 in Appendix J.

The spacing of the treatment lines is based on a groundwater flow velocity of 306 ft/yr (see Table 8) and the viability of the carbon source remaining in the aquifer for approximately two years. The distance between each treatment line is based on two years of treatment. Based on the geology and hydrogeology associated with the plume, a 25-foot radius of influence is anticipated to provide sufficient distribution of the EVO within the aquifer. The radius of influence is measured from the injection well or point location radially, out to the maximum extent of EVO product distribution. Each treatment line would be designed to fully capture contaminated groundwater migrating downgradient.

Though EVO is a proven technology to effectively treat chlorinated solvents and energetics, a field-scale pilot test would be necessary to determine the site specific constraints and a design to be developed to target 2,6-DNT within the plume at BAAP. Upon successful completion of a field-scale pilot test, the remedial design could be finalized.

Overall Protection of Human Health and the Environment

This alternative would be designed to meet the requirements of the RAO as it would effectively degrade the contaminants in the PBG Plume. The provision of the alternate water supply condition would address concerns associated with residential well impacts. Groundwater access restrictions would continue for areas within the BAAP.

Compliance with ARARs

Concentrations of contaminants in the treated area are expected to comply with ARARs relatively quickly (approximately two years). The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

This alternative would be designed to reduce the concentration in groundwater to comply with regulatory standards for 2,6-DNT. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. It is anticipated that a single round of injections of the biochemical product would be sufficient to treat the plume. Based on a groundwater flow velocity and the viability of the carbon source, treatment is expected to take approximately two years. However, depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications. The proposed biochemical product for use with this technology has shown successful contaminant reduction with explosives and chlorinated solvents; however, it has not been applied at full scale for 2,6-DNT treatment. Lastly, potential increases in groundwater table elevation may have the ability to mobilize residual contamination remaining in the vadose zone. The groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative is expected to reduce the toxicity, mobility, and volume of 2,6-DNT and chlorinated solvents in the treated areas more quickly than natural processes alone. It is assumed that there would be no additional contribution of 2,6-DNT from the source areas into the groundwater. The groundwater contamination would also continue to decrease due to natural attenuation processes.

Short-Term Effectiveness

There would be some short-term effects to workers, residents and the environment during implementation. As described above, this alternative would require both on-site and off-site injection points.

There is some risk associated with heavy equipment necessary for permanent injection well installation, temporary injection point installation and injection. Proper training and equipment would be required to mitigate these risks. The bioremediation is expected to occur over the course of two years and no additional worker safety issues have been identified. Near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

To maximize contaminant reduction, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately two years. Construction and implementation of this alternative including permanent well installation, temporary injection point installation, biochemical injection and injection point abandonment is expected to be completed in approximately one year.

Implementability

The installation of permanent injection wells and temporary injection points may be challenging at certain locations based on the stratigraphy. The area has been studied extensively and previous investigations have identified glacial outwash that may contain larger boulders. The potential stratigraphic obstructions may result in the need to change the location of permanent injection wells or temporary injection points.

Equipment and materials required for construction are readily available. However, permanent injection wells and temporary injection point locations would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the PBG Plume.

The biochemical product has been demonstrated to be effective in treating explosives and chlorinated solvents. Depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications.

Cost

The estimated total cumulative costs for Alternative 4 are shown below. See Appendix I for a summary of the costs for Alternative 4.

Alternative 4 – Active Groundwater Remediation – Anaerobic Bioremediation

Direct Capital Cost:	$ 3,254,729
Indirect Capital Cost:	$ 1,464,628
30 Years of Annual O&M:	$ 4,913,113
Total Cost:	**$ 9,632,470**

* Total costs use current rates and do not include inflation

9.5 Alternative 5 – Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer wells, meeting replacement criteria, within the PBG Plume area with deeper aquifer wells. This alternative would also include continued groundwater monitoring of residential and monitoring wells and on-site groundwater access restrictions.

A reasonable worst-case scenario was developed considering potential plume migration which resulted in the potential for 47 existing wells being impacted. If sampling results indicate an increasing trend for a plume's COC in three consecutive rounds and that the plume is migrating toward a residential well, the Army will evaluate if well replacement is necessary.

Based on deeper aquifer well information in the area, replacement wells would be drilled to approximately 500 feet below the existing ground surface and into the Mt. Simon Sandstone Formation. This formation is isolated from the shallow impacted groundwater by a confining shale layer. The 500-foot depth is necessary to satisfy water quality and production criteria. Wells would be installed by a state licensed well driller and would be cased to isolate the shallow aquifer from the deeper bedrock aquifer. Connections from the well to the dwelling would be completed. Well replacement would be completed with abandonment of the shallow well and restoration of disturbed areas.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health as potential receptors would be provided potable water from a deeper aquifer. Effectively, there would be no route of entry through groundwater consumption, eliminating the risk of exposure through groundwater. Groundwater access is restricted within the BAAP boundary based on conditions of property transfer documentation. The groundwater access restrictions would require Army and WDNR authorization prior to well installation within the BAAP boundary.

Compliance with ARARs

Groundwater monitoring would continue in monitoring and residential wells to monitor groundwater quality. Since the deep aquifer has been unimpacted by BAAP production or disposal activities, compliance with ARARs is expected. The contaminants within the plume are expected to comply with ARARs over time though natural degradation processes only.

Long-Term Effectiveness and Permanence

This alternative would be an effective long-term and permanent solution. These wells are expected to provide receptors with long-term access to potable water that has been unimpacted by BAAP production or disposal activities. This alternative would also continue to restrict groundwater access within the BAAP property. Groundwater contamination within the plume is expected to decrease over time due to natural degradation processes only. The groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

The well replacement alternative would eliminate the groundwater exposure pathway by providing potential receptors access to potable water from a deep aquifer. Limited reductions in toxicity, mobility, and volume of contaminants within the plume is expected to occur through natural degradation processes only. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

For this alternative, there would be some short-term effects to workers, residents and the environment during implementation. The alternative would require off-site well installation on private property. Wells would be installed by a state licensed well driller and would be cased to isolate the shallow aquifer from the deeper bedrock aquifer. There is some risk associated with heavy equipment necessary for well installation. Proper training and equipment would be required to mitigate these risks. Near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

Implementation and construction of this alternative is expected to be completed in approximately three months once qualifying criteria have been established for a residential well. Additional well replacements would be addressed as necessary upon establishment of qualifying criteria.

Implementability

Implementation of this alternative would involve well installation and residential connections on private property. Equipment and materials required for construction are readily available and wells would be installed by a state licensed well driller. However, well replacement would have to be coordinated with private land owners.

Cost

The estimated total cumulative costs for Alternative 5 are shown below. See Appendix I for a summary of the costs for Alternative 5.

Alternative 5 – Well Replacement – Plume Area

Direct Capital Cost:	$ 2,350,000
Indirect Capital Cost:	$ 1,057,500
30 Years of Annual O&M:	$ 4,511,746
Total Cost:	**$ 7,919,246**

* Total costs use current rates and do not include inflation

9.6 Alternative 6 – Source Area Treatment

The Source Area Treatment Alternative would involve in-situ biochemical injection to treat elevated 2,6-DNT concentrations directly downgradient of the source area. This alternative would also include continued groundwater monitoring of residential and monitoring wells, on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 9.0, active remedial alternatives are only being developed for 2,6-DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the in-situ biochemical injection locations would be strategically located to target elevated 2,6-DNT concentrations directly downgradient of the source area. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for 2,6-DNT.

For this alternative, a nutrient-enriched emulsified vegetable oil (EVO) is being proposed as the injection product. EVO has been used to stimulate in-situ anaerobic biodegradation of groundwater contaminants at commercial, industrial, and military sites. The procedures and applications of EVO are applicable to numerous anaerobically biodegradable contaminants including but not limited to chlorinated solvents, energetics, and nitrates.

The primary objective of injecting EVO into the groundwater is to stimulate the anaerobic biodegradation of the target contaminants. Groundwater aquifers are complex ecosystems populated by a broad and diverse array of microbial communities. The composition and activity of these microbial communities’ changes continuously as their environment changes. Alterations in aquifer geochemistry and the availability of substrates and nutrients that can be used to generate energy and support growth and reproduction significantly affect microbial activity.

EVO would be distributed in the aquifer as an oil-in-water emulsion (mixture). In this approach, an oil-in-water emulsion would be first prepared using a food-grade oil, food-grade surfactants, and water. The emulsion would have small uniform droplets to allow transport in the aquifer. The emulsion would be injected into the aquifer (through injection wells or direct-push-technology) with additional water to distribute the oil droplets. The oil droplets would be distributed through the aquifer pore spaces and adhere to soil particles. The soil particle surfaces would gradually become coated with a thin layer of oil droplets that provide a carbon source for long-term anaerobic biodegradation. The oil droplets remain in the aquifer as a viable carbon source for approximately two years. Soluble substrates and nutrients (e.g., lactate, yeast extract, vitamins) can be added to the mixture prior to injection to stimulate rapid growth of desired bacteria. When the contaminated groundwater naturally flows toward and through the distributed EVO, the groundwater contaminants interact with the carbon source and break-down into less harmful byproducts.

It is anticipated that nine permanent injection wells would be installed and arranged in one treatment line located just downgradient of the source area. It is assumed that the source area would no longer contribute to the groundwater contamination. However, should this occur, the permanent wells could be utilized for additional injections. Anticipated treatment line locations are shown on Drawing PBG-ALT 6 in Appendix J.

The spacing of the treatment lines is based on a groundwater flow velocity of 306 ft/yr (see Table 8) and the viability of the carbon source remaining in the aquifer for approximately two years. Based on the geology and hydrogeology associated with the plume, a 25-foot radius of influence is anticipated to provide sufficient distribution of the EVO within the aquifer. The radius of influence is measured from the injection well or point location radially, out to the maximum extent of EVO product distribution. Each treatment line would be designed to fully capture contaminated groundwater migrating downgradient.

Though EVO is a proven technology to effectively treat chlorinated solvents and energetics, a field-scale pilot test would be necessary to determine the site specific constraints and a design to be developed to target 2,6-DNT within the PBG Plume. Upon successful completion of a field-scale pilot test, the remedial design could be finalized.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. This alternative would be designed to treat the highest concentrations of 2,6-DNT in the PBG Plume directly downgradient of the source area. The remainder of the plume would degrade over time through natural processes only; however, the provision of the alternate water supply condition would address concerns associated with residential well impacts. Groundwater access restrictions would continue for areas within the BAAP.

Compliance with ARARs

Concentrations of contaminants in the treated area are expected to comply with ARARs relatively quickly (approximately two years). The remainder of the plume would degrade over time through natural processes only; however, the provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

It is anticipated that this alternative would be effective in the long term as the highest concentrations of 2,6-DNT would be treated directly downgradient of the source area. It is anticipated that a single round of injections of the biochemical product would be sufficient to treat the highest concentrations in the plume directly downgradient of the source. Based on a groundwater flow velocity and the viability of the carbon source, treatment is expected to take at approximately two years. However, depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications. The proposed biochemical product for use with this technology has shown successful contaminant reduction with explosives and chlorinated solvents; however, it has not been applied at full scale for 2,6-DNT treatment. Lastly, potential increases in groundwater table elevation may have the ability to mobilize residual contamination remaining in the vadose zone. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. The groundwater monitoring program is expected to continue at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative would reduce toxicity, mobility and volume of 2,6-DNT and chlorinated solvents in the treated areas more quickly than natural processes alone. It is assumed that there would be no additional contribution of 2,6-DNT from the source areas into the groundwater. Parts of the plume untreated are expected to decrease in concentration due to natural degradation processes. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

There would be minimal short-term effects to workers, residents and the environment during implementation as most of the work would be completed on-site. Generally, there is some risk associated with heavy equipment necessary for well installation and injection. Proper training and equipment would be required to mitigate these risks.

To maximize contaminant reduction, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately two years. Construction and implementation of this alternative including permanent injection well installation, temporary injection point installation, biochemical injection and injection point abandonment is expected to be complete in approximately one year.

Implementability

The installation of the permanent injection wells may be challenging at certain locations based on the stratigraphy. The area has been studied extensively and previous investigations have identified glacial outwash that may contain larger boulders. The potential stratigraphic obstructions may result in the need to change the location of the permanent injection wells.

Equipment and materials required for construction are readily available. However, permanent injection well locations would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the PBG Plume.

The biochemical product has been demonstrated to be effective in treating explosives and chlorinated solvents. Depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications.

Cost

The estimated total cumulative costs for Alternative 6 are shown below. See Appendix I for a summary of the costs for Alternative 6.

Alternative 6 – Source Area Treatment

Direct Capital Cost:	$ 201,433
Indirect Capital Cost:	$ 90,645
30 Years of Annual O&M:	$ 4,913,113
Total Cost:	**$ 5,205,190**

* Total costs use current rates and do not include inflation

9.7 PBG Plume Remedial Alternative Summary

A summary of the cleanup timeframe, treatment duration, groundwater monitoring duration, and cost for each of the six proposed remedial alternatives for the PBG Plume is presented below.

Propellant Burning Ground Plume
Remedial Alternative Summary

Alternative	Time to Achieve Cleanup	Active Treatment Duration	Groundwater Monitoring Duration	Total Cost
Alternative 1 – No Action	NA	NA	NA	$0
Alternative 2 – MNA and Alternate Water Supply	30 Years	NA	30 Years	$4.9
Alternative 3 – Pump and Treat	30 Years	8 Years	30 Years	$12.7
Alternative 4 – Anaerobic Bioremediation	30 Years	2 Years	30 Years	$9.6
Alternative 5 – Well Replacement	30 Years	NA	30 Years	$7.9
Alternative 6 – Source Area Treatment	30 Years	2 Years	30 Years	$5.2

Notes: Total cost in millions of dollars & includes direct capital, indirect capital and annual operation and maintenance costs. Total cost is based on current rates and does not include inflation.

An evaluation criteria summary of the proposed remedial alternatives for the PBG Plume is presented below. Each of the six proposed alternatives are listed in the left column. As described in Section 8.8, nine evaluation criteria have been developed to serve as the basis for conducting a detailed analysis of the remedial alternatives. The nine criteria include threshold, primary balancing and modifying criteria are listed below in the top row. The two modifying criteria (State Acceptance and Community Acceptance) are incorporated during the remedy selection stage and presented in the Proposed Plan.

An objective and qualitative evaluation was completed to compare the six proposed remedial alternatives. A designation of “H” represents a high confidence of the alternative meeting the criteria. Similarly, a designation of “L” represents a low and “M” represents a moderate confidence of the alternative meeting the criteria. A designation of “N” represents no confidence of the alternative meeting the criteria and a designation of “TBD” represents to be determined. The designations are supported by their respective preceding text section for each remedial alternative and were made in relation to other alternatives. Approximate total costs for each remedial alternative are shown in the right column.

Propellant Burning Ground Plume Evaluation Criteria Summary

Alternative	Evaluation Criteria								
	Overall Protection to Human Health & Environment	Compliance with ARARs	Long-Term Effectiveness & Permanence	Reduction in Toxicity, Mobility & Volume Through Treatment	Short-Term Effectiveness	Implementability	State Acceptance	Community Acceptance	Total Cost (1)(2)
Alternative 1 – No Action • Groundwater access restrictions	L	N	N	N	N	H	TBD	TBD	$0
Alternative 2 – MNA and Alternate Water Supply • Groundwater access restrictions • Groundwater monitoring • Alternate water supply	M	L	M	L	M	H	TBD	TBD	$4.9
Alternative 3 – Pump and Treat (3) • Extraction wells (four) • Mobile treatment units (four)	H	H	H	H	M	M	TBD	TBD	$12.7
Alternative 4 – Anaerobic Bioremediation (3) • Permanent injection wells (nine) • Temporary injection points (150)	H	H	M	H	M	M	TBD	TBD	$9.6
Alternative 5 – Well Replacement (4) • Replacement of residential wells (47)	M	M	H	L	M	M	TBD	TBD	$7.9
Alternative 6 – Source Area Treatment (3) • Permanent injection wells (nine)	M	M	M	M	H	M	TBD	TBD	$5.2

Notes: H – High, L – Low, M – Moderate, N – None, TBD – To Be Determined.
(1) Cost in millions of dollars & includes direct capital, indirect capital and annual operation and maintenance costs.
(2) Based on current rates and does not include inflation.
(3) Alternative includes groundwater access restrictions, groundwater monitoring and alternate water supply.
(4) Alternative includes groundwater access restrictions and groundwater monitoring.

10.0 REMEDIAL ALTERNATIVES – DBG PLUME

As identified in Section 7.2, total DNT was the only risk-related COC considered for the development of remedial alternatives in the DBG Plume. The RAO for the DBG Plume requires the remedy to protect human health by preventing exposure to contaminated groundwater, to minimize the impact of the contaminants on the environment, and to restore groundwater to the extent practicable. The RAO for the DBG Plume will be achieved when groundwater concentrations of total DNT are below the groundwater cleanup level listed in Table 16.

Based on site conditions and the screening of process options, six remedial alternatives were developed to address the presence of total DNT in the DBG Plume. Alternative 1 - No Action, provides a baseline to evaluate the other alternatives.

Alternative 1: No Action

The No Action Alternative is a mandatory evaluation that provides a baseline to evaluate the other alternatives. This alternative would have no impact on the contaminant plume and would not require groundwater monitoring of residential wells or monitoring wells. This alternative would include on-site groundwater access restrictions.

Alternative 2: Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation and Alternate Water Supply Alternative would continue the current remedial action approach and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement

Alternative 3: Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would target removing and treating impacted groundwater with elevated total DNT concentrations and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater removal through the installation of three groundwater extraction wells
- Groundwater treatment through the use of three mobile treatment units
- Groundwater disposal through the construction of piping leading to the Wisconsin River

Alternative 4: Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would target treating impacted groundwater with elevated total DNT concentrations and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater treatment through in-situ biochemical injection at 406 temporary locations (on-site and off-site)

Alternative 5: Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing all shallow aquifer wells (meeting qualifying criteria) within the DBG Plume area with deeper aquifer wells and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Replacement of as many as 57 existing residential wells

Alternative 6: Source Area Treatment

The Source Area Treatment Alternative would target treating impacted groundwater with elevated total DNT concentrations directly downgradient of the source area and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater treatment through in-situ biochemical injection at 56 temporary on-site locations

10.1 Alternative 1 – No Action

The No Action Alternative would have no impact on any of the contaminant plumes and would not require groundwater monitoring of residential wells or monitoring wells. There would be no contaminant removal, treatment, containment or monitoring related to this alternative. As a condition of the Army’s property transfer, groundwater access restrictions would continue for areas within the BAAP boundary.

Overall Protection of Human Health and the Environment

Groundwater access is restricted within the BAAP boundary based on conditions of property transfer documentation. The groundwater access restrictions would require Army and WDNR authorization prior to well installation within the BAAP boundary; however, there are no groundwater access restrictions outside the BAAP boundary. This alternative would not provide any protection of human health or the environment beyond the groundwater access restrictions within the BAAP boundary. This alternative would result in the Army terminating the residential and monitoring well sampling program.

Compliance with ARARs

The residential and monitoring well sampling program is being conducted in accordance with the most recent regulatory approval. This alternative would result in the Army terminating the residential and monitoring well sampling program. This alternative would not comply with ARARs.

Long-Term Effectiveness and Permanence

This alternative would not provide an effective or permanent long-term solution. In this alternative, groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process (dilution, dispersion, and sorption). This alternative would result in the Army terminating the residential and monitoring well sampling program. Consequently, the degradation process would not be evaluated under this alternative.

Reduction of Toxicity, Mobility, and Volume through Treatment

Limited reductions in toxicity, mobility, and volume would occur through natural degradation processes only. This alternative would discontinue the sampling of residential and groundwater monitoring wells. Consequently, the degradation process would not be evaluated.

Short-Term Effectiveness

There would be no action taken for this alternative. Since groundwater monitoring would be discontinued, any groundwater exceedances would go unidentified. Therefore, this alternative has no short-term effects.

Implementability

This alternative is inherently implementable as no remedial action would be taken.

Cost

There is no cost associated with the No Action Alternative.

10.2 Alternative 2 – Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation and Alternate Water Supply Alternative would include MNA for the DBG Plume, on-site groundwater access restrictions and a provision for an alternate water supply condition for residential wells. This alternative would also continue residential and monitoring well sampling of the DBG Plume as previously specified in Section 4.2 and Appendix D.

MNA relies on natural attenuation processes to achieve the RAO within a time frame that is reasonable compared to that offered by other more active remedial methods. MNA is expected to reduce the concentrations of the COCs that were carried forward in the development of remedial alternatives (see Section 7.2), which includes only total DNT. These natural attenuation processes include a variety of physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These in-situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

The Army currently has an environmental monitoring and health protection program in place that is protective of the residential water well users, "alternate water supply". If a Chapter NR 140 ES is exceeded in a residential well once, bottled water is made available to the occupant. If the exceedance occurs a second, consecutive time, well replacement is offered to the owner. Bottled water would be made available to the occupant until the well is replaced, operational and water quality verified (typically 3 months and based on driller availability). If the NR 140 ES exceedance is not detected for two consecutive rounds after the first NR 140 ES exceedance detection, bottled water would be discontinued. The Army has replaced one residential well associated with the DBG Plume that has been impacted by total DNT.

Overall Protection of Human Health and the Environment

This alternative would provide protection of human health and the environment due to groundwater access restrictions within the BAAP boundary and the provision of an alternate water supply condition for residential wells. The groundwater sampling program would monitor the groundwater concentrations for compliance and contaminant reduction.

Compliance with ARARs

The residential and monitoring well sampling program is being conducted in accordance with the most recent regulatory approval. This alternative would continue the residential and groundwater monitoring program and comply with ARARs over time through natural degradation processes only.

Long-Term Effectiveness and Permanence

This alternative offers a long-term solution as groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process (dilution, dispersion, and sorption). The alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition would address concerns associated with residential well impacts. Groundwater impacts are expected to remain and the groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

Limited reductions in toxicity, mobility, and volume is expected to occur through natural degradation processes only. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

This alternative offers a short-term solution as it is currently being applied and no additional work associated with implementation would be required. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition would address concerns associated with residential wells. If the alternate water supply provision is necessary, state licensed well drillers would be utilized for well replacement. The well drillers would be appropriately trained and would maintain applicable certifications to install any replacement well necessary.

Implementability

This alternative would be easily implementable as this action is currently being applied to the site. No remedial activities other than sampling under the MNA program would be performed. Groundwater access restrictions are already in place within BAAP.

Cost

The estimated total cumulative costs for Alternative 2 are shown below. See Appendix I for a summary of the costs for Alternative 2.

Alternative 2 – Monitored Natural Attenuation

Direct Capital Cost:	$	0
Indirect Capital Cost:	$	0
30 Years of Annual O&M:	$	4,240,490
Total Present Worth:	**$**	**4,240,490**

* Total costs use current rates and do not include inflation

10.3 Alternative 3 – Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would include groundwater extraction and treatment with mobile treatment units and continued groundwater monitoring of residential and monitoring wells. This alternative would also include on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 10.0, active remedial alternatives are only being developed for total DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the extraction wells would be strategically located to target elevated total DNT concentrations. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for total DNT.

It is anticipated that three extraction wells and three mobile treatment units (one treatment unit per extraction well) would be necessary to provide source control and minimize off site migration of the plume. Three extraction wells were selected based on previous performance (capture zone) of extraction wells located in the PBG Plume area. One extraction well would be located directly downgradient of the source area (on-site), along the long axis of the plume, and within the highest total DNT concentration for source control. The other on-site extraction well would be located at the BAAP boundary to minimize off-site plume migration. One additional extraction well would be located off-site toward the southeastern end of the DBG Plume. Proposed pumping well locations and target pumping capture zones are shown on Drawing DBG-ALT 3 in Appendix J.

Each extraction well is expected to pump at approximately 500 gpm. Similarly, each mobile treatment unit would be designed to treat 500 gpm. Based on previous experience with pump and treat systems at BAAP (MIRM), groundwater flow velocities of 109 ft/yr (see Table 8) and assuming no additional source area contribution, the individual extraction wells and mobile treatment units are expected to operate continuously for various durations. The extraction well located closest to the source area is expected to operate for at least 10 years. The two other extraction wells are expected to operate for at least 22 years. The mobile treatment units are expected to use activated carbon as the primary treatment media as activated carbon has successfully treated DNT at BAAP. Site improvements including mobile treatment trailer staging area construction, electrical utility provision and site security would be necessary at each one of the extraction well/mobile treatment trailer areas.

A network of piping and appurtenances would be necessary to route extracted water from the extraction wells to the mobile treatment units and treated water from the mobile treatment units to a discharge pipeline leading to the Wisconsin River. It is anticipated that the pump and treat system would require the services of an environmental technician to monitor and maintain the extraction wells and mobile treatment units.

Overall Protection of Human Health and the Environment

This alternative would be designed to control and limit the migration of and treat the groundwater with elevated total DNT concentrations. The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Compliance with ARARs

This alternative would be designed to comply with ARARs. The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

This alternative would be designed to reduce contaminant concentrations to comply with regulatory standards in groundwater through recovery and treatment of the portion of the DBG Plume with elevated total DNT concentrations. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. A similar pump and treat system was operated at BAAP (MIRM) and showed effective DNT concentration reduction.

Based on previous experience, the groundwater pump and treat system's individual extraction wells and mobile treatment units are expected to operate continuously for various durations for up to 22 years. The groundwater monitoring program is expected to continue for at least 24 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative is expected to result in reductions in toxicity, mobility, and volume through treatment of the DBG Plume with elevated total DNT concentrations. It is assumed that there would be no additional contribution of total DNT from the source areas into the groundwater. The previous performance of this technology at the BAAP (MIRM), showed effective DNT concentration reduction. The groundwater contamination would also continue to decrease due to natural attenuation processes.

Short-Term Effectiveness

For this alternative there would be some short-term effects to workers, residents and the environment during implementation. As described above, the technology would require two on-site and one off-site extraction wells coupled with a mobile treatment units for each extraction well. These locations would require construction of a staging area for the well and mobile treatment trailer, security and electricity for the site for operations and lighting.

It is anticipated that a new discharge pipeline would need to be constructed for the mobile treatment unit's discharge. From each extraction well and mobile treatment unit staging areas a discharge pipe would be constructed to transport treated water to the discharge piping leading to the Wisconsin River.

There is some risk associated with the operation of heavy equipment for site preparation, well drilling, excavation, piping installation and backfilling; however, proper training and equipment would be required to mitigate these risks. Utility crossing, near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

To maximize contaminant reduction and plume migration control, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately one year. Construction and implementation of this alternative including well installation, piping construction, treatment area preparation and utility extension is expected to be completed in approximately one year.

Implementability

Equipment and materials required for construction of this alternative are readily available. However, extraction well and mobile treatment unit locations would have to be coordinated carefully and with input from the existing land owners as they are responsible for the ownership and/or management of the area around the DBG Plume. In addition, utilities to support the extraction wells and mobile treatment facility would need to be extended to the site, since none currently exist. The discharge line location would need to be determined and appropriate piping and appurtenance construction competed. The discharge location to the Wisconsin River would need to be identified during winter months with a high-visibility buoy system. This would identify open water as a safety precaution to those who utilize the Wisconsin River in the winter for recreational activities such as ice fishing and snowmobiling. It is expected that this buoy system would be installed during the winter months and subsequently removed in the spring. This process of installation and decommissioning the buoy system would need to be repeated each winter and spring, respectively, as long as the system continued operation.

Cost

The estimated total cumulative costs for Alternative 3 are shown below. See Appendix I for a summary of the costs for Alternative 3.

Alternative 3 – Active Groundwater Remediation – Pump and Treat

Direct Capital Cost:	$ 2,776,030
Indirect Capital Cost:	$ 1,249,214
24 Years of Annual O&M:	$ 8,522,395
Total Cost:	**$ 12,547,639**

* Total costs use current rates and do not include inflation

10.4 Alternative 4 – Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would include in-situ anaerobic biodegradation targeting elevated concentrations of total DNT in groundwater and continued groundwater monitoring of residential and monitoring wells. This alternative would also include on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 10.0, active remedial alternatives are only being developed for total DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the in-situ biochemical injection locations would be strategically located to target elevated total DNT concentrations. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for total DNT.

For this alternative, a nutrient-enriched emulsified vegetable oil (EVO) is being proposed as the injection product. EVO has been used to stimulate in-situ anaerobic biodegradation of groundwater contaminants at commercial, industrial, and military sites. The procedures and applications of EVO are applicable to numerous anaerobically biodegradable contaminants including but not limited to chlorinated solvents, energetics, and nitrates.

The primary objective of injecting EVO into the groundwater is to stimulate the anaerobic biodegradation of the target contaminants. Groundwater aquifers are complex ecosystems populated by a broad and diverse array of microbial communities. The composition and activity of these microbial communities' changes continuously as their environment changes. Alterations in aquifer geochemistry and the availability of substrates and nutrients that can be used to generate energy and support growth and reproduction significantly affect microbial activity.

EVO would be distributed in the aquifer as an oil-in-water emulsion (mixture). In this approach, an oil-in-water emulsion would be first prepared using a food-grade oil, food-grade surfactants, and water. The emulsion would have small uniform droplets to allow transport in the aquifer. The emulsion would be injected into the aquifer (through injection wells or DPT) with additional water to distribute the oil droplets. The oil droplets would be distributed through the aquifer pore spaces and adhere to soil particles. The soil particle surfaces would gradually become coated with a thin layer of oil droplets that provide a carbon source for long-term anaerobic biodegradation. The oil droplets remain in the aquifer as a viable carbon source for approximately two years. Soluble substrates and nutrients (e.g., lactate, yeast extract, vitamins) can be added to the mixture prior to injection to stimulate rapid growth of desired bacteria. When the contaminated groundwater naturally flows toward and through the distributed EVO, the groundwater contaminants interact with the carbon source and break-down into less harmful byproducts.

It is anticipated that 406 injection points (both on-site and off-site and at varying stratigraphic depths) would be required to treat the plume. These injection points would be arranged in a series of 29 treatment lines and consist of temporary injection points. It is assumed that the source area would no longer contribute to the groundwater contamination. Anticipated treatment line locations are shown on Drawing DBG-ALT 4 in Appendix J.

The spacing of the treatment lines is based on a groundwater flow velocity of 109 ft/yr (see Table 8) and the viability of the carbon source remaining in the aquifer for approximately two years. The distance between each treatment line is based on two years of treatment. Based on the geology and hydrogeology associated with the plume, a 25-foot radius of influence is anticipated to provide sufficient distribution of the EVO within the aquifer. The radius of influence is measured from the injection well or point location radially, out to the maximum extent of EVO product distribution. Each treatment line would be designed to fully capture contaminated groundwater migrating downgradient.

Though EVO is a proven technology to effectively treat chlorinated solvents and energetics, a field-scale pilot test would be necessary to determine the site specific constraints and a design to be developed to target total DNT within the plume at BAAP. Upon successful completion of a field-scale pilot test, the remedial design could be finalized.

Overall Protection of Human Health and the Environment

This alternative would be designed to meet the requirements of the RAO as it would effectively degrade the contaminants in the DBG Plume. The provision of the alternate water supply condition would address concerns associated with residential well impacts. Groundwater access restrictions would continue for areas within the BAAP.

Compliance with ARARs

Concentrations of contaminants in the treated area are expected to comply with ARARs relatively quickly (approximately two years). The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

This alternative would be designed to reduce the concentration in groundwater to comply with regulatory standards for total DNT. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. Several issues have been identified regarding the alternative’s long-term effectiveness and permanence. It is anticipated that a single round of injections of the biochemical product would be sufficient to treat the plume. Based on a groundwater flow velocity and the viability of the carbon source, treatment is expected to take approximately two years. However, depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications. The proposed biochemical product for use with this technology has shown successful contaminant reduction with chlorinated solvents; however, it has not been applied at full scale for total DNT treatment. The groundwater monitoring program is expected to continue for at least four years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative is expected to reduce the toxicity, mobility, and volume of total DNT and chlorinated solvents in the treated areas more quickly than natural processes alone. It is assumed that there would be no additional contribution of total DNT from the source areas into the groundwater. The groundwater contamination would also continue to decrease due to natural attenuation processes.

Short-Term Effectiveness

There would be some short-term effects to workers, residents and the environment during implementation. As described above, this alternative would require both on-site and off-site injection points.

There is some risk associated with heavy equipment necessary for temporary injection point installation and injection. Proper training and equipment would be required to mitigate these risks. The bioremediation is expected to occur over the course of two years and no additional worker safety issues have been identified. Near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

To maximize contaminant reduction, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately two years. Construction and implementation of this alternative including temporary injection point installation, biochemical injection and injection point abandonment is expected to be completed in approximately one year.

Implementability

The installation of temporary injection points may be challenging at certain locations based on the stratigraphy. The area has been studied extensively and previous investigations have identified glacial outwash that may contain larger boulders. The potential stratigraphic obstructions may result in the need to change locations of temporary injection points.

Equipment and materials required for construction are readily available. However, temporary injection point locations would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the DBG Plume.

The biochemical product has been demonstrated to be effective in treating explosives and chlorinated solvents. Depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications.

Cost

The estimated total cumulative costs for Alternative 4 are shown below. See Appendix I for a summary of the costs for Alternative 4.

Alternative 4 – Active Groundwater Remediation – Anaerobic Bioremediation

Direct Capital Cost:	$ 8,107,868
Indirect Capital Cost:	$ 3,648,540
4 Years of Annual O&M:	$ 706,748
Total Cost:	**$ 12,463,156**

* Total costs use current rates and do not include inflation

10.5 Alternative 5 – Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer wells, meeting replacement criteria, within the DBG Plume area with deeper aquifer wells. This alternative would also include continued groundwater monitoring of residential and monitoring wells and on-site groundwater access restrictions.

A reasonable worst-case scenario was developed considering potential plume migration which resulted in the potential for 57 existing wells being impacted. If sampling results indicate an increasing trend for a plume's COC in three consecutive rounds and that the plume is migrating toward a residential well, the Army will evaluate if well replacement is necessary.

Based on deeper aquifer well information in the area, replacement wells would be drilled to approximately 400 feet below the existing ground surface and into the Mt. Simon Sandstone

Formation. This sandstone formation is isolated from the shallow impacted groundwater by a confining layer of dolomite, shale, and siltstone. The 400-foot depth is necessary to satisfy water quality and production criteria. Wells would be installed by a state licensed well driller and would be cased to isolate the shallow aquifer from the deeper bedrock aquifer. Connections from the well to the dwelling would be completed. Well replacement would be completed with abandonment of the shallow well and restoration of disturbed areas.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health as potential receptors would be provided potable water from a deeper aquifer. Effectively, there would be no route of entry through groundwater consumption, eliminating the risk of exposure through groundwater. Groundwater access is restricted within the BAAP boundary based on conditions of property transfer documentation. The groundwater access restrictions would require Army and WDNR authorization prior to well installation within the BAAP boundary.

Compliance with ARARs

Groundwater monitoring would continue in monitoring and residential wells to monitor groundwater quality. Since the deep aquifer has been unimpacted by BAAP production or disposal activities, compliance with ARARs is expected. The contaminants within the plume are expected to comply with ARARs over time through natural degradation processes only.

Long-Term Effectiveness and Permanence

This alternative would be an effective long-term and permanent solution. These wells are expected to provide receptors with long-term access to potable water that has been unimpacted by BAAP production or disposal activities. This alternative would also continue to restrict groundwater access within the BAAP property. Groundwater contamination within the plume is expected to decrease over time due to natural degradation processes only. The groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative would eliminate the groundwater exposure pathway by providing potential receptors access to potable water from a deep aquifer. Limited reductions in toxicity, mobility, and volume of contaminants within the plume is expected to occur through natural degradation processes only. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

For this alternative, there would be some short-term effects to workers, residents and the environment during implementation. The alternative would require off-site well installation on private property. Wells would be installed by a state licensed well driller and would be cased to isolate the shallow aquifer from the deeper bedrock aquifer. There is some risk associated with heavy equipment necessary for well installation. Proper training and equipment would be required to mitigate these risks. Near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

Implementation and construction of this alternative is expected to be completed in approximately three months once qualifying criteria have been established for a residential well. Additional well replacements would be addressed as necessary upon establishment of qualifying criteria.

Implementability

Implementation of this alternative would involve well installation and residential connections on private property. Equipment and materials required for construction are readily available and wells would be installed by a state licensed well driller. However, well replacement would have to be coordinated with private land owners.

Cost

The estimated total cumulative costs for Alternative 5 are shown below. See Appendix I for a summary of the costs for Alternative 5.

Alternative 5 – Well Replacement – Plume Area

Direct Capital Cost:	$	2,280,000
Indirect Capital Cost:	$	1,026,000
30 Years of Annual O&M:	$	3,839,123
Total Cost:	**$**	**7,145,123**

* Total costs use current rates and do not include inflation

10.6 Alternative 6 – Source Area Treatment

The Source Area Treatment Alternative would involve in-situ biochemical injection to treat elevated total DNT concentrations directly downgradient of the source area. This alternative would also include continued groundwater monitoring of residential and monitoring wells, on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 10.0, active remedial alternatives are only being developed for total DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the in-situ biochemical injection locations would be strategically located to target elevated total DNT concentrations directly downgradient of the source area. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for total DNT.

For this alternative, a nutrient-enriched emulsified vegetable oil (EVO) is being proposed as the injection product. EVO has been used to stimulate in-situ anaerobic biodegradation of groundwater contaminants at commercial, industrial, and military sites. The procedures and applications of EVO are applicable to numerous anaerobically biodegradable contaminants including but not limited to chlorinated solvents, energetics, and nitrates.

The primary objective of injecting EVO into the groundwater is to stimulate the anaerobic biodegradation of the target contaminants. Groundwater aquifers are complex ecosystems populated by a broad and diverse array of microbial communities. The composition and activity of these microbial communities' changes continuously as their environment changes. Alterations in aquifer geochemistry and the availability of substrates and nutrients that can be used to generate energy and support growth and reproduction significantly affect microbial activity.

EVO would be distributed in the aquifer as an oil-in-water emulsion (mixture). In this approach, an oil-in-water emulsion would be first prepared using a food-grade oil, food-grade surfactants, and water. The emulsion would have small uniform droplets to allow transport in the aquifer. The emulsion would be injected into the aquifer (through injection wells or direct-push-technology) with additional water to distribute the oil droplets. The oil droplets would be distributed through the aquifer pore spaces and adhere to soil particles. The soil particle surfaces would gradually become coated with a thin layer of oil droplets that provide a carbon source for long-term anaerobic biodegradation. The oil droplets remain in the aquifer as a viable carbon source for approximately two years. Soluble substrates and nutrients (e.g., lactate, yeast extract, vitamins) can be added to the mixture prior to injection to stimulate rapid growth of desired bacteria. When the contaminated groundwater naturally flows toward and through the distributed EVO, the groundwater contaminants interact with the carbon source and break-down into less harmful byproducts.

It is anticipated that 56 temporary injection points would be installed on-site. These injection points would be arranged in a series of four treatment lines located just downgradient of the source area. It is assumed that the source area would no longer contribute to the groundwater contamination. Anticipated treatment line locations are shown on Drawing DBG-ALT 6 in Appendix J.

The spacing of the treatment lines is based on a groundwater flow velocity of 109 ft/yr (see Table 8) and the viability of the carbon source remaining in the aquifer for approximately two years. Based on the geology and hydrogeology associated with the plume, a 25-foot radius of influence is anticipated to provide sufficient distribution of the EVO within the aquifer. The radius of influence is measured from the injection well or point location radially, out to the maximum extent of EVO product distribution. Each treatment line would be designed to fully capture contaminated groundwater migrating downgradient.

Though EVO is a proven technology to effectively treat chlorinated solvents and energetics, a field-scale pilot test would be necessary to determine the site specific constraints and a design to be developed to target total DNT within the DBG Plume. Upon successful completion of a field-scale pilot test, the remedial design could be finalized.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. This alternative would be designed to treat the highest concentrations of total DNT in the DBG Plume. The provision of the alternate water supply condition would address concerns associated with residential well impacts. Groundwater access restrictions would continue for areas within the BAAP.

Compliance with ARARs

Concentrations of contaminants in the treated area are expected to comply with ARARs relatively quickly (approximately two years). The remainder of the plume’s contamination would decrease over time through natural processes only; however, the provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

It is anticipated that this alternative would be effective in the long term as the highest concentrations of total DNT would be treated directly downgradient of the source area. It is anticipated that a single round of injections of the biochemical product would be sufficient to treat the highest concentrations in the plume directly downgradient of the source area. Based on a groundwater flow velocity and the viability of the carbon source, treatment is expected to take at approximately two years. However, depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications. The proposed biochemical product for use with this technology has shown successful contaminant reduction with explosives and chlorinated solvents; however, it has not been applied at full scale for total DNT treatment. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. The groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative would reduce toxicity, mobility and volume of total DNT and chlorinated solvents in the treated areas more quickly than natural processes alone. It is assumed that there would be no additional contribution of total DNT from the source areas into the groundwater. Portions of the plume untreated are expected to decrease in concentration due to natural attenuation processes. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

There would be minimal short-term effects to workers, residents and the environment during implementation as most of the work would be completed on-site. Generally, there is some risk associated with heavy equipment necessary for temporary injection point installation, and injection. Proper training and equipment would be required to mitigate these risks.

To maximize contaminant reduction, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately two years. Construction and implementation of this alternative including temporary injection point installation, biochemical injection and injection point abandonment is expected to be complete in approximately one year.

Implementability

The installation of temporary injection points may be challenging at certain locations based on the stratigraphy. The area has been studied extensively and previous investigations have identified glacial outwash that may contain larger boulders. The potential stratigraphic obstructions may result in the need to change locations of temporary injection points.

Equipment and materials required for construction are readily available. However, temporary injection point locations would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the DBG Plume.

The biochemical product has been demonstrated to be effective in treating explosives and chlorinated solvents. Depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications.

Cost

The estimated total cumulative costs for Alternative 6 are shown below. See Appendix I for a summary of the costs for Alternative 6.

<u>Alternative 6 – Source Area Treatment</u>

Direct Capital Cost:	$ 645,631
Indirect Capital Cost:	$ 290,534
30 Years of Annual O&M:	$ 4,240,490
Total Cost:	**$ 5,176,654**

* Total costs use current rates and do not include inflation

10.7 DBG Plume Remedial Alternative Summary

A summary of the cleanup timeframe, treatment duration, groundwater monitoring duration, and cost for each of the six proposed remedial alternatives for the DBG Plume is presented below.

Deterrent Burning Ground Plume
Remedial Alternative Summary

Alternative	Time to Achieve Cleanup	Active Treatment Duration	Groundwater Monitoring Duration	Total Cost
Alternative 1 – No Action	NA	NA	NA	$0
Alternative 2 – MNA and Alternate Water Supply	30 Years	NA	30 Years	$4.2
Alternative 3 – Pump and Treat	24 Years	22 Years	24 Years	$12.5
Alternative 4 – Anaerobic Bioremediation	4 Years	2 Years	4 Years	$12.5
Alternative 5 – Well Replacement	30 Years	NA	30 Years	$7.1
Alternative 6 – Source Area Treatment	30 Years	2 Years	30 Years	$5.2

Notes: Total cost in millions of dollars & includes direct capital, indirect capital and annual operation and maintenance costs. Total cost is based on current rates and does not include inflation.

An evaluation criteria summary of the proposed remedial alternatives for the DBG Plume is presented below. Each of the six proposed alternatives are listed in the left column. As described in Section 8.8, nine evaluation criteria have been developed to serve as the basis for conducting a detailed analysis of the remedial alternatives. The nine criteria include threshold, primary balancing and modifying criteria are listed below in the top row. The two modifying criteria (State Acceptance and Community Acceptance) are incorporated during the remedy selection stage and presented in the Proposed Plan.

An objective and qualitative evaluation was completed to compare the six proposed remedial alternatives. A designation of “H” represents a high confidence of the alternative meeting the criteria. Similarly, a designation of “L” represents a low and “M” represents a moderate confidence of the alternative meeting the criteria. A designation of “N” represents no confidence of the alternative meeting the criteria and a designation of “TBD” represents to be determined. The designations are supported by their respective preceding text section for each remedial alternative and were made in relation to other alternatives. Approximate total costs for each remedial alternative are shown in the right column.

Deterrent Burning Ground Plume
Evaluation Criteria Summary

Alternative	**Evaluation Criteria**								
	Overall Protection to Human Health & Environment	**Compliance with ARARs**	**Long-Term Effectiveness & Permanence**	**Reduction in Toxicity, Mobility & Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**State Acceptance**	**Community Acceptance**	**Total Cost** $^{(1)(2)}$
Alternative 1 – No Action • Groundwater access restrictions	L	N	N	N	N	H	TBD	TBD	$0
Alternative 2 – MNA and Alternate Water Supply • Groundwater access restrictions • Groundwater monitoring • Alternate water supply	M	L	M	L	M	H	TBD	TBD	$4.2
Alternative 3 – Pump and Treat $^{(3)}$ • Extraction wells (three) • Mobile treatment units (three)	H	H	H	H	M	M	TBD	TBD	$12.5
Alternative 4 – Anaerobic Bioremediation $^{(3)}$ • Biochemical injection points (406)	H	H	M	H	M	M	TBD	TBD	$12.5
Alternative 5 – Well Replacement $^{(4)}$ • Replacement of residential wells (57)	M	M	H	L	M	M	TBD	TBD	$7.1
Alternative 6 – Source Area Treatment $^{(3)}$ • Temporary injection points (56)	M	M	M	M	H	M	TBD	TBD	$5.2

Notes: H – High, L – Low, M – Moderate, N – None, TBD – To Be Determined.

(1) Cost in millions of dollars & includes direct capital, indirect capital and annual operation and maintenance costs.
(2) Based on current rates and does not include inflation.
(3) Alternative includes groundwater access restrictions, groundwater monitoring and alternate water supply.
(4) Alternative includes groundwater access restrictions and groundwater monitoring.

11.0 REMEDIAL ALTERNATIVES – CENTRAL PLUME

As identified in Section 7.3, 2,6-DNT was the only risk-related COC considered for the development of remedial alternatives in the Central Plume. The RAO for the Central Plume requires the remedy to protect human health by preventing exposure to contaminated groundwater, to minimize the impact of the contaminants on the environment, and to restore groundwater to the extent practicable. The RAO for the Central Plume will be achieved when groundwater concentrations of 2,6-DNT are below the groundwater cleanup level listed in Table 16.

Based on site conditions and the screening of process options, five remedial alternatives were developed to address the presence of 2,6-DNT in the Central Plume. A source area alternative was not developed for the Central Plume due to no known source areas remaining. Alternative 1 - No Action, provides a baseline to evaluate the other alternatives.

Alternative 1: No Action

The No Action Alternative is a mandatory evaluation that provides a baseline to evaluate the other alternatives. This alternative would have no impact on the contaminant plume and would not require groundwater monitoring of residential wells or monitoring wells. This alternative would include on-site groundwater access restrictions.

Alternative 2: Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation and Alternate Water Supply Alternative would continue the current remedial action approach and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement

Alternative 3: Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would target removing and treating impacted groundwater with elevated 2,6-DNT concentrations and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater removal through the installation of eight groundwater extraction wells
- Groundwater treatment through the use of eight mobile treatment units
- Groundwater disposal through the construction of piping leading to the Wisconsin River

Alternative 4: Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would target treating impacted groundwater with elevated 2,6-DNT concentrations and include the following components:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Provision for an alternate water supply condition including bottled water and well replacement
- Groundwater treatment through in-situ biochemical injection at 988 temporary locations (on-site and off-site)

Alternative 5: Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer wells (meeting qualifying criteria) within the Central Plume area with deeper aquifer wells and include the following:

- Continued groundwater monitoring of residential and monitoring wells
- On-site groundwater access restrictions
- Replacement of as many as 23 existing residential wells

11.1 Alternative 1 – No Action

The No Action Alternative would have no impact on any of the contaminant plumes and would not require groundwater monitoring of residential wells or monitoring wells. There would be no contaminant removal, treatment, containment or monitoring related to this alternative. As a condition of the Army’s property transfer, groundwater access restrictions would continue for areas within the BAAP boundary.

Overall Protection of Human Health and the Environment

Groundwater access is restricted within the BAAP boundary based on conditions of property transfer documentation. The groundwater access restrictions would require Army and WDNR authorization prior to well installation within the BAAP boundary; however, there are no groundwater access restrictions outside the BAAP boundary. This alternative would not provide any protection of human health or the environment beyond the groundwater access restrictions within the BAAP boundary. This alternative would result in the Army terminating the residential and monitoring well sampling program.

Compliance with ARARs

The residential and monitoring well sampling program is being conducted in accordance with the most recent regulatory approval. This alternative would result in the Army terminating the residential and monitoring well sampling program. This alternative would not comply with ARARs.

Long-Term Effectiveness and Permanence

This alternative would not provide an effective or permanent long-term solution. In this alternative, groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process (dilution, dispersion, and sorption). This alternative would result in the Army terminating the residential and monitoring well sampling program. Consequently, the degradation process would not be evaluated under this alternative.

Reduction of Toxicity, Mobility, and Volume through Treatment

Limited reductions in toxicity, mobility, and volume would occur through natural degradation processes only. This alternative would discontinue the sampling of residential and groundwater monitoring wells. Consequently, the degradation process would not be evaluated.

Short-Term Effectiveness

There would be no action taken for this alternative. Since groundwater monitoring would be discontinued, any groundwater exceedances would go unidentified. Therefore, this alternative has no short-term effects.

Implementability

This alternative is inherently implementable as no remedial action would be taken.

Cost

There is no cost associated with the No Action Alternative.

11.2 Alternative 2 – Monitored Natural Attenuation and Alternate Water Supply

The Monitored Natural Attenuation and Alternate Water Supply Alternative would include MNA for the Central Plume, on-site groundwater access restrictions and a provision for an alternate water supply condition for residential wells. This alternative would also continue residential and monitoring well sampling of the Central Plume as previously specified in Section 4.2 and Appendix D.

MNA relies on natural attenuation processes to achieve the RAO within a time frame that is reasonable compared to that offered by other more active remedial methods. MNA is expected to reduce the concentrations of the COCs that were carried forward in the development of remedial alternatives (see Section 7.3), which includes only 2,6-DNT. These natural attenuation processes include a variety of physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These in-situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

The Army currently has an environmental monitoring and health protection program in place that is protective of the residential water well users, "alternate water supply". If a Chapter NR 140 ES is exceeded in a residential well once, bottled water is made available to the occupant. If the exceedance occurs a second, consecutive time, well replacement is offered to the owner. Bottled water would be made available to the occupant until the well is replaced, operational and water quality verified (typically 3 months and based on driller availability). If the NR 140 ES exceedance is not detected for two consecutive rounds after the first NR 140 ES exceedance detection, bottled water would be discontinued. To date, the Army has replaced three shallow residential wells within the Central Plume.

Overall Protection of Human Health and the Environment

This alternative would provide protection of human health and the environment due to groundwater access restrictions within the BAAP boundary and the provision of an alternate water supply condition for residential wells. The MNA program would monitor the groundwater concentrations for compliance and contaminant reduction.

Compliance with ARARs

The residential and monitoring well sampling program is being conducted in accordance with the most recent regulatory approval. This alternative would continue the residential and groundwater monitoring program and comply with ARARs over time through natural degradation processes only.

Long-Term Effectiveness and Permanence

This alternative offers long-term solution as groundwater concentrations are expected to decrease as the chemicals would continue to undergo a slow degradation process (dilution, dispersion, and sorption). The alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition would address concerns associated with residential well impacts. Groundwater impacts are expected to remain and the groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

Limited reductions in toxicity, mobility, and volume is expected to occur through natural degradation processes only. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

This alternative offers a short-term solution as it is currently being applied and no additional work associated with implementation would be required. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition would address concerns associated with residential wells. If the alternate water supply provision is necessary, state licensed well drillers would be utilized for well replacement. The well drillers would be appropriately trained and would maintain applicable certifications to install any replacement well necessary.

Implementability

This alternative would be easily implementable as this action is currently being applied to the site. No remedial activities other than sampling under the MNA program would be performed. Groundwater access restrictions are already in place within BAAP.

Cost

The estimated total cumulative costs for Alternative 2 are shown below. See Appendix I for a summary of the costs for Alternative 2.

Alternative 2 – Monitored Natural Attenuation and Alternate Water Supply

Direct Capital Cost:	$	0
Indirect Capital Cost:	$	0
30 Years of Annual O&M:	$	2,398,538
Total Cost:	**$**	**2,398,538**

* Total costs use current rates and do not include inflation

11.3 Alternative 3 - Active Groundwater Remediation – Pump and Treat

The Active Groundwater Remediation – Pump and Treat Alternative would include groundwater extraction and treatment with mobile treatment units and continued groundwater monitoring of residential and monitoring wells. This alternative would also include on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 11.0, active remedial alternatives are only being developed for 2,6-DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the extraction wells would be strategically located to target elevated 2,6-DNT concentrations. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for 2,6-DNT.

It is anticipated that eight extraction wells and eight mobile treatment units (one treatment unit per extraction well) would be necessary for source are reduction and plume migration control. Eight extraction wells were selected based on previous performance (capture zone) of extraction wells at the BAAP. Spatially, the wells would be located along the long axis of the plume and equidistant from one another and the plume’s upgradient and downgradient extents. Proposed pumping well locations and target pumping capture zones are shown on Drawing Central-ALT 3 in Appendix J.

Each extraction well is expected to pump at approximately 500 gpm. Similarly, each mobile treatment unit would be designed to treat 500 gpm. Based on previous experience with pump and treat systems at BAAP, groundwater flow velocities of 143 ft/yr (see Table 8) and assuming no additional source area contribution, the individual extraction wells and mobile treatment units are expected to operate continuously for at least 10 years. The mobile treatment units are expected to use activated carbon as the primary treatment media as activated carbon has successfully treated DNT at BAAP. Site improvements including mobile treatment trailer staging area construction, electrical utility provision and site security would be necessary at each one of the extraction well/mobile treatment trailer areas.

A network of piping and appurtenances would be necessary to route extracted water from the extraction wells to the mobile treatment units and treated water from the mobile treatment units to a discharge location. Treated groundwater would ultimately discharge to the Wisconsin River.

It is anticipated that the pump and treat system would require the services of an environmental technician to monitor and maintain the extraction wells and mobile treatment units.

Overall Protection of Human Health and the Environment

This alternative would be designed to control and limit the migration of and treat the groundwater with elevated 2,6-DNT concentrations. The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Compliance with ARARs

This alternative would be designed to comply with ARARs. The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

This alternative would be designed to reduce contaminant concentrations to comply with regulatory standards in groundwater through recovery and treatment of the portion of the Central Plume with total elevated 2,6-DNT concentrations. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. A similar pump and treat system (MIRM) showed effective DNT concentration reduction.

Based on previous experience, the groundwater pump and treat system is expected to operate continuously for 10 years. The groundwater monitoring program is expected to continue for at least 12 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative is expected to result in reductions in toxicity, mobility, and volume through treatment of the Central Plume with elevated 2,6-DNT concentrations. It is assumed that there would be no additional contribution of 2,6-DNT from the source areas into the groundwater. Based on performance of this technology at the BAAP (MIRM), the pump and treat system showed effective DNT concentration reduction. The groundwater contamination would also continue to decrease due to natural attenuation processes.

Short-Term Effectiveness

For this alternative there would be some short-term effects to workers, residents and the environment during implementation. As described above, the alternative would require eight extraction wells coupled with a mobile treatment units for each extraction well. These locations would require construction of a staging area for the well and mobile treatment unit, security and electricity for the site for operations and lighting.

It is anticipated that from each extraction well to the and mobile treatment and from the mobile treatment unit to a discharge location, a discharge pipe would be constructed. Treated water is expected to be discharged to the Wisconsin River.

There is some risk associated with the operation of heavy equipment for site preparation, well drilling, excavation, piping installation and backfilling; however, proper training and equipment would be required to mitigate these risks. Utility crossing, near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

To maximize contaminant reduction and plume migration control, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately one year. Construction and implementation of this alternative including well installation, piping construction, treatment area preparation and utility extension is expected to be completed in approximately one year.

Implementability

Equipment and materials required for construction of this alternative are readily available. However, extraction well, mobile treatment unit locations and piping alignment would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the Central Plume. In addition, utilities to support the extraction wells and mobile treatment facility would need to be extended to the site, since none currently exist. The discharge line location would need to be determined and appropriate piping and appurtenance construction competed. The discharge location to the Wisconsin River would need to be identified during winter months with a high-visibility buoy system. This would identify open water as a safety precaution to those who utilize the Wisconsin River in the winter for recreational activities such as ice fishing and snowmobiling. It is expected that this buoy system would be installed during the winter months and subsequently removed in the spring. This process of installation and decommissioning the buoy system would need to be repeated each winter and spring, respectively, as long as the system continued operation.

Cost

The estimated total cumulative costs for Alternative 3 are shown below. See Appendix I for a summary of the costs for Alternative 3.

Alternative 3 – Active Groundwater Remediation – Pump and Treat

Direct Capital Cost:	$ 6,939,247
Indirect Capital Cost:	$ 3,122,661
12 Years of Annual O&M:	$ 7,953,709
Total Cost:	**$ 18,015,617**

* Total costs use current rates and do not include inflation

11.4 Alternative 4 – Active Groundwater Remediation – Anaerobic Bioremediation

The Active Groundwater Remediation – Anaerobic Bioremediation Alternative would include in-situ anaerobic biodegradation targeting elevated concentrations of 2,6-DNT in groundwater and continued groundwater monitoring of residential and monitoring wells. This alternative would also include on-site groundwater access restrictions and a provision for an alternate water supply condition.

As identified in Section 11.0, active remedial alternatives are only being developed for 2,6-DNT concentrations above the groundwater cleanup level listed in Table 16. Consequently, the in-situ biochemical injection locations would be strategically located to target elevated 2,6-DNT concentrations. This technology is expected to also reduce the concentrations of chlorinated solvents that coexist within the targeted treatment areas for 2,6-DNT.

For this alternative, a nutrient-enriched emulsified vegetable oil (EVO) is being proposed as the injection product. EVO has been used to stimulate in-situ anaerobic biodegradation of groundwater contaminants at commercial, industrial, and military sites. The procedures and applications of EVO are applicable to numerous anaerobically biodegradable contaminants including but not limited to chlorinated solvents, energetics, and nitrates.

The primary objective of injecting EVO into the groundwater is to stimulate the anaerobic biodegradation of the target contaminants. Groundwater aquifers are complex ecosystems populated by a broad and diverse array of microbial communities. The composition and activity of these microbial communities' changes continuously as their environment changes. Alterations in aquifer geochemistry and the availability of substrates and nutrients that can be used to generate energy and support growth and reproduction significantly affect microbial activity.

EVO would be distributed in the aquifer as an oil-in-water emulsion (mixture). In this approach, an oil-in-water emulsion would be first prepared using a food-grade oil, food-grade surfactants, and water. The emulsion would have small uniform droplets to allow transport in the aquifer. The emulsion would be injected into the aquifer (through injection wells or DPT) with additional water to distribute the oil droplets. The oil droplets would be distributed through the aquifer pore spaces and adhere to soil particles. The soil particle surfaces would gradually become coated with a thin layer of oil droplets that provide a carbon source for long-term anaerobic biodegradation. The oil droplets remain in the aquifer as a viable carbon source for approximately two years. Soluble substrates and nutrients (e.g., lactate, yeast extract, vitamins) can be added to the mixture prior to injection to stimulate rapid growth of desired bacteria. When the contaminated groundwater naturally flows toward and through the distributed EVO, the groundwater contaminants interact with the carbon source and break-down into less harmful byproducts.

It is anticipated that 988 injection points (both on-site and off-site and at varying stratigraphic depths) would be required to treat the plume. These injection points would be arranged in a series of 38 treatment lines and consist of temporary injection points. It is assumed that the source area would no longer contribute to the groundwater contamination. Anticipated treatment line locations are shown on Drawing Central-ALT 4 in Appendix J.

The spacing of the treatment lines is based on a groundwater flow velocity of 143 ft/yr (see Table 8) and the viability of the carbon source remaining in the aquifer for approximately two years. The distance between each treatment line is based on two years of treatment. Based on the geology and hydrogeology associated with the plume, a 25-foot radius of influence is anticipated to provide sufficient distribution of the EVO within the aquifer. The radius of influence is measured from the injection well or point location radially, out to the maximum extent of EVO product distribution. Each treatment line would be designed to fully capture contaminated groundwater migrating downgradient.

Though EVO is a proven technology to effectively treat chlorinated solvents and energetics, a field-scale pilot test would be necessary to determine the site specific constraints and a design to be developed to target 2,6-DNT within the plume at BAAP. Upon successful completion of a field-scale pilot test, the remedial design could be finalized.

Overall Protection of Human Health and the Environment

This alternative would be designed to meet the requirements of the RAO as it would effectively degrade the contaminants in the Central Plume. The provision of the alternate water supply condition would address concerns associated with residential well impacts. Groundwater access restrictions would continue for areas within the BAAP.

Compliance with ARARs

Concentrations of contaminants in the treated area are expected to comply with ARARs relatively quickly (approximately two years). The provision of the alternate water supply condition would address concerns associated with residential well impacts.

Long-Term Effectiveness and Permanence

This alternative would be designed to reduce the concentration in groundwater to comply with regulatory standards for 2,6-DNT. This alternative would continue to restrict groundwater access within the BAAP and the provision of an alternate water supply condition for residential wells. It is anticipated that a single round of injections of the biochemical product would be sufficient to treat the plume. Based on a groundwater flow velocity and the viability of the carbon source, treatment is expected to take approximately two years. However, depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications. The proposed biochemical product for use with this technology has shown successful contaminant reduction with explosives and chlorinated solvents; however, it has not been applied at full scale for 2,6-DNT treatment. The groundwater monitoring program is expected to continue for at least 4 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative is expected to reduce the toxicity, mobility, and volume of 2,6-DNT and chlorinated solvents in the treated areas more quickly than natural processes alone. It is assumed that there would be no additional contribution of 2,6-DNT from the source areas into the groundwater. The groundwater contamination would also continue to decrease due to natural attenuation processes.

Short-Term Effectiveness

There would be some short-term effects to workers, residents and the environment during implementation. As described above, this alternative would require both on-site and off-site injection points.

There is some risk associated with heavy equipment necessary for temporary injection point installation and injection. Proper training and equipment would be required to mitigate these risks. The bioremediation is expected to occur over the course of two years and no additional worker safety issues have been identified. Near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

To maximize contaminant reduction, it is anticipated that additional investigation, sampling and testing would need to be completed. This effort is expected to take approximately two years. Construction and implementation of this alternative including temporary injection point installation, biochemical injection and injection point abandonment is expected to be completed in approximately one year.

Implementability

The installation of temporary injection points may be challenging at certain locations based on the stratigraphy. The area has been studied extensively and previous investigations have identified glacial outwash that may contain larger boulders. The potential stratigraphic obstructions may result in the need to change the location of temporary injection points.

Equipment and materials required for construction are readily available. However, temporary injection point locations would have to be coordinated carefully and with input from existing land owners as they are responsible for the ownership and/or management of the area around the Central Plume.

The biochemical product has been demonstrated to be effective in treating explosives and chlorinated solvents. Depending upon groundwater monitoring results, it is possible that this technology may require supplemental post-treatment applications.

Cost

The estimated total cumulative costs for Alternative 4 are shown below. See Appendix I for a summary of the costs for Alternative 4.

Alternative 4 – Active Groundwater Remediation – Anaerobic Bioremediation

Direct Capital Cost:	$ 16,082,742
Indirect Capital Cost:	$ 7,237,234
4 Years of Annual O&M:	$ 399,756
Total Cost:	**$ 23,719,733**

* Total costs use current rates and do not include inflation

11.5 Alternative 5 – Well Replacement – Plume Area

The Well Replacement – Plume Area Alternative would involve replacing shallow aquifer wells, meeting replacement criteria, within the Central Plume area with deeper aquifer wells. This alternative would also include continued groundwater monitoring of residential and monitoring wells and on-site groundwater access restrictions.

A reasonable worst-case scenario was developed considering potential plume migration which resulted in the potential for 23 existing wells being impacted. If sampling results indicate an increasing trend for a plume's COC in three consecutive rounds and that the plume is migrating toward a residential well, the Army will evaluate if well replacement is necessary.

Based on deeper aquifer well information in the area, replacement wells would be drilled to approximately 400 feet below the existing ground surface and into the Mt. Simon Sandstone Formation. This formation is isolated from the shallow impacted groundwater by a confining shale layer. The 400-foot depth is necessary to satisfy water quality and production criteria. Wells would be installed by a state licensed well driller and would be cased to isolate the shallow aquifer from the deeper bedrock aquifer. Connections from the well to the dwelling would be completed. Well replacement would be completed with abandonment of the shallow well and restoration of disturbed areas.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health as potential receptors would be provided potable water from a deeper aquifer. Effectively, there would be no route of entry through groundwater consumption, eliminating the risk of exposure through groundwater. Groundwater access is restricted within the BAAP boundary based on conditions of property transfer documentation. The groundwater access restrictions would require Army and WDNR authorization prior to well installation within the BAAP boundary.

Compliance with ARARs

Groundwater monitoring would continue in monitoring and residential wells to monitor groundwater quality. Since the deep aquifer has been unimpacted by BAAP production or disposal activities, compliance with ARARs is expected. The contaminants within the plume are expected to comply with ARARs over time through natural degradation processes only.

Long-Term Effectiveness and Permanence

This alternative would be an effective long-term and permanent solution. These wells are expected to provide receptors with long-term access to potable water that has been unimpacted by BAAP production or disposal activities. This alternative would also continue to restrict groundwater access within the BAAP property. Groundwater contamination within the plume is expected to decrease over time due to natural degradation processes only. The groundwater monitoring program is expected to continue for at least 30 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative would eliminate the groundwater exposure pathway by providing potential receptors access to potable water from a deep aquifer. Limited reductions in toxicity, mobility, and volume of contaminants within the plume is expected to occur through natural degradation processes only. This reduction would be verified through the monitoring program.

Short-Term Effectiveness

For this alternative, there would be some short-term effects to workers, residents and the environment during implementation. The alternative would require off-site well installation on private property. Wells would be installed by a state licensed well driller and would be cased to isolate the shallow aquifer from the deeper bedrock aquifer. There is some risk associated with heavy equipment necessary for well installation. Proper training and equipment would be required to mitigate these risks. Near public road working conditions and work on private land would also be items that would need planning, coordination, and health and safety training.

Implementation and construction of this alternative is expected to be completed in approximately three months once qualifying criteria have been established for a residential well. Additional well replacements would be addressed as necessary upon establishment of qualifying criteria.

Implementability

Equipment and materials required for construction of this alternative are readily available and wells would be installed by a state licensed well driller. However, well replacement would have to be coordinated with private land owners.

Cost

The estimated total cumulative costs for Alternative 5 are shown below. See Appendix I for a summary of the costs for Alternative 5.

Alternative 5 – Well Replacement – Plume Area

Direct Capital Cost:	$	920,000
Indirect Capital Cost:	$	414,000
30 Years of Annual O&M:	$	1,997,172
Total Cost:	**$**	**3,331,172**

* Total costs use current rates and do not include inflation

11.6 Central Plume Remedial Alternative Summary

A summary of the cleanup timeframe, treatment duration, groundwater monitoring duration, and cost for each of the five proposed remedial alternatives for the Central Plume is presented below.

Central Plume
Remedial Alternative Summary

Alternative	Time to Achieve Cleanup	Active Treatment Duration	Groundwater Monitoring Duration	Total Cost
Alternative 1 – No Action	NA	NA	NA	$0
Alternative 2 – MNA and Alternate Water Supply	30 Years	NA	30 Years	$2.4
Alternative 3 – Pump and Treat	12 Years	10 Years	12 Years	$18.0
Alternative 4 – Anaerobic Bioremediation	4 Years	2 Years	4 Years	$23.7
Alternative 5 – Well Replacement	30 Years	NA	30 Years	$3.3

Notes: Total cost in millions of dollars & includes direct capital, indirect capital and annual operation and maintenance costs.
Total cost is based on current rates and does not include inflation.

An evaluation criteria summary of the proposed remedial alternatives related to the Central Plume is presented below. Each of the five proposed alternatives are listed in the left column. As described in Section 8.8, nine evaluation criteria have been developed to serve as the basis for conducting a detailed analysis of the remedial alternatives. The nine criteria include threshold, primary balancing and modifying criteria are listed below in the top row. The two modifying criteria (State Acceptance and Community Acceptance) are incorporated during the remedy selection stage and presented in the Proposed Plan.

An objective and qualitative evaluation was completed to compare the six proposed remedial alternatives. A designation of "H" represents a high confidence of the alternative meeting the criteria. Similarly, a designation of "L" represents a low and "M" represents a moderate confidence of the alternative meeting the criteria. A designation of "N" represents no confidence of the alternative meeting the criteria and a designation of "TBD" represents to be determined. The designations are supported by their respective preceding text section for each remedial alternative and were made in relation to other alternatives. Approximate total costs for each remedial alternative are shown in the right column.

Central Plume
Evaluation Criteria Summary

Alternative	**Evaluation Criteria**								
	Overall Protection to Human Health & Environment	**Compliance with ARARs**	**Long-Term Effectiveness & Permanence**	**Reduction in Toxicity, Mobility & Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**State Acceptance**	**Community Acceptance**	**Total Cost (1)(2)**
Alternative 1 – No Action • Groundwater access restrictions	L	N	N	N	N	H	TBD	TBD	$0
Alternative 2 – MNA and Alternate Water Supply • Groundwater access restrictions • Groundwater monitoring • Alternate water supply	M	L	M	L	M	H	TBD	TBD	$2.4
Alternative 3 – Pump and Treat (3) • Extraction wells (eight) • Mobile treatment units (eight)	H	H	H	H	M	M	TBD	TBD	$18.0
Alternative 4 – Anaerobic Bioremediation (3) • Biochemical injection points (988)	H	H	M	H	M	M	TBD	TBD	$23.7
Alternative 5 – Well Replacement (4) • Replacement of residential wells (23)	M	M	H	L	M	M	TBD	TBD	$3.3

Notes: H – High, L – Low, M – Moderate, N – None, TBD – To Be Determined.
(1) Cost in millions of dollars & includes direct capital, indirect capital and annual operation and maintenance costs.
(2) Based on current rates and does not include inflation.
(3) Alternative includes groundwater access restrictions, groundwater monitoring and alternate water supply.
(4) Alternative includes groundwater access restrictions and groundwater monitoring.

12.0 REMEDY SELECTION

The Army's preferred alternative or remedy will be presented in the Proposed Plan; the remedy will be based on the results of this RI/FS. The Proposed Plan will briefly summarize the remedial investigation and the remedial alternatives evaluated in this RI/FS, highlighting the key factors that led to identifying the preferred alternative. The Army will submit the Proposed Plan to the regulatory agencies and then the public for review. After this review, the Army will release a Decision Document that documents the selected remedy, certifies that the remedy selection process was carried out in accordance with CERCLA, and addresses public comments on the Proposed Plan.

13.0 REFERENCES

ABB Environmental Services, Inc., 1993. *Final Remedial Investigation Report, Badger Army Ammunition Plant.* Prepared for United States Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland. April.

ABB, 1994. *Final Feasibility Study, Badger Army Ammunition Plant.* Prepared for United States Army Environmental Center, Aberdeen Proving Ground, Maryland. August.

Agency for Toxic Substances and Disease Registry (ATSDR), 1999. *Public Health Assessment for U.S. Army Badger Army Ammunition Plant, Baraboo, Sauk County, Wisconsin.* CERLIS No. WI9210020054. U.S. Department of Health and Human Services. May 28.

ATSDR, 2006. Health Consultation for Dinitrotoluene in Private Wells. U.S. Army Badger Army Ammunition Plant, Baraboo, Sauk County, Wisconsin. EPA Facility ID: WI9210020054. U.S. Department of Health and Human Services. September 30.

Attig, J.W., 1990. *Geology of the Badger Army Ammunition Plant Area.* Wisconsin Geological and Natural History Survey.

Badger Technical Services, LLC (BTS), 2012. *Interim Remedial Measures Shutdown Plan*. October.

BTS, 2012. *Modified Interim Remedial Measures Shutdown Plan*. January.

BTS, 2012. *Letter, Subject: Vapor Intrusion Pathway Analysis Report.* April 19.

BTS, 2012. *Letter, Subject: Supplemental Vapor Intrusion Pathway Analysis Report.* July 16.

BTS, 2013. *Surface Waters Impact Investigation, Badger Army Ammunition Plant.* November.

Clayton, L. and Attig, J.W., 1990. *Geology of Sauk County, Wisconsin.* Wisconsin Geological and Natural History Survey, Information Circular 67.

Department of the Army, 2011. *Letter, Subject: Deterrent Burning Ground – Final Remedy, Enhanced Biodegradation System Notification of Discontinuance, Badger Army Ammunition Plant.* November 17.

Department of the Army, 2012. *Letter, Subject: Vapor Intrusion Pathway Analysis Reports.* August 15.

Department of the Army, 2012. *Letter, Subject: Surface Waters Impact Investigation Workplan.* October 31.

Department of the Army, 2014. *Letter, Subject: Request to Dismantle the Interim Remedial Measures System.* June 17.

Department of the Army, 2016. *Letter, Subject: Submittal of May 2016 MIRM Phase 2 Groundwater Data.* Request to Dismantle Modified Interim Remedial Measures (MIRM) System. June 27.

Department of the Army, 2017. *Letter, Subject: Badger Army Ammunition Plant – Public Drinking Water System*. July 25.

Department of Defense (DoD), 2012. DoD Manual 4715.2. *Defense Environmental Restoration Program (DERP) Management*, March.

Gotkowitz, M.B. and Zeiler, K.K., 2005. *Water-Table Elevation Map of Sauk County, Wisconsin.* Wisconsin Geological and Natural History Survey, Miscellaneous Map 54-DI.

Gotkowitz, M.B., Zeiler, K.K., Dunning, C.P., Thomas, J.C., and Lin, Y.F., 2005. *Hydrogeology and Simulation of Groundwater Flow in Sauk County, Wisconsin.* Wisconsin Geological and Natural History Survey, Bulletin 102.

Hindall, S.M. and Borman, R.G., 1974. *Water Resources of Wisconsin Lower Wisconsin River Basin.* Wisconsin Geological and Natural History Survey, Atlas HA-479.

Hanson, G.F., 1970. *Geology of the Baraboo District, Wisconsin.* Wisconsin Geological and Natural History Survey, Informational Circular Number 14. Madison, Wisconsin.

Olin Corporation (Olin), 1996. *Final Documentation Report For Soil Cover Construction, Racetrack And Thermal Treatment Unit Closure, Badger Army Ammunition Plant.* October.

Olin, 1998. *Landfill #1 Final Cap Construction Report, Badger Army Ammunition Plant.* January.

Olin, 1999. *1949 Pit Phase One Cap, Final Construction Report, Badger Army Ammunition Plant.* January.

Shaw Environmental, Inc. (Shaw), 2003. *Technical Memorandum - Data Report Biologically Enhanced Subsurface Treatment System – Soil Boring and Air Sparge Well Installation – Propellant Burning Ground, Badger Army Ammunition Plant*. Prepared for United States Army Corps of Engineers. July 16.

Shaw, 2004. *Draft Preliminary Groundwater Investigation Report, Southern Boundary Groundwater, Badger Army Ammunition Plant.* Prepared for United States Army Corps of Engineers. April 26.

Shaw, 2005. *January 2005 Field Activities Technical Memorandum – Propellant Burning Ground, Badger Army Ammunition Plant*. Prepared for United States Army Corps of Engineers. June 6.

Shaw, 2005. *Draft Groundwater and Soil Investigation Report, Water's Edge Development, Badger Army Ammunition Plant*. Prepared for United States Army Corps of Engineers. August 5.

Shaw, 2005. *Draft Southern Boundary Groundwater Phase II Investigation Report, Badger Army Ammunition Plant.* Prepared for United States Army Corps of Engineers. March 28.

Shaw, 2005. *Draft Technical Memorandum Performance Assessment and Recommended Disposition of the Biologically Enhanced Subsurface Treatment System, Propellant Burning*

Ground, Badger Army Ammunition Plant. Prepared for United States Army Corps of Engineers. November 14.

Shaw, 2006. *Draft Alternative Feasibility Study, Propellant Burning Ground Waste Pits Subsurface Soil, Badger Army Ammunition Plant.* Prepared for United States Army Corps of Engineers. April 6.

Shaw, 2006. *Draft Corrective Measures Implementation Report, MIRM Extraction Well Realignment Project, Badger Army Ammunition Plant.* Prepared for United States Army Corps of Engineers. April 10.

SpecPro, Inc., 2008. *Dinitrotoluene Sources Remedial Investigation Report, Badger Army Ammunition Plant.* March.

SpecPro, Inc., 2009. *Construction Documentation Report, Propellant Burning Ground Phase 2 Cap Construction, Badger Army Ammunition Plant.* February.

SpecPro, Inc., 2009. *Northeast Boundary Groundwater Investigation Report, Badger Army Ammunition Plant.* December.

SpecPro, Inc., 2010. *Feasibility Report Contiguous Addition to Landfill 3646, Badger Army Ammunition Plant.* October.

SpecPro, Inc. and Badger Technical Services, LLC, 2011. *Revised Alternative Feasibility Study, Groundwater Remedial Strategy, Badger Army Ammunition Plant.* December.

Stone and Webster, Inc. 1999. *Draft Technical Report – Natural Attenuation Screening Study for the Propellant Burning Ground, Badger Army Ammunition Plant*. Prepared for United States Army Corps of Engineers. August 25.

Stone and Webster, Inc. 2002. *Draft Alternative Feasibility Study – Deterrent Burning Ground Waste Pits Subsurface Soil – Revision 2, Badger Army Ammunition Plant*. Prepared for United States Army Corps of Engineers. April 24.

Stone and Webster, Inc., 2003. *Draft Groundwater Investigation Report, Deterrent Burning Ground, Badger Army Ammunition Plant.* Prepared for United States Army Corps of Engineers. January 3.

Sverdrup Environmental, Inc., 1997. *Final Documentation of Construction and Completion for Modified Interim Remedial Measures System at the Badger Army Ammunition Plant.* Prepared for United States Army Corps of Engineers. May.

Tsai, S.Y., Benioff, P.A., Chiu, S.Y., and Quinn, J.J., 1988. *Master Environmental Plan for the Badger Army Ammunition Plant.* Prepared for the U.S. Army Toxic and Hazardous Materials Agency. Argonne National Laboratory.

United States Army Corps of Engineers (USACE), Omaha District, 2013. *Five-Year Review Report Deterrent Burning Ground, Badger Army Ammunition Plant.* Prepared for Base Realignment and Closure Division, United States Army Environmental Command. June 26.

USACE, Omaha District, 2013. *Five-Year Review Report Propellant Burning Ground, Badger Army Ammunition Plant.* Prepared for Base Realignment and Closure Division, United States Army Environmental Command. June 26.

United States Army Toxic and Hazardous Materials Agency, 1989. *Decision Memorandum for an Interim Remedial Measures Plan at Badger Army Ammunition Plant Propellant Burning Grounds.* February.

U.S. Environmental Protection Agency (USEPA), 1987. *Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements*, Office of Solid Waste and Emergency Response, (OSWER) Directive 9234.0-05, July 9, 1987.

USEPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. USEPA 540/G-89/004. October.

USEPA, 1989. *Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual (Part A).* Interim Final. EPA/540/1-89/002. December.

USEPA, 1994. *National Oil and Hazardous Substances Pollution Contingency Plan*. Office of Solid Waste and Emergency Response. Final Rule. September.

USEPA, 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, Office of Solid Waste and Emergency Response, (OSWER) Directive 9200.4-17P, April.

USEPA, 2009. National Primary Drinking Water Regulations, EPA 816-F-09-004. May.

USEPA, 2009. *2009 Edition of the Drinking Water Standards and Health Advisories*, Office of Water, EPA 822-R-09-011. October.

USEPA, 2011. *Code of Federal Regulations (CFR), Remedial Investigation/Feasibility Study and Selection of Remedy.* 40 CFR 300.430. July.

USEPA, 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, Office of Solid Waste and Economy Response, (OSWER) Publication 9200.2-154, June.

USEPA, 2017. *Regional Screening Levels (RSLs) - Generic Tables (November 2017).* November.

Wisconsin Department of Natural Resources (WDNR), 1987. *Letter, Subject: Final Review of In-Field Conditions Report at the Badger Army Ammunition Plant (BAAP), Sauk County.* September 14.

WDNR, 1989. *Letter, Subject: Closure Documentation Approval, Badger Army Ammunition Plant.* September 20.

WDNR, 1995. *Letter, Subject: Plan Modification of the September 14, 1987, In-Field Conditions Report Approval: Approval of Corrective Measures Selected in the Final Feasibility Study Report/Corrective Measures Study Report for the Badger Army Ammunition Plant.* June 1.

WDNR, 1997. *Letter, Subject: Final Remedial Investigation Report, Racetrack Area Waste Pile Delineation/Characterization, Badger Army Ammunition Plant.* December 2.

WDNR, 2002. *Letter, Subject: Final Determination of Remedy for the Deterrent Burning Ground.* October 14.

WDNR, 2003. *Understanding Chlorinated Hydrocarbon Behavior in Groundwater: Investigation, Assessment and Limitations of Monitored Natural Attenuation, PUB-RR-699.* April.

WDNR, 2007. *WPDES Permit No. WI-0043975-05-0, Badger Army Ammunition Plant. (Effective July 1, 2007, through June 30, 2012).* June 29.

WDNR, 2008. *Letter, Subject: Final Determination of Remedy for Propellant Burning Ground Waste Pits Subsurface Soil.* March 17.

WDNR, 2009. *Letter, Subject: WDNR Review of Propellant Burning Ground Phase 2 Cap Construction Documentation Report.* March 25.

WDNR, 2010. *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin, PUB-RR-800.* December 16.

WDNR, 2012. *Letter, Subject: Final Determination of Feasibility for an Alternative Groundwater Remedial Strategy at and near the Badger Army Ammunition Plant.* June 28.

WDNR, 2012. *Letter, Subject: WDNR Review of IRM Shutdown Proposal Report.* December 11.

WDNR, 2013. *Letter, Subject: WDNR Review of the Surface Water Investigation Proposal Report.* January 4.

WDNR, 2014. *Email Communication, Subject: Surface Water Investigation.* January 16.

WDNR, 2014. *Letter, Subject: Department Approval to Dismantle the Interim Remedial Measures Pump and Treat System.* August 4.

WDNR, 2014. *Letter, Subject: Department Approval of the Modified Interim Remedial Measures (MIRM) Shutdown Plan.* August 4.

WDNR, 2014. *Letter, Subject: Liability Clarification and Current Environmental Conditions at Badger Army Ammunition Plant, Landfill #1.* August 27.

WDNR, 2016. *Letter, Subject: Department Approval to Dismantle the Modified Interim Remedial Measures (MIRM) System.* July 15.

WDNR, 2017. *Chapter NR 140, Groundwater Quality, Wisconsin Administrative Code Register.* February.

WDNR, 2017. *Groundwater and Environmental Monitoring System (GEMS).* Public access to groundwater monitoring data. *http://dnr.wi.gov/topic/Landfills/gems.html*

Wisconsin State Climatology Office, 2010. *http://www.aos.wisc.edu/~sco/*

Figures

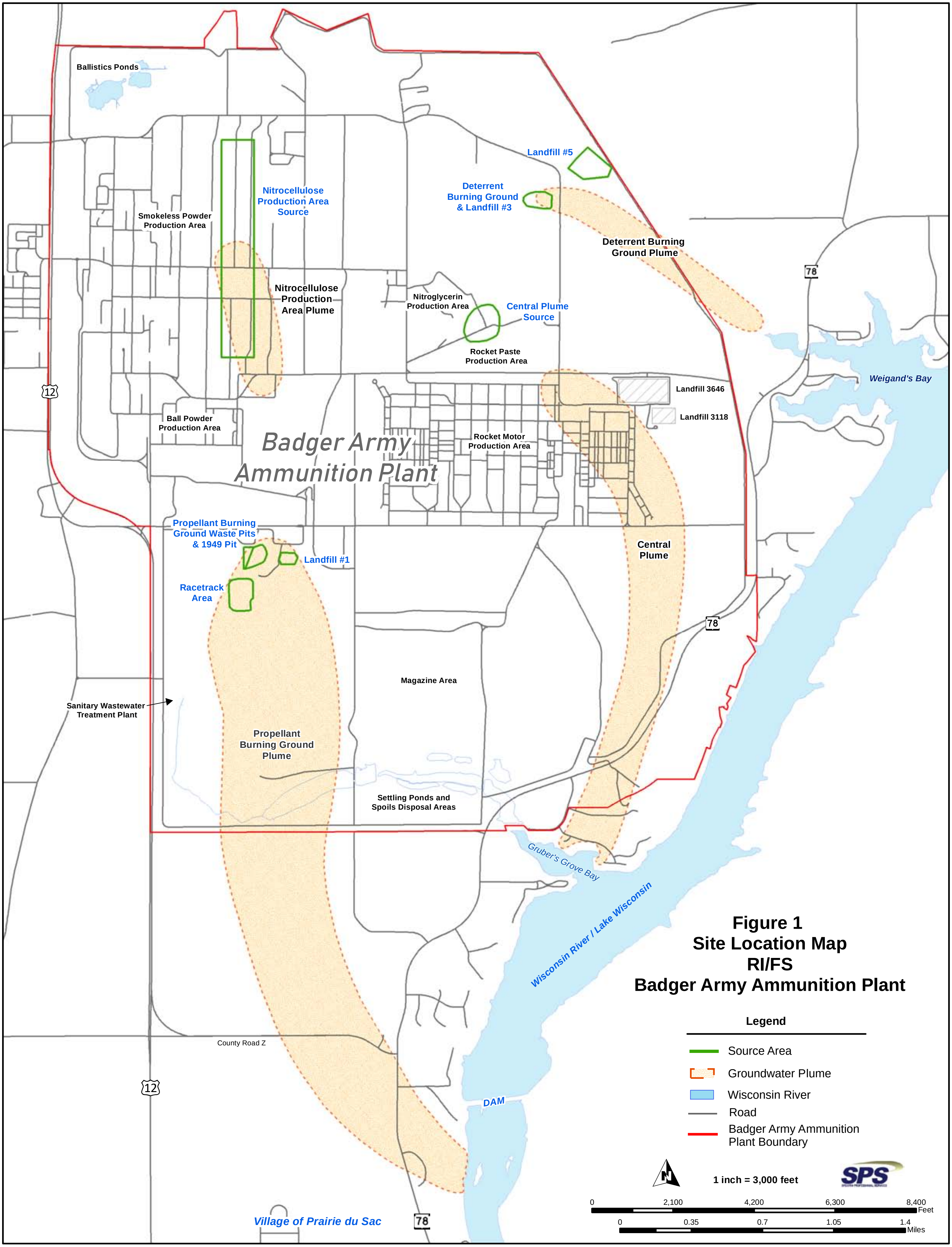
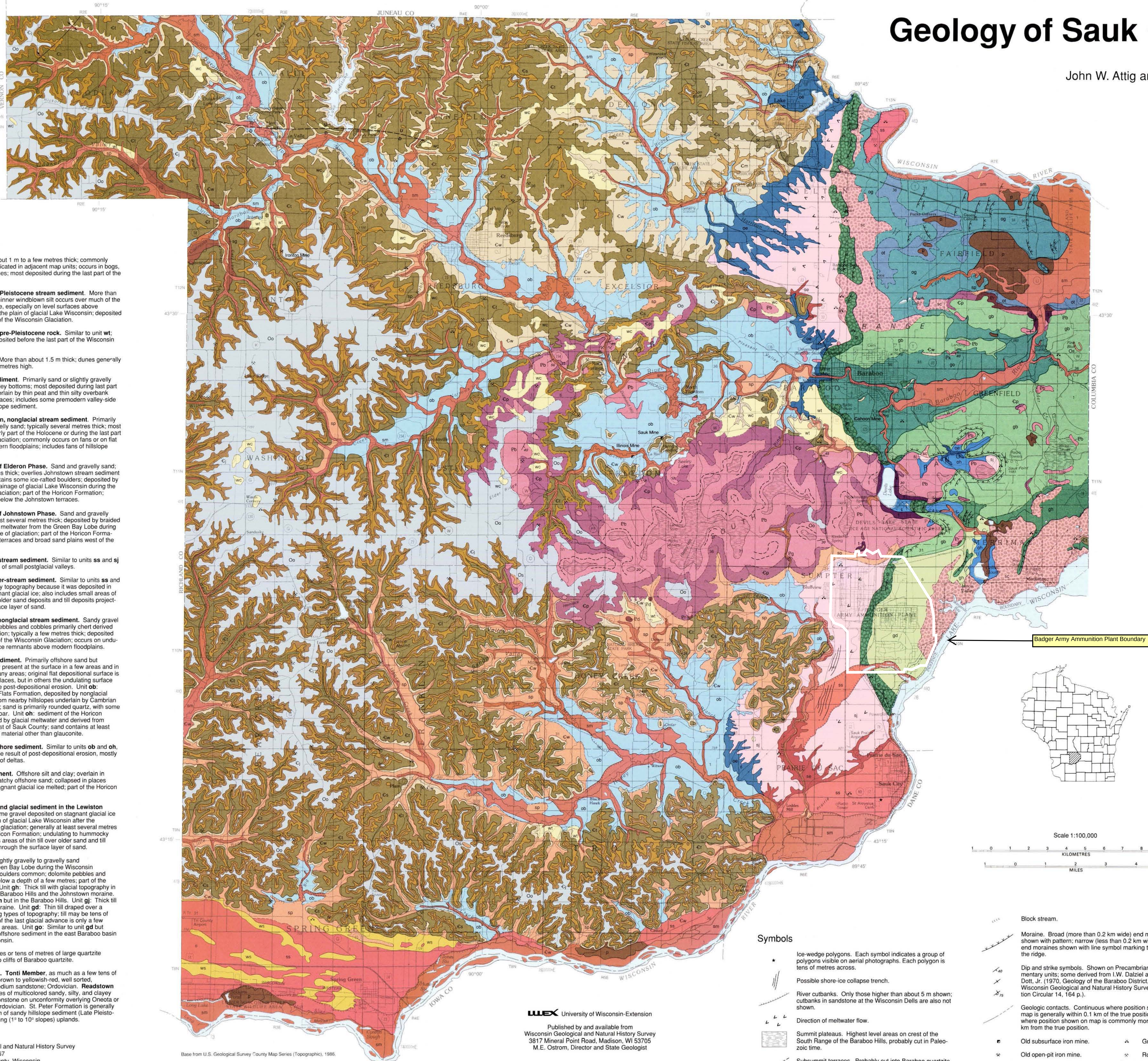


Figure 1
Site Location Map
RI/FS
Badger Army Ammunition Plant

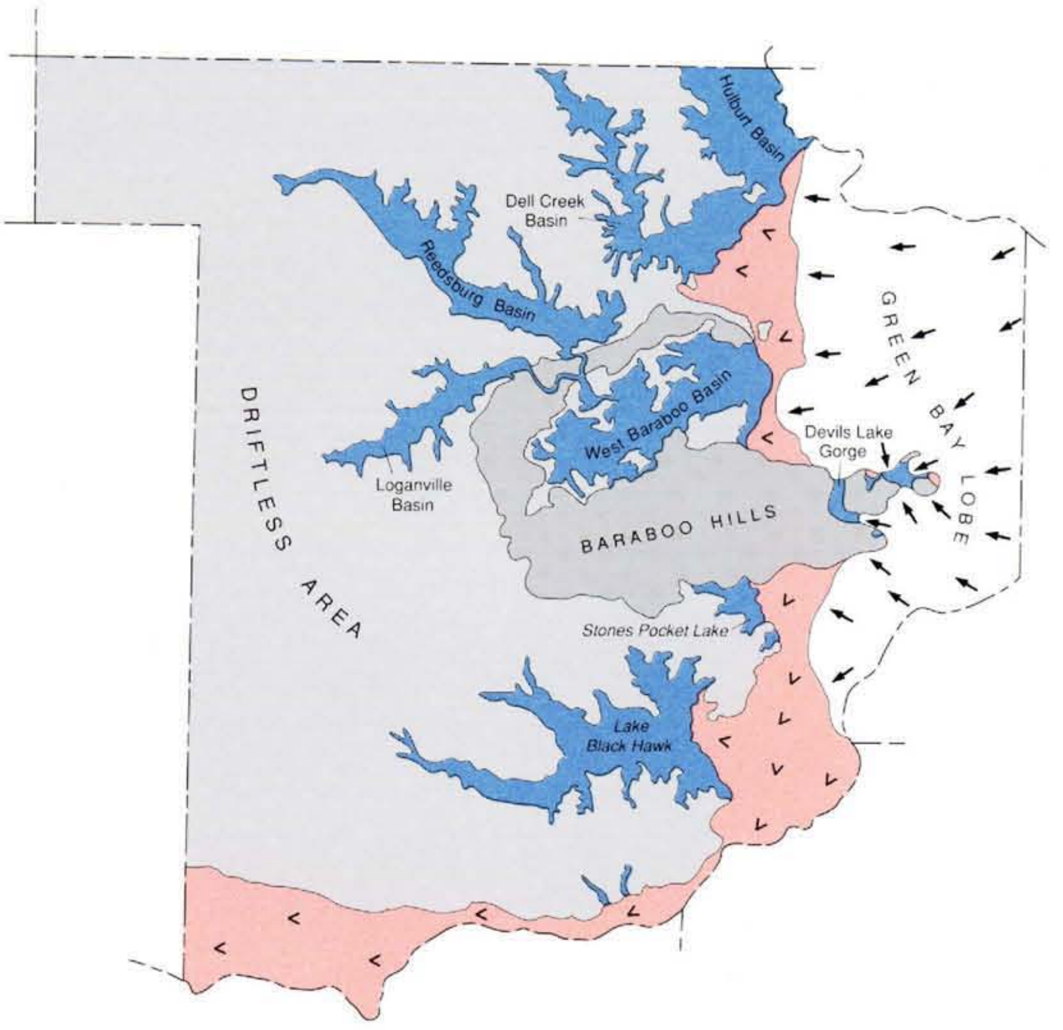
Geology of Sauk County, Wisconsin

John W. Attig and Lee Clayton, 1990

Figure 2



Base from U.S. Geological Survey County Map Series (Topographic), 1986.



Major geologic features of Sauk County during the maximum late Wisconsin extent of the Green Bay Lobe. The map shows the location of the western edge of the Green Bay Lobe (arrows show direction of ice flow), outwash plains (red), and lakes (blue). The Baraboo Hills and the remainder of the Driftless Area in Sauk County are shown in shades of gray.

Explanation

p	**Peat**. Generally about 1 m to a few metres thick; commonly overlies material indicated in adjacent map units; occurs in bogs, swamps, and marshes; most deposited during the last part of the Holocene.
wt	**Windblown silt on Pleistocene stream sediment**. More than about 1.5 m thick; thinner windblown silt occurs over much of the rest of the landscape, especially on level surfaces above outwash plains and the plain of glacial Lake Wisconsin; deposited during the last part of the Wisconsin Glaciation.
wc	**Windblown silt on pre-Pleistocene rock.** Similar to unit **wt**; may include silt deposited before the last part of the Wisconsin Glaciation.
ws	**Windblown sand**. More than about 1.5 m thick; dunes generally no more than a few metres high.
sm	**Modern stream sediment**. Primarily sand or slightly gravelly sand on modern valley bottoms; most deposited during last part of the Holocene; overlain by thin peat and thin silty overbank sediment in many places; includes some premodern valley-side fans of fluvial and slope sediment.
sp	**Younger premodern, nonglacial stream sediment**. Primarily sand or slightly gravelly sand; typically several metres thick; most deposited during early part of the Holocene or during the last part of the Wisconsin Glaciation; commonly occurs on fans or on flat terraces above modern floodplains; includes fans of hillslope sediment.
ss	**Stream sediment of Elderon Phase.** Sand and gravelly sand; typically a few metres thick; overlies Johnstown stream sediment in many places; contains some ice-rafted boulders; deposited by floodwater during drainage of glacial Lake Wisconsin during the Elderon Phase of glaciation; part of the Horicon Formation; occurs on terraces below the Johnstown terraces.
sj	**Stream sediment of Johnstown Phase.** Sand and gravelly sand; typically at least several metres thick; deposited by braided streams that carried meltwater from the Green Bay Lobe during the Johnstown Phase of glaciation; part of the Horicon Formation; occurs as high terraces and broad sand plains west of the Johnstown moraine.
se	**Eroded meltwater-stream sediment.** Similar to units **ss** and **sj** but exposed in sides of small postglacial valleys.
sc	**Collapsed meltwater-stream sediment.** Similar to units **ss** and **sj** but has hummocky topography because it was deposited in some areas on stagnant glacial ice; also includes small areas of thin till draped over older sand deposits and till deposits projecting through the surface layer of sand.
sg	**Older premodern, nonglacial stream sediment.** Sandy gravel and gravelly sand; pebbles and cobbles primarily chert derived from Oneota Formation; typically a few metres thick; deposited before the last part of the Wisconsin Glaciation; occurs on undulating to rolling terrace remnants above modern floodplains.
ob oh	**Coarse offshore sediment.** Primarily offshore sand but offshore silt and clay present at the surface in a few areas and in the subsurface in many areas; original flat depositional surface is preserved in many places, but in others the undulating surface has undergone some post-depositional erosion. Unit **ob**: sediment of the Big Flats Formation, deposited by nonglacial water and derived from nearby hillslopes underlain by Cambrian sand and sandstone; sand is primarily rounded quartz, with some glauconite and feldspar. Unit **oh**: sediment of the Horicon Formation, deposited by glacial meltwater and derived from areas to the northeast of Sauk County; sand contains at least several percent dark material other than glauconite.
oe	**Eroded coarse offshore sediment.** Similar to units **ob** and **oh**, but much hillier as the result of post-depositional erosion, mostly on the foreset faces of deltas.
ot	**Fine offshore sediment.** Offshore silt and clay; overlain in places by thin and patchy offshore sand; collapsed in places where underlying stagnant glacial ice melted; part of the Horicon Formation.
og	**Offshore, stream, and glacial sediment in the Lewiston basin.** Sand and some gravel deposited on stagnant glacial ice in the Lewiston basin of glacial Lake Wisconsin after the Johnstown Phase of glaciation; generally at least several metres thick; part of the Horicon Formation; undulating to hummocky topography; includes areas of thin till over older sand and till deposits projecting through the surface layer of sand.
gh gb gj gd go	**Till.** Clayey, silty, slightly gravelly to gravelly sand deposited by the Green Bay Lobe during the Wisconsin Glaciation; surface boulders common; dolomite pebbles and cobbles abundant below a depth of a few metres; part of the Horicon Formation. Unit **gh**: Thick till with glacial topography in areas other than the Baraboo Hills and the Johnstown moraine. Unit **gb**: Same as **gh** but in the Baraboo Hills. Unit **gj**: Thick till of the Johnstown moraine. Unit **gd**: Thin till draped over a variety of pre-existing types of topography; till may be tens of metres thick, but till of the last glacial advance is only a few metres thick in many areas. Unit **go**: Similar to unit **gd** but includes patches of offshore sediment in the east Baraboo basin of glacial Lake Wisconsin.
t	**Talus.** Several metres or tens of metres of large quartzite boulders below steep cliffs of Baraboo quartzite.
Os	**St. Peter Formation. Tonti Member**, as much as a few tens of metres of very pale brown to yellowish-red, well sorted, quartzose, fine to medium sandstone; Ordovician. **Readstown Member**, a few metres of multicolored sandy, silty, and clayey breccia with some ironstone on unconformity overlying Oneota or Jordan Formation; Ordovician. St. Peter Formation is generally overlain by about 1 m of sandy hillslope sediment (Late Pleistocene); flat to undulating (1° to 10° slopes) uplands.
Oo	**Oneota and Rountree Formations. Oneota Formation**–up to 20 m of very pale brown to light brownish-gray dolomite, commonly algal, with chert nodules; some sandstone near base of formation; some caverns and cavities, mostly filled with red clay; Ordovician; flat to undulating (1° to 10° slopes) upland plateaus; unit includes some unmappable small areas of St. Peter Formation; scattered residual boulders of St. Peter sandstone are present in many places on the Oneota plateau. **Rountree Formation**–several metres of clay, sandy clay, and clayey sand, typically with red hues, with cobbles and pebbles of chert; includes hillslope sediment derived from residuum from the underlying Oneota dolomite; late Cenozoic.
Ꞓj	**Jordan Formation.** About 20 m of white to brown, quartzose, fine to coarse sandstone, coarsening upward; silicified zone at top; Cambrian; generally overlain by about 1 m of sandy hillslope sediment (Late Pleistocene); outcrops at edge of Oneota plateaus; upper slope is a sandstone cliff in many places, especially in the northwestern part of county; below the cliff is a tree-covered slope of about 15° to 30°.
Ꞓs	**St. Lawrence Formation. Lodi Member**, about 10 to 20 m of pale yellow, thin-bedded, siltstone, and very fine to fine sandstone with some gray shale; Cambrian. **Black Earth Member**, as much as a few metres of dolomite at base of the formation; Cambrian. St. Lawrence Formation is generally overlain by less than 1 m of sandy hillslope sediment (Late Pleistocene); upper part of the St. Lawrence slope is a continuation of the Jordan escarpment (10° to 25°), which flattens into an undulating (5° to 10°) bench near the base of the unit.
Ꞓt	**Tunnel City Formation.** 30 to 45 m thick. **Lone Rock Member**, thin-bedded, quartzose, glauconitic, fine sand and sandstone; shaley near base; Cambrian. **Mazomanie Member**, slightly glauconitic sandstone near middle of the formation; thickens eastward; Cambrian. Tunnel City Formation is generally overlain by less than 1 m of hillslope sediment (Late Pleistocene); commonly a series of billowy hills or a rounded bench (2° to 10°, with slopes of 10° to 15° above and below) occurs near the middle of the formation; flat bench (1° to 7°) occurs near the base of formation in the northwestern part of the county.
Ꞓw	**Wonewoc and Eau Claire Formations. Ironton Member**, at the top of the Wonewoc Formation, a few metres of brown, burrowed, quartzose, fine to medium sandstone; Cambrian; forms a low cliff in most places, especially in the northwestern part of the county. **Galesville Member**, at the bottom of the Wonewoc Formation, 15 to more than 20 m of white, quartzose, medium sandstone; Cambrian; generally a steep (10° to 30°) tree-covered slope, but in some places steeper or flatter; commonly overlain by about 1 m of sandy hillslope sediment (Late Pleistocene). **Eau Claire Formation**--a few metres of poorly sorted, variably colored, quartzose sandstone; commonly silty and bioturbated; Cambrian; forms a low undulating (1° to 5°) bench; overlain by thin (generally less than 1 m) sandy hillslope or shoreline sediment (Late Pleistocene).
Ꞓm	**Mount Simon Formation**. More than 30 m of white, quartzose, fine to medium sand and sandstone; Cambrian; commonly overlain by a few metres of hillslope, shoreline, offshore, or windblown sand (Late Pleistocene); flat to undulating (1° to 3°) in most areas but steeper in some places, with vertical cliffs in the Wisconsin Dells.
Ꞓp	**Parfreys Glen Formation**. Mostly quartz sandstone; parts conglomeratic; locally contains angular talus blocks several metres across, adjacent to the Baraboo Formation; some zones glauconitic; commonly very hard (silica cement); generally unfossiliferous; generally occurs within several hundred metres of the Baraboo Hills; bedding generally slopes a few degrees away from the Baraboo Hills; chronologic equivalent of the Mount Simon, Eau Claire, Wonewoc, Tunnel City, St. Lawrence, and Jordan Formations, and perhaps also of the Oneota, St. Peter, and younger formations; contact with the Baraboo Formation is imprecisely located in most areas.
Ꝑk	**"Dake formation"?** Similar to the Baraboo quartzite; Early Proterozoic.
Ꝑb	**Baraboo Formation.** About 1.5 km of gray to pink quartzite; very well cemented in most places; Early Proterozoic; generally overlain by hillslope debris consisting of quartzose sand and gravel on steep slopes and finer material on gentle slopes (Late Pleistocene).
Ꝑg	**Granite in Baxter Hollow**. Pink to red granite and quartz diorite beneath the Baraboo Formation; Early Proterozoic.
Ꝑd	**Diorite near Denzer**. Gray to red diorite or granodiorite; Early Proterozoic.
Ꝑr	**Rhyolite near the Lower Narrows, Denzer, and Devils Nose**. Metamorphosed red to black tuffaceous rock and lava flows; Early Proterozoic.

Symbols

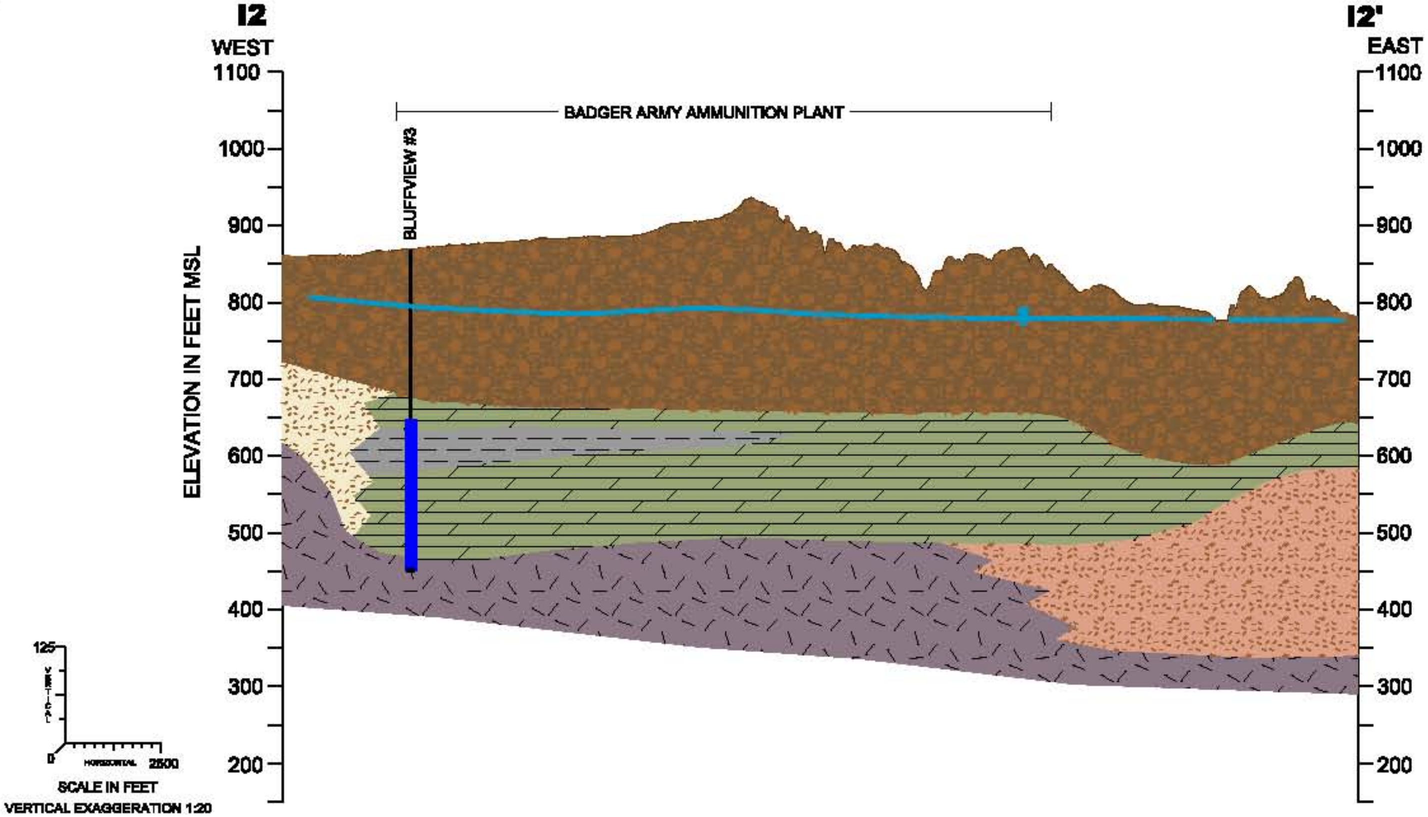
★	Ice-wedge polygons. Each symbol indicates a group of polygons visible on aerial photographs. Each polygon is tens of metres across.
	Possible shore-ice collapse trench.
	River cutbanks. Only those higher than about 5 m shown; cutbanks in sandstone at the Wisconsin Dells are also not shown.
	Direction of meltwater flow.
	Summit plateaus. Highest level areas on crest of the South Range of the Baraboo Hills, probably cut in Paleozoic time.
	Subsummit terraces. Probably cut into Baraboo quartzite by wave erosion during the Ordovician.
	Block stream.
	Moraine. Broad (more than 0.2 km wide) end moraines shown with pattern; narrow (less than 0.2 km wide) end moraines shown with line symbol marking the crest of the ridge.
40 75	Dip and strike symbols. Shown on Precambrian metasedimentary units; some derived from I.W. Dalziel and R.H. Dott, Jr. (1970, Geology of the Baraboo District, Wisconsin: Wisconsin Geological and Natural History Survey Information Circular 14, 164 p.).
	Geologic contacts. Continuous where position shown on map is generally within 0.1 km of the true position; dashed where position shown on map is commonly more than 0.1 km from the true position.
■	Old subsurface iron mine.
	Old open-pit iron mine.
U D	Fault (or narrow monocline).
	Gravel pit.
	Rock quarry.
	Anticline.

University of Wisconsin-Extension

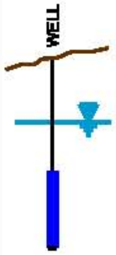
Published by and available from
Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, WI 53705
M.E. Ostrom, Director and State Geologist

Cartography by D.L. Patterson

Wisconsin Geological and Natural History Survey
Information Circular 67
Geology of Sauk County, Wisconsin
Plate 1 (Map 90-1a): Geologic map



LEGEND



WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E & F)

GROUND SURFACE

WATER TABLE ELEVATION

WELL SCREEN

BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

- SAND AND GRAVEL, AQUIFER
- WONEWOC FORMATION, AQUIFER (SANDSTONE)
- EAU CLAIRE FORMATION, AQUITARD/AQUIFER (SHALE, DOLOMITE, SILTSTONE, SANDSTONE)
- EAU CLAIRE FORMATION, AQUITARD (SHALE)
- MT. SIMON FORMATION, AQUIFER (SANDSTONE)
- BARABOO FORMATION, AQUITARD (QUARTZITE)

NOTES:
ADAPTED FROM GOTKOWITZ AND OTHERS (2005), HYDROGEOLOGY AND SIMULATION OF GROUNDWATER FLOW IN SAUK COUNTY, WISCONSIN

CROSS SECTION LOCATION

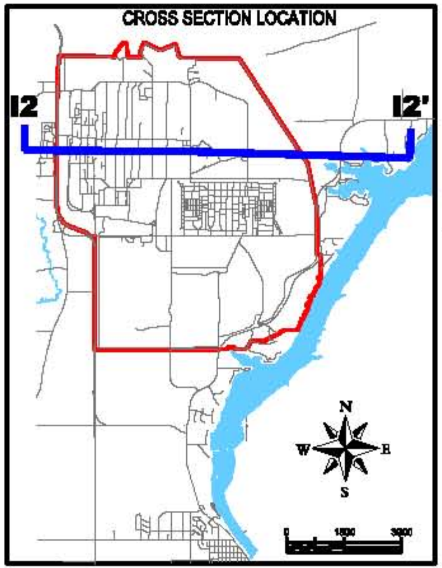
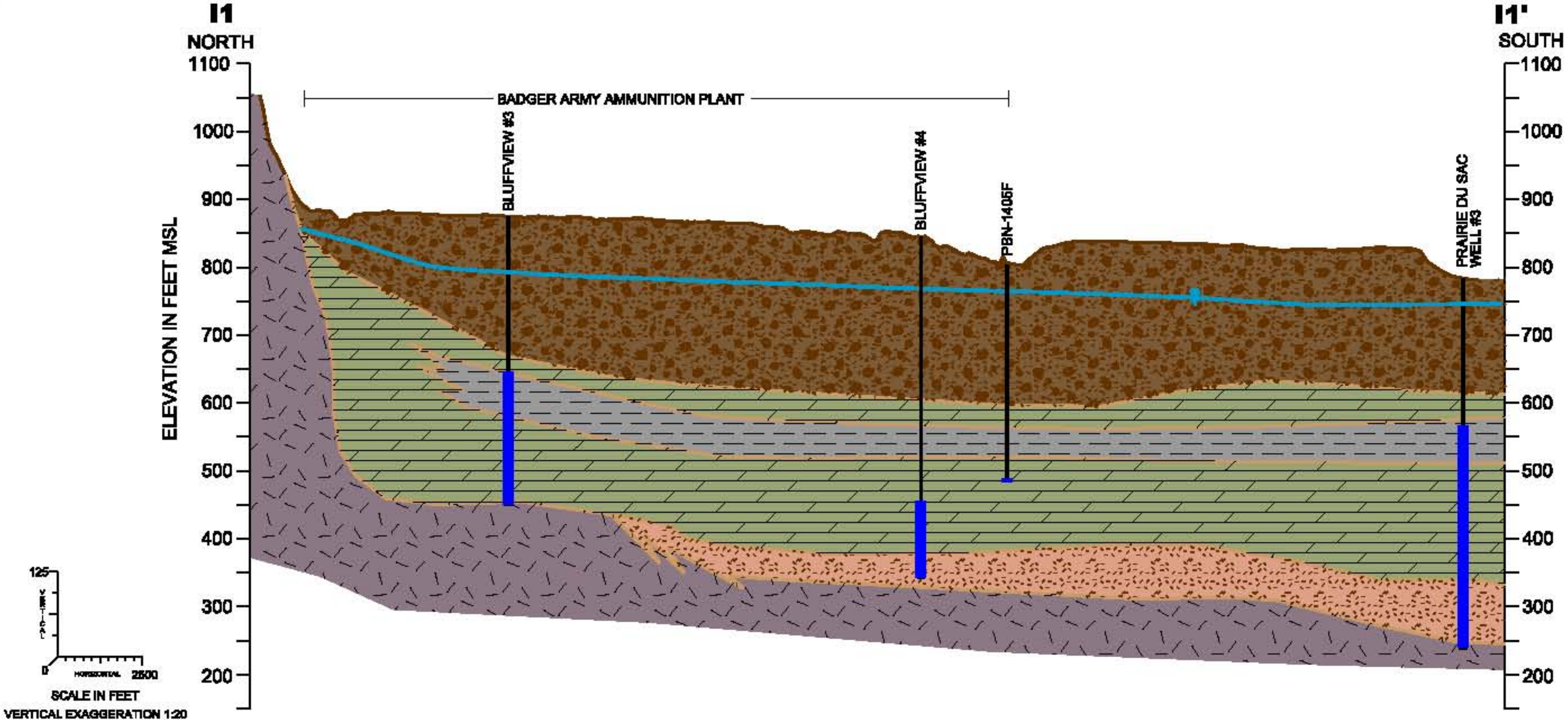


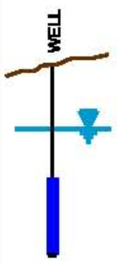
FIGURE 3

GENERALIZED GEOLOGIC
CROSS SECTION
WEST-EAST
RI/FS
BADGER ARMY AMMUNITION PLANT

SPECPRO PROFESSIONAL SERVICES



LEGEND



WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E & F)

GROUND SURFACE

WATER TABLE ELEVATION

WELL SCREEN

BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

▨	SAND AND GRAVEL, AQUIFER
▨	EAU CLAIRE FORMATION, AQUITARD/AQUIFER (SHALE, DOLOMITE, SILTSTONE, SANDSTONE)
▨	EAU CLAIRE FORMATION, AQUITARD (SHALE)
▨	MT. SIMON FORMATION, AQUIFER (SANDSTONE)
▨	BARABOO FORMATION, AQUITARD (QUARTZITE)

NOTES:
ADAPTED FROM GOTKOWITZ AND OTHERS (2005), HYDROGEOLOGY AND SIMULATION OF GROUNDWATER FLOW IN SAUK COUNTY, WISCONSIN

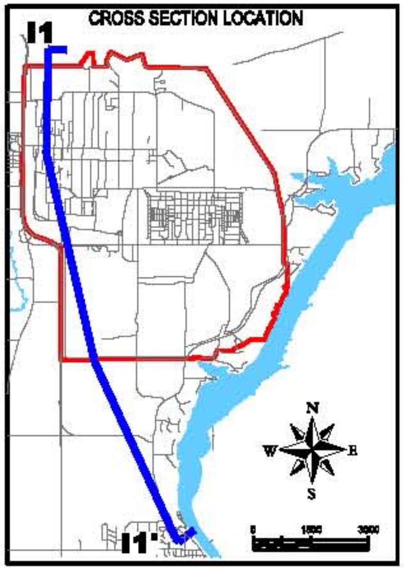
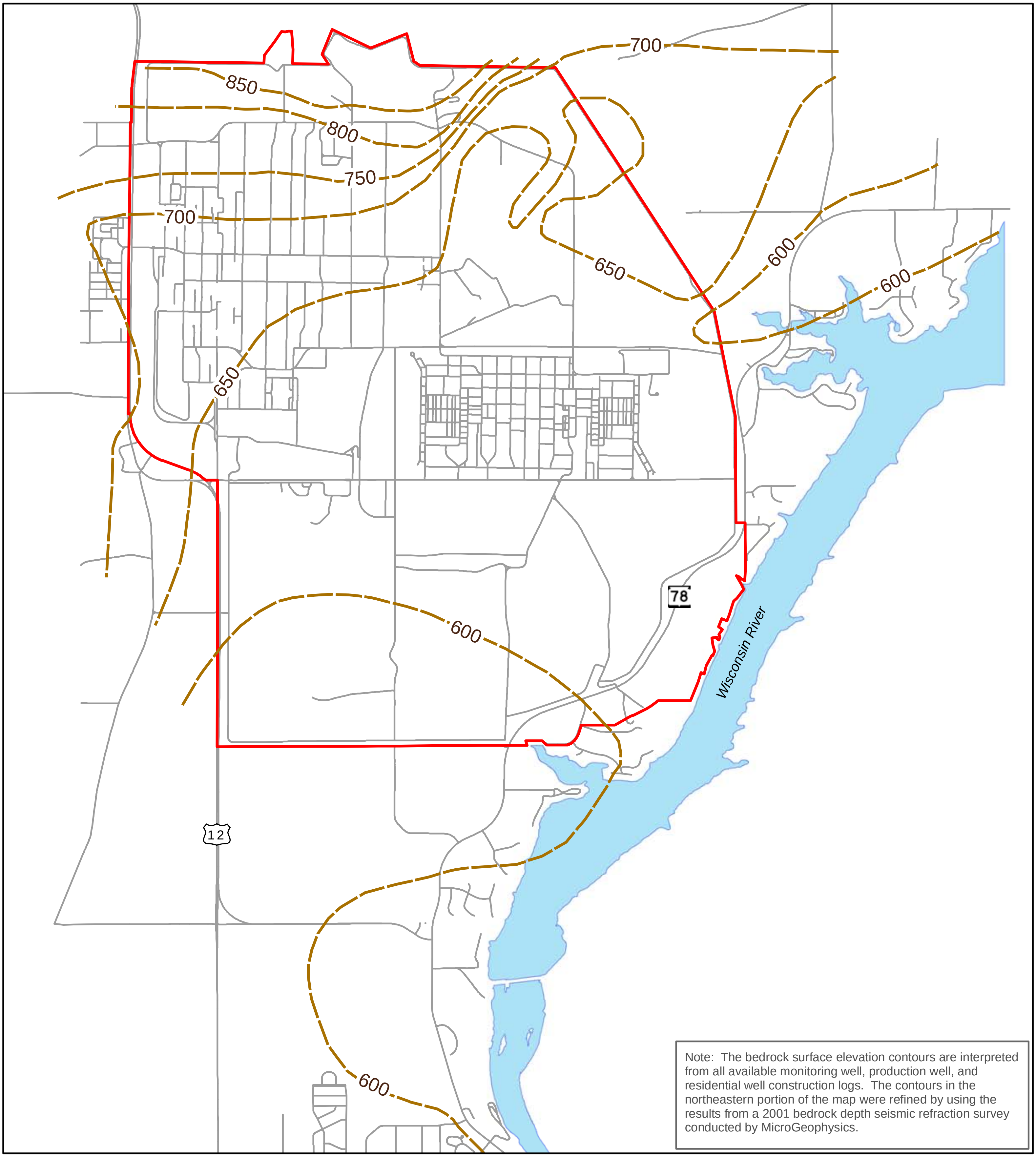


FIGURE 4

GENERALIZED GEOLOGIC CROSS SECTION NORTH-SOUTH

RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



Note: The bedrock surface elevation contours are interpreted from all available monitoring well, production well, and residential well construction logs. The contours in the northeastern portion of the map were refined by using the results from a 2001 bedrock depth seismic refraction survey conducted by MicroGeophysics.

Legend

🟥	Badger Army Ammunition Plant Boundary
🟫	Bedrock Surface Elevation Contour Contour Interval = 50 feet
🟦	Wisconsin River
▬	Road

Figure 5

Bedrock Surface Map
RI/FS
Badger Army Ammunition Plant

1 inch = 3,750 feet

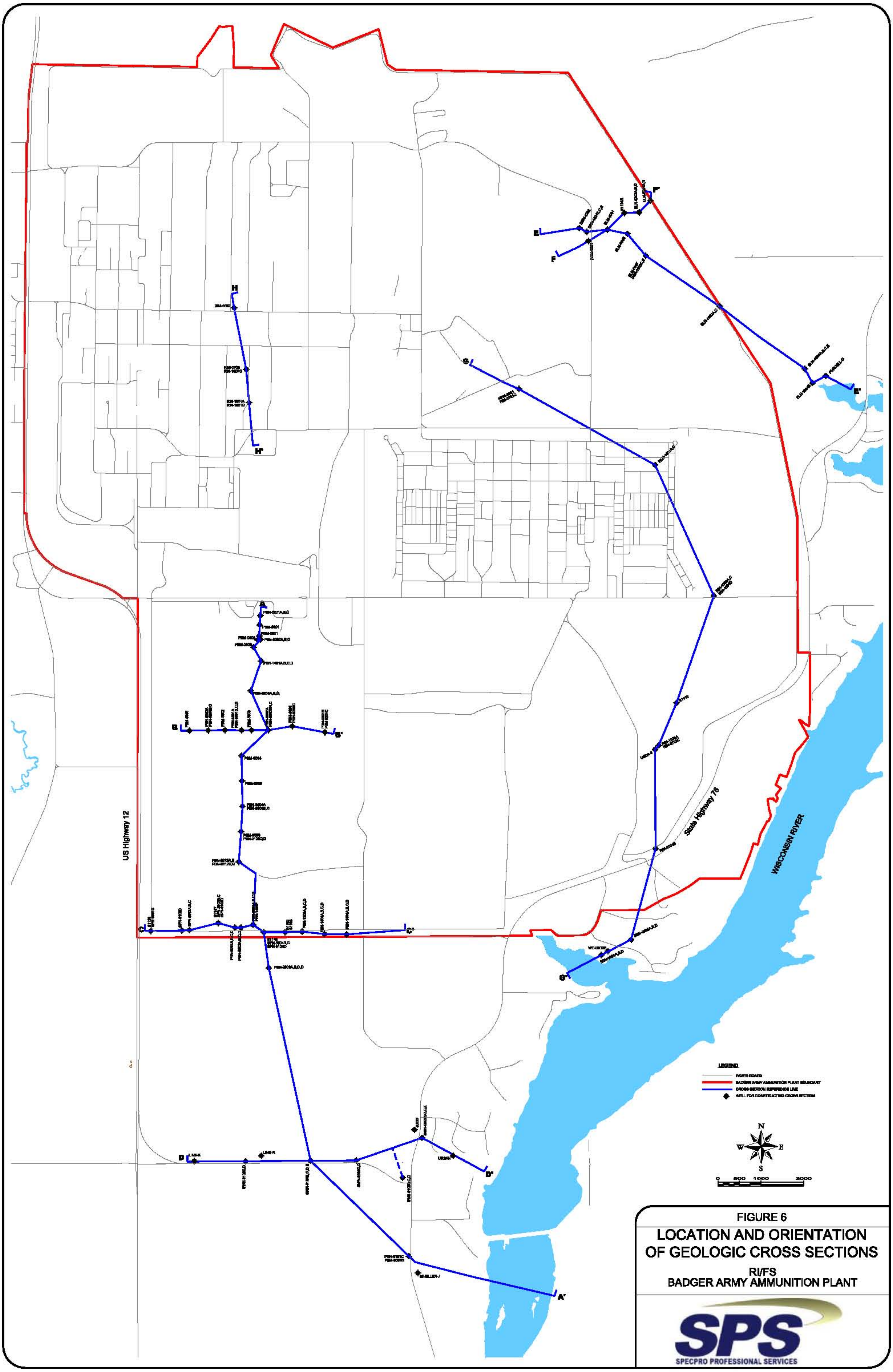
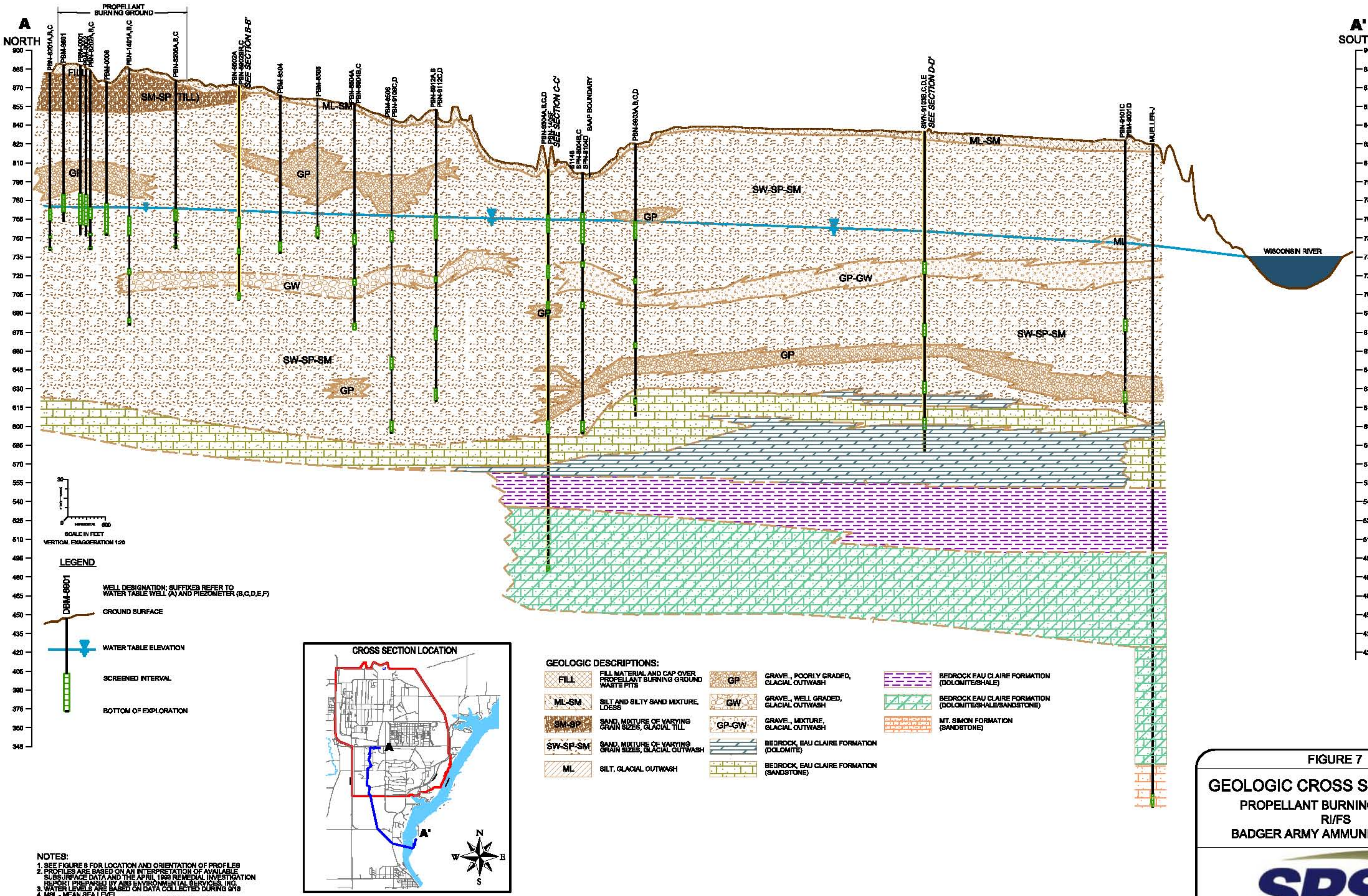


FIGURE 6

LOCATION AND ORIENTATION OF GEOLOGIC CROSS SECTIONS

RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



NOTES:

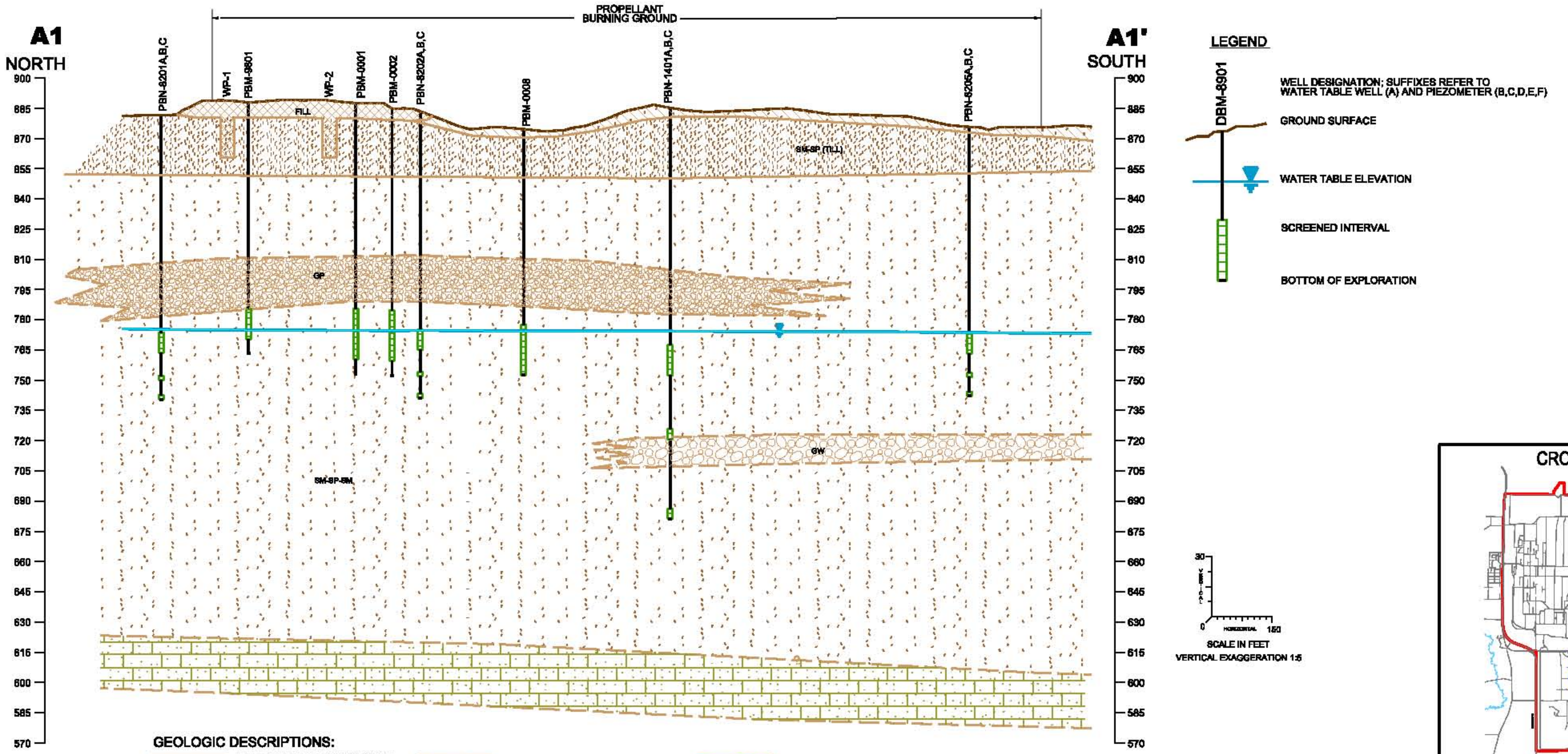
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 7

GEOLOGIC CROSS SECTION A-A'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

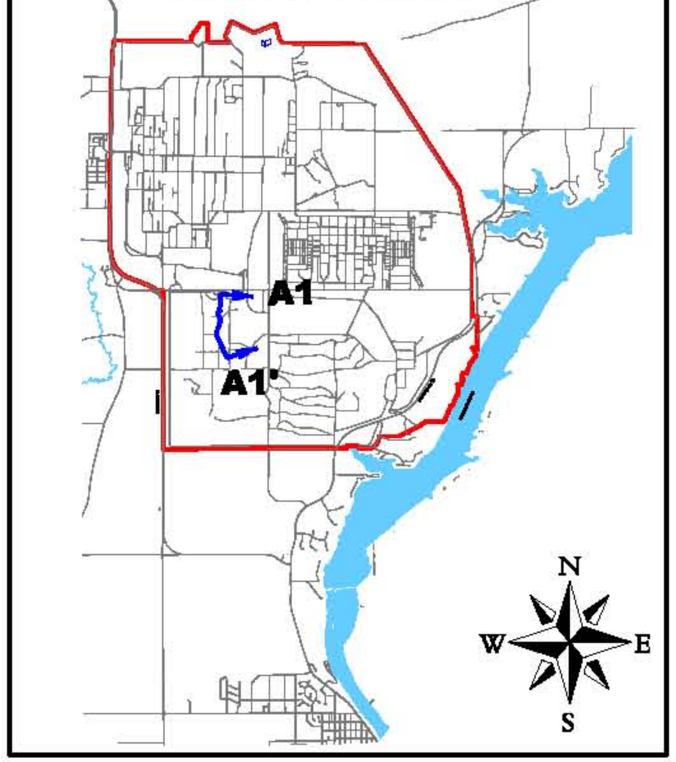
SPS
SPECPRO PROFESSIONAL SERVICES



GEOLOGIC DESCRIPTIONS:

FILL	FILL MATERIAL AND CAP OVER PROPELLANT BURNING GROUND WASTE PITS
ML-SM	SILT AND SILTY SAND MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
ML	SILT, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GW	GRAVEL, WELL GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▨	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▨	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)
▨	BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE)
▨	BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE/SANDSTONE)
▨	MT. SIMON FORMATION (SANDSTONE)

CROSS SECTION LOCATION



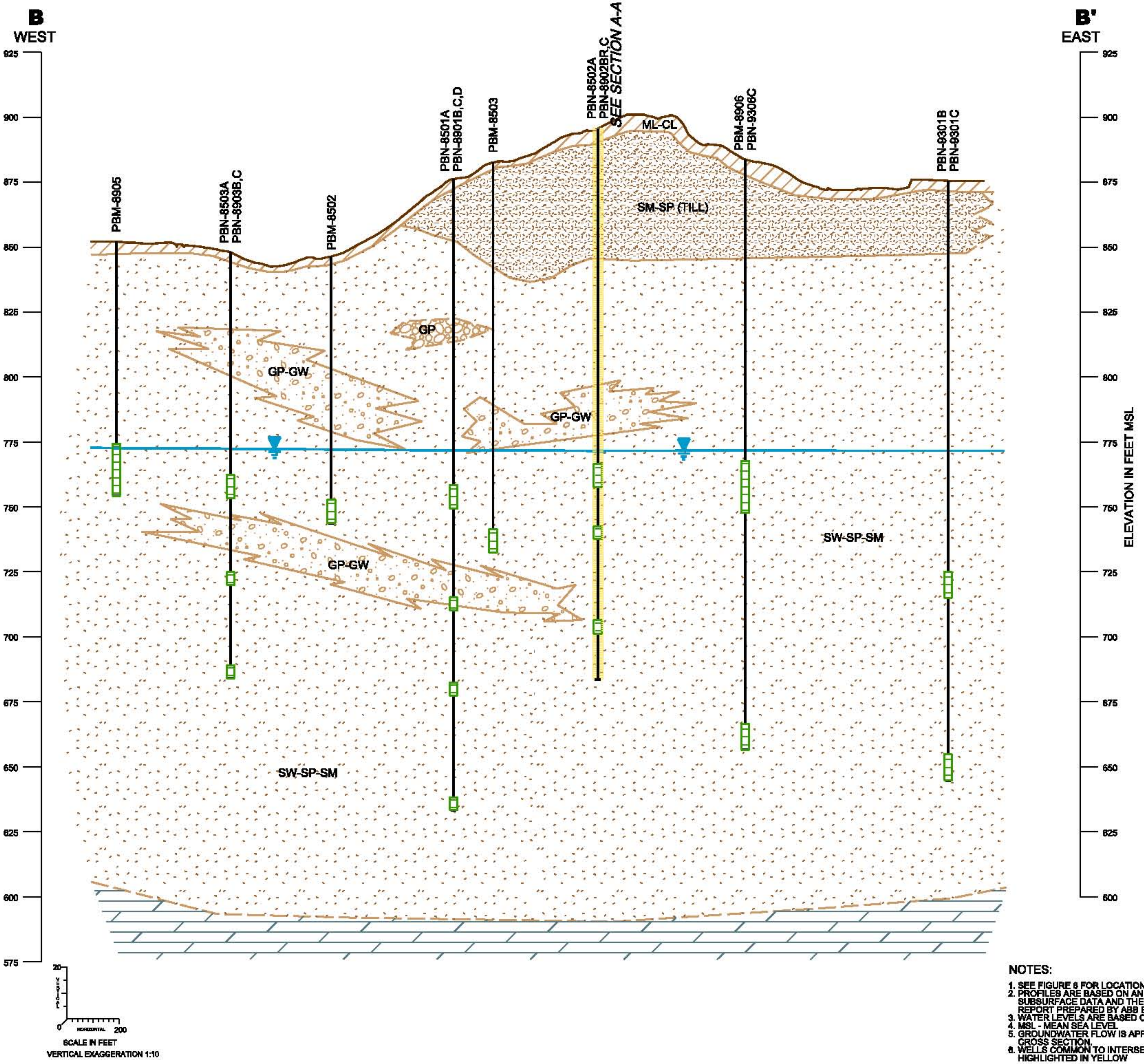
NOTES:
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 8

GEOLOGIC CROSS SECTION A1-A1'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 — WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

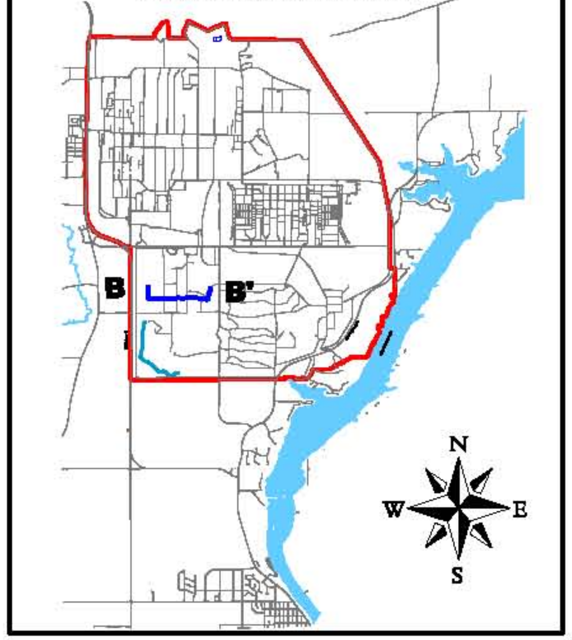
SCREENED INTERVAL

BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▤	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)

CROSS SECTION LOCATION



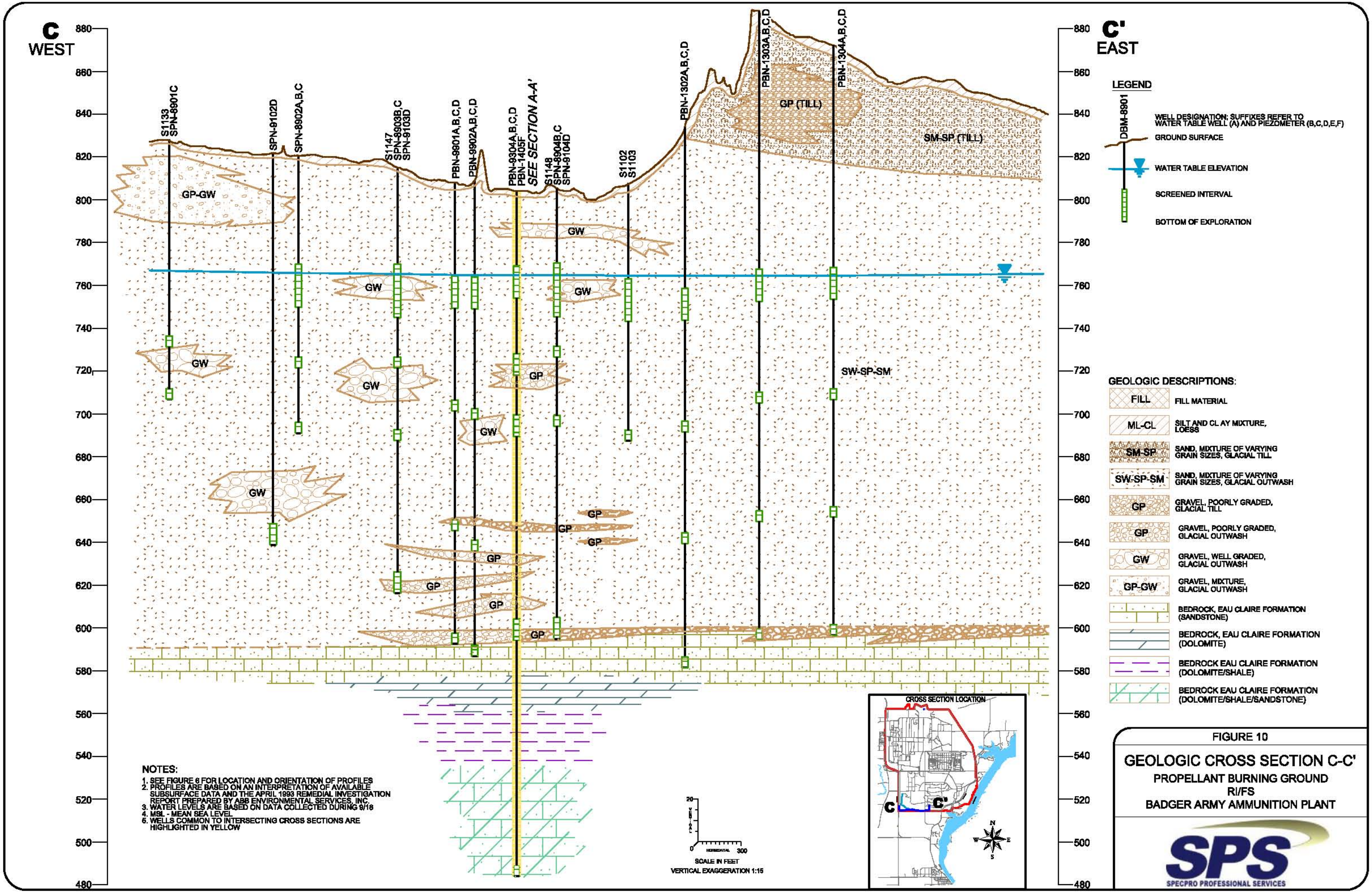
NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 9

GEOLOGIC CROSS SECTION B-B'
PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



NOTES:

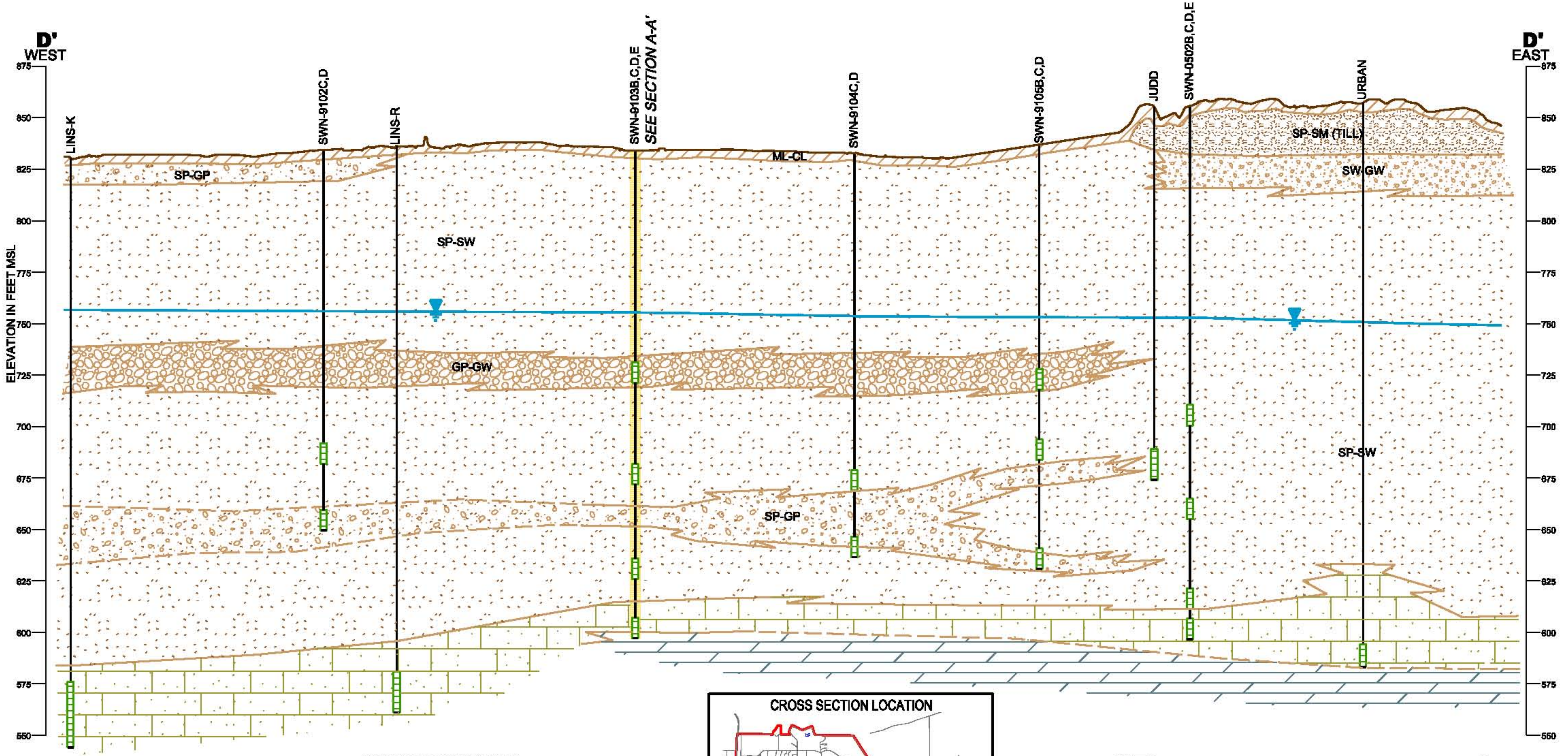
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 10

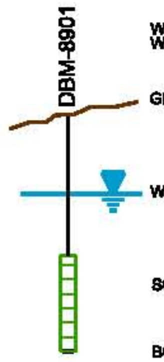
GEOLOGIC CROSS SECTION C-C'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND



WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

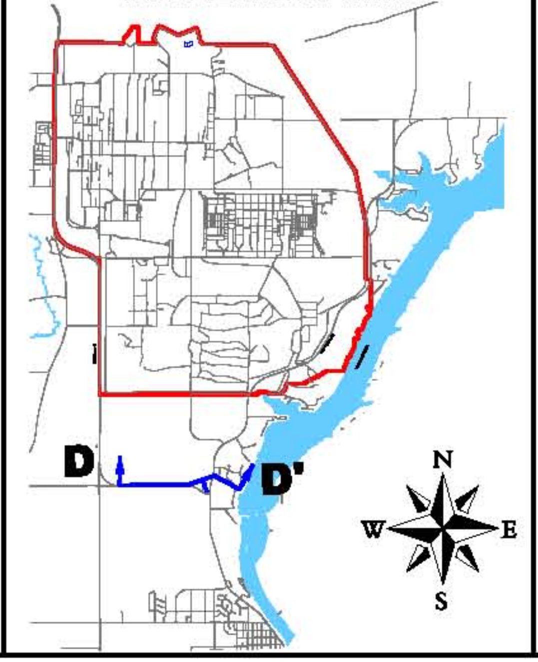
SCREENED INTERVAL

BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

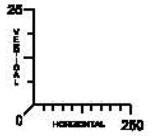
ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SP-GP	SAND AND GRAVEL, GLACIAL OUTWASH
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SP-SW	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▨	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▨	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)

CROSS SECTION LOCATION



NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. SWN-9105 B,C,D ARE OFFSET 750 FEET SOUTH OF THE SECTION LINE.
6. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW



SCALE IN FEET

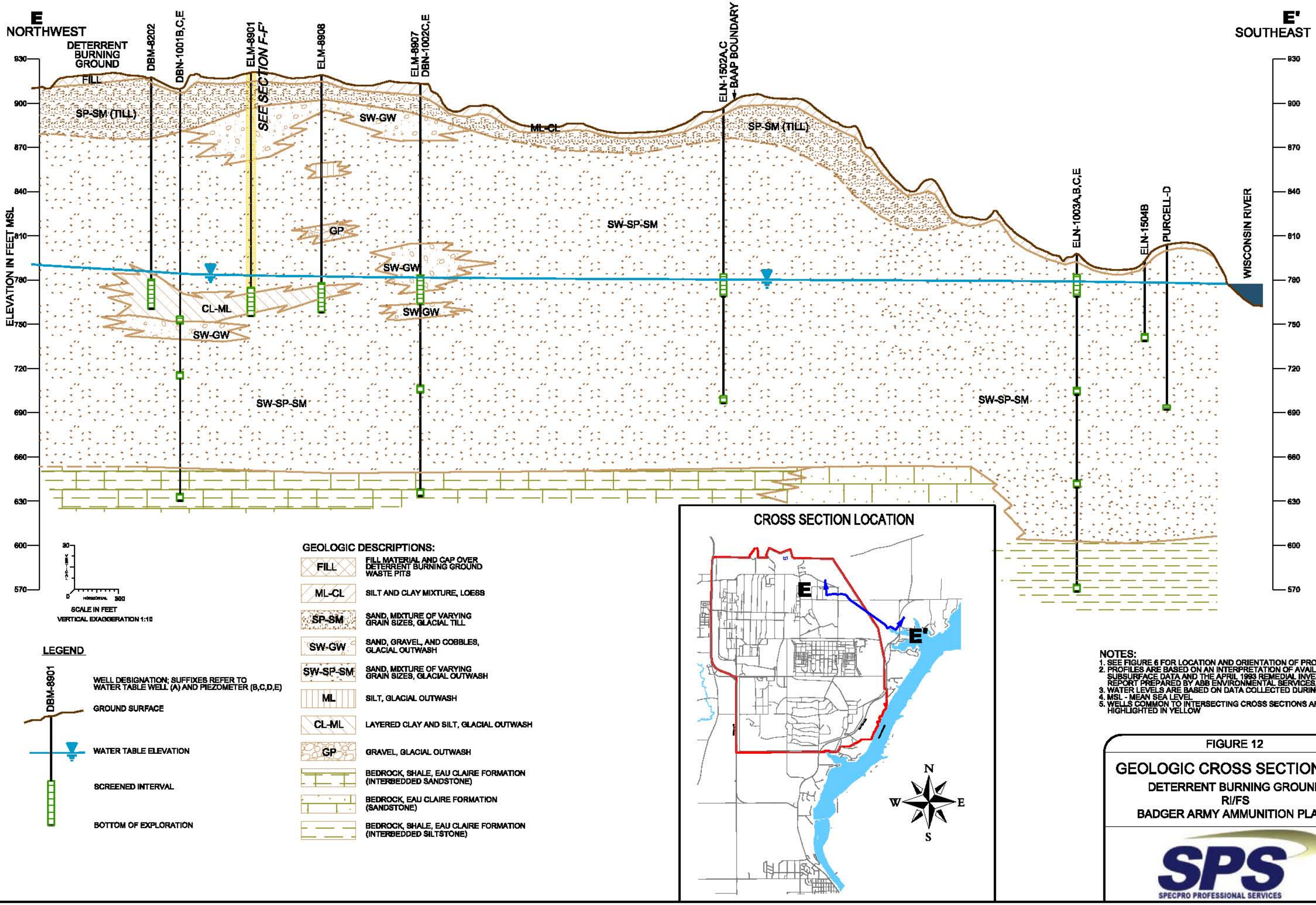
VERTICAL EXAGGERATION 1:10

FIGURE 11

GEOLOGIC CROSS SECTION D-D'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



SCALE IN FEET
VERTICAL EXAGGERATION 1:10

LEGEND

DBM-8901 — WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

FILL	FILL MATERIAL AND CAP OVER DETERRENT BURNING GROUND WASTE PITS
ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
ML	SILT, GLACIAL OUTWASH
CL-ML	LAYERED CLAY AND SILT, GLACIAL OUTWASH
GP	GRAVEL, GLACIAL OUTWASH
	BEDROCK, SHALE, EAU CLAIRE FORMATION (INTERBEDDED SANDSTONE)
	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)
	BEDROCK, SHALE, EAU CLAIRE FORMATION (INTERBEDDED SILTSTONE)

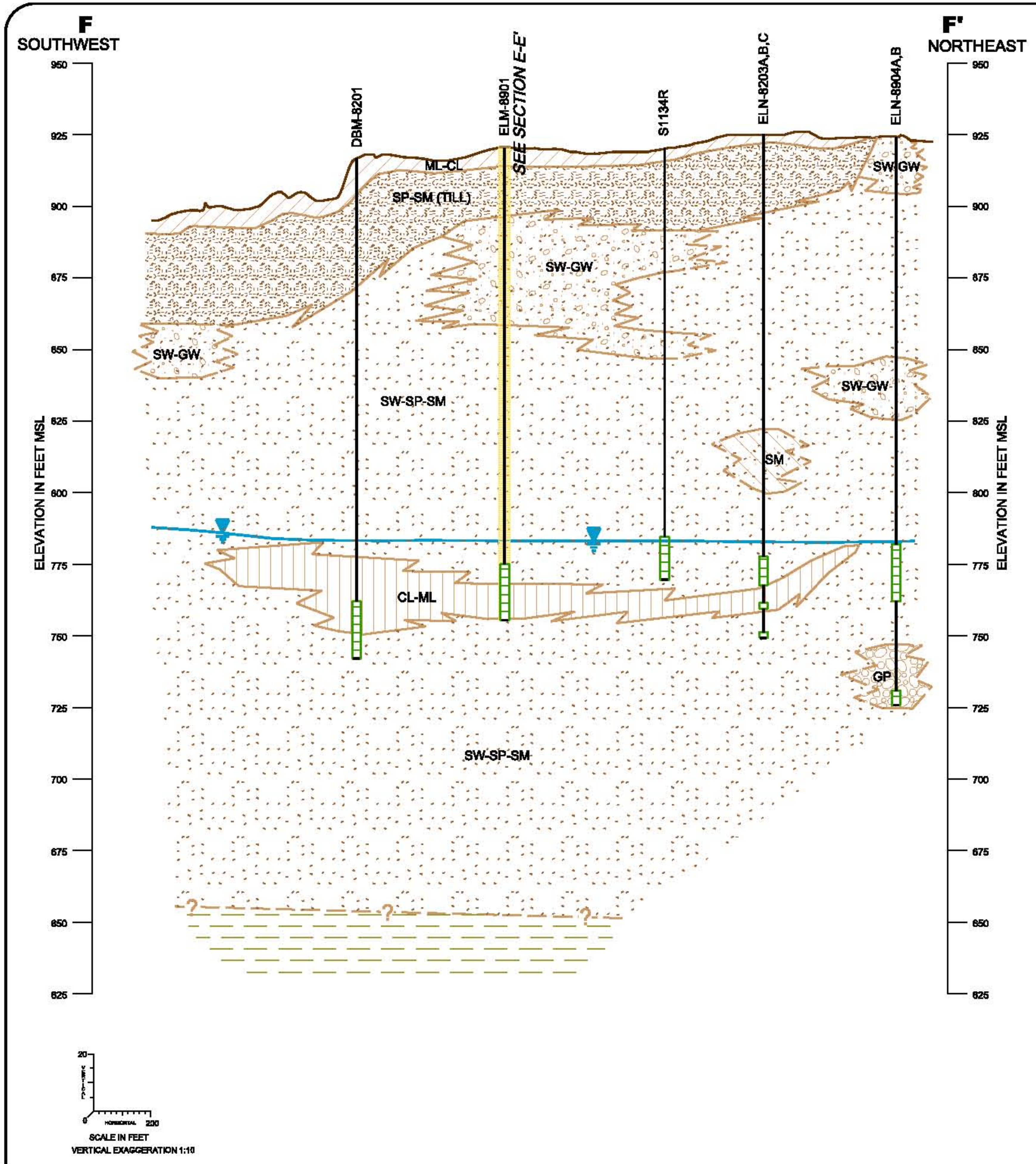
NOTES:
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

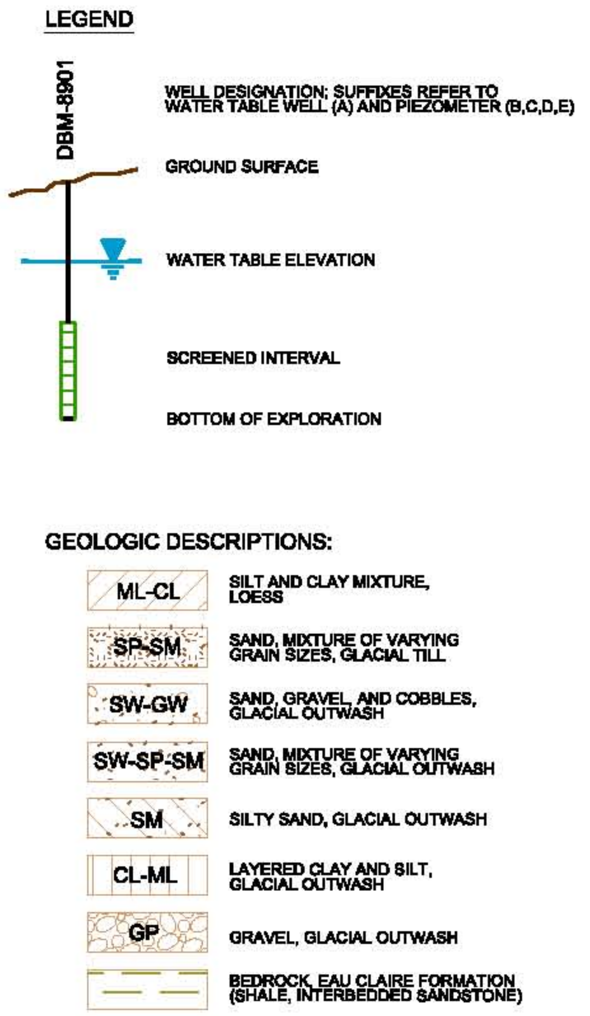
FIGURE 12

GEOLOGIC CROSS SECTION E-E'

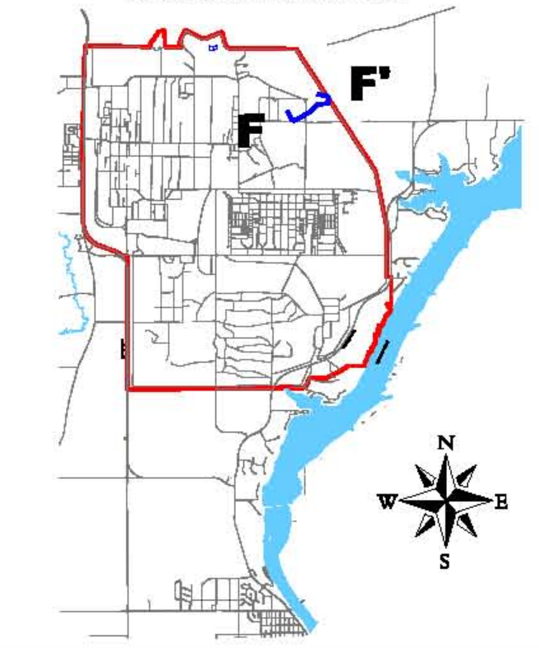
DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPECPRO PROFESSIONAL SERVICES





CROSS SECTION LOCATION



NOTES:

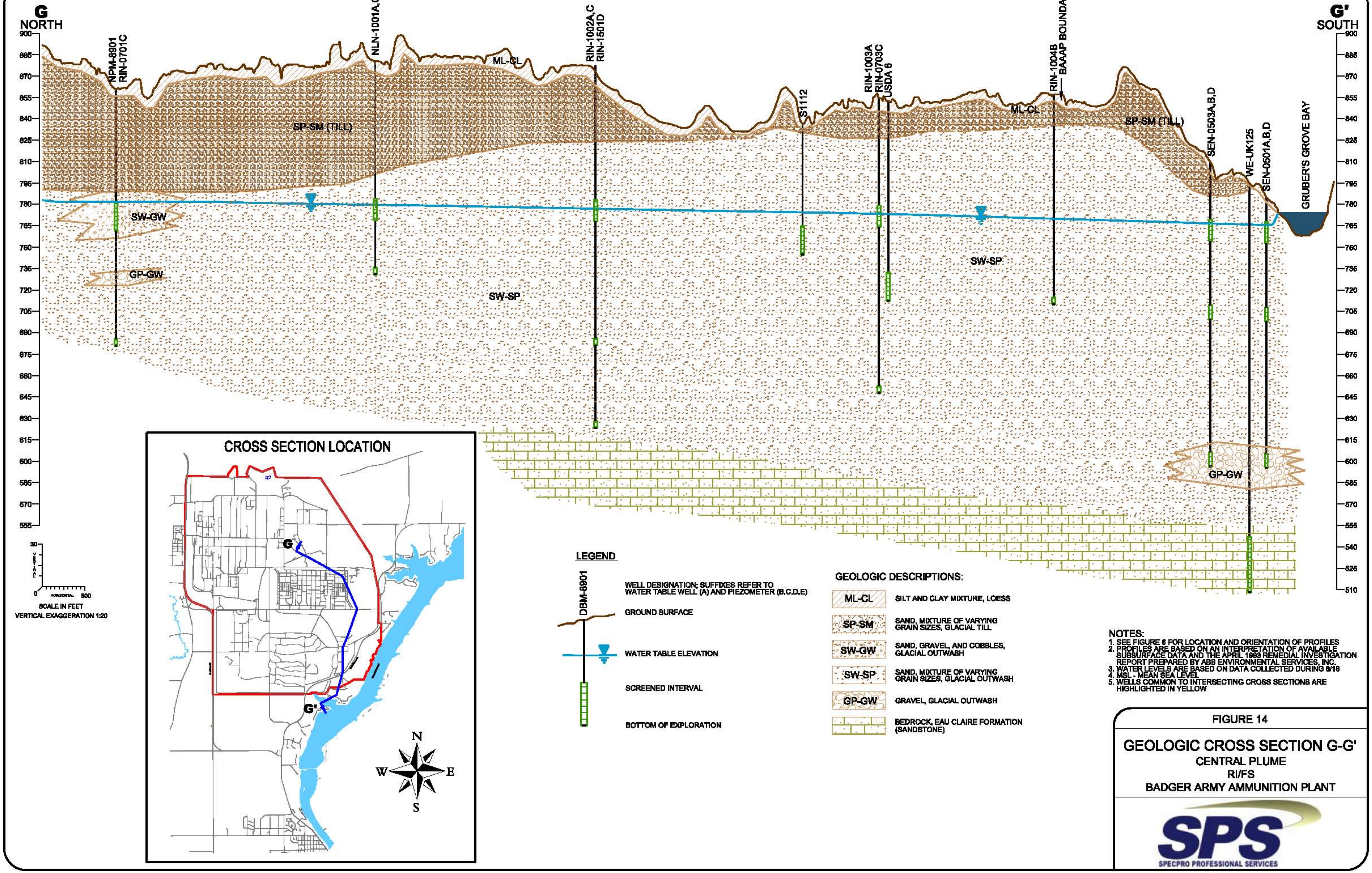
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 13

GEOLOGIC CROSS SECTION F-F'

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901	WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)
	GROUND SURFACE
	WATER TABLE ELEVATION
	SCREENED INTERVAL
	BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SW-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▦	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)

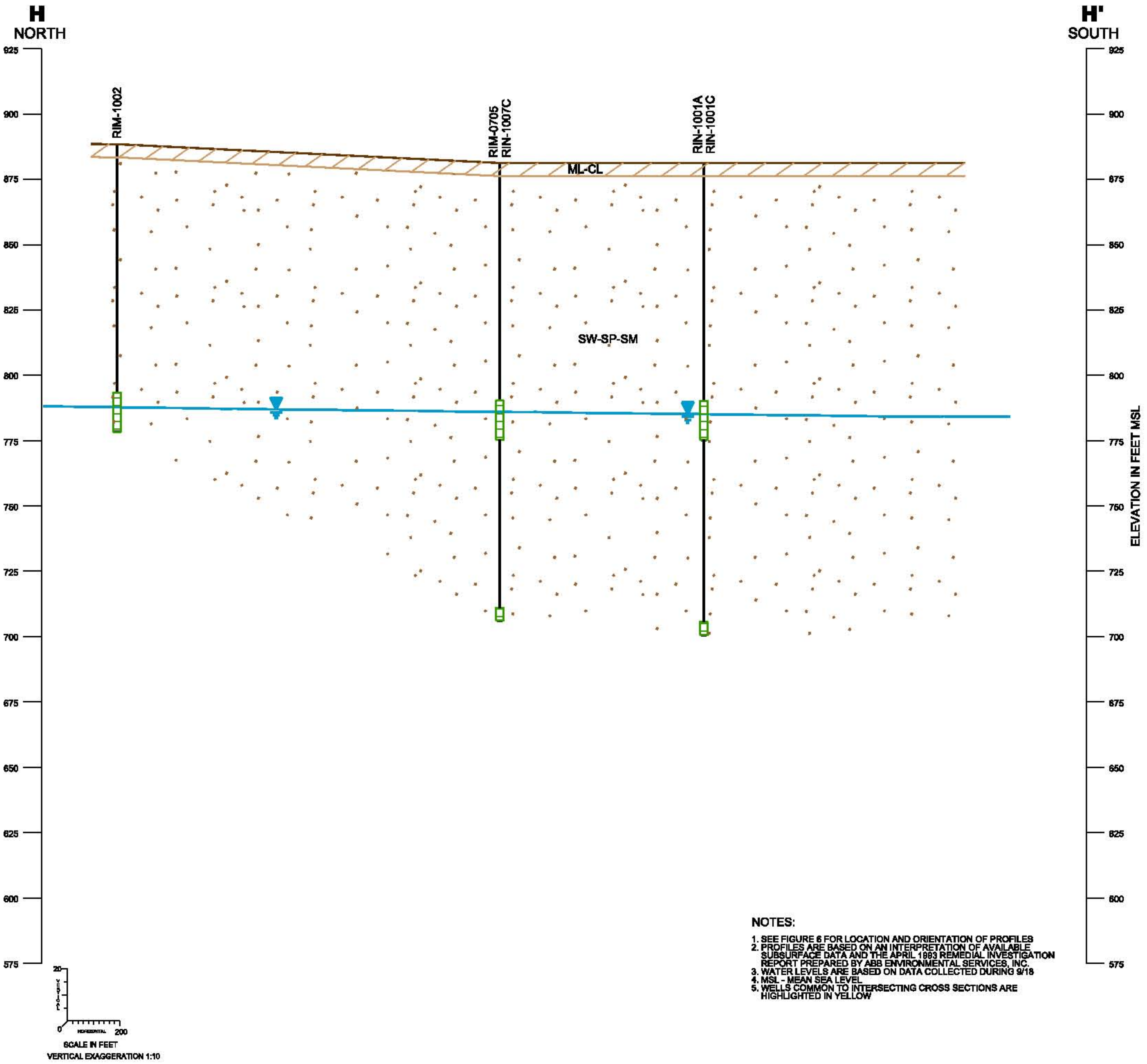
NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 6/18
4. MSL - MEAN SEA LEVEL
5. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

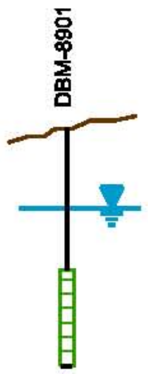
FIGURE 14

GEOLOGIC CROSS SECTION G-G'
CENTRAL PLUME
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND



WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

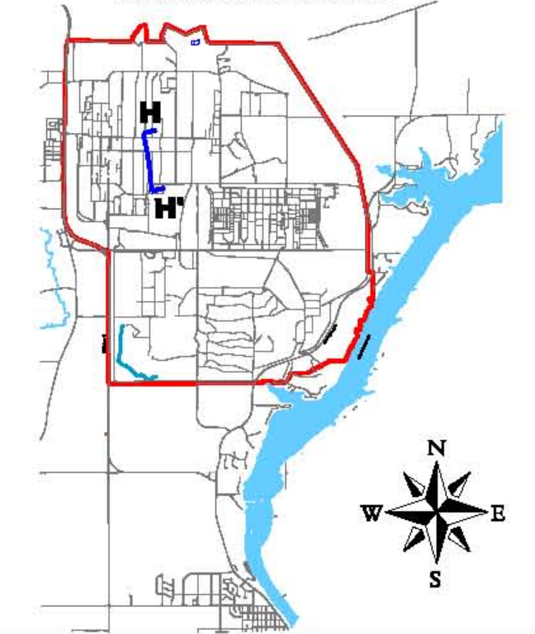
SCREENED INTERVAL

BOTTOM OF EXPLORATION

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▭	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)

CROSS SECTION LOCATION



NOTES:

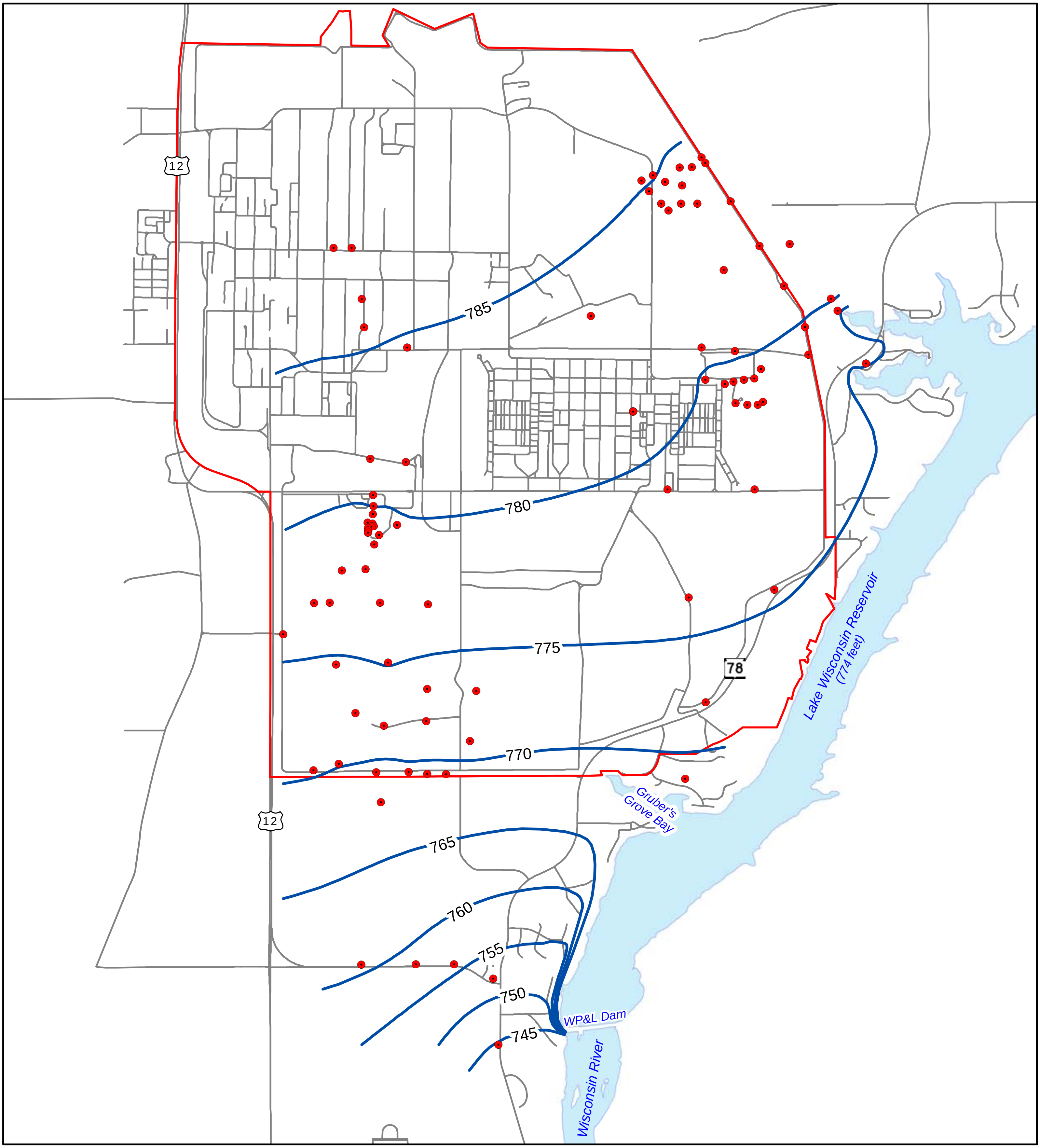
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. WATER LEVELS ARE BASED ON DATA COLLECTED DURING 9/18
4. MSL - MEAN SEA LEVEL
5. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 15

GEOLOGIC CROSS SECTION H-H'

NITROCELLULOSE PRODUCTION AREA
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



Legend

- Badger Army Ammunition Plant Boundary
- ● Monitoring Well (used to draw contours)
- 🟦 Wisconsin River
- Road
- Groundwater Contour

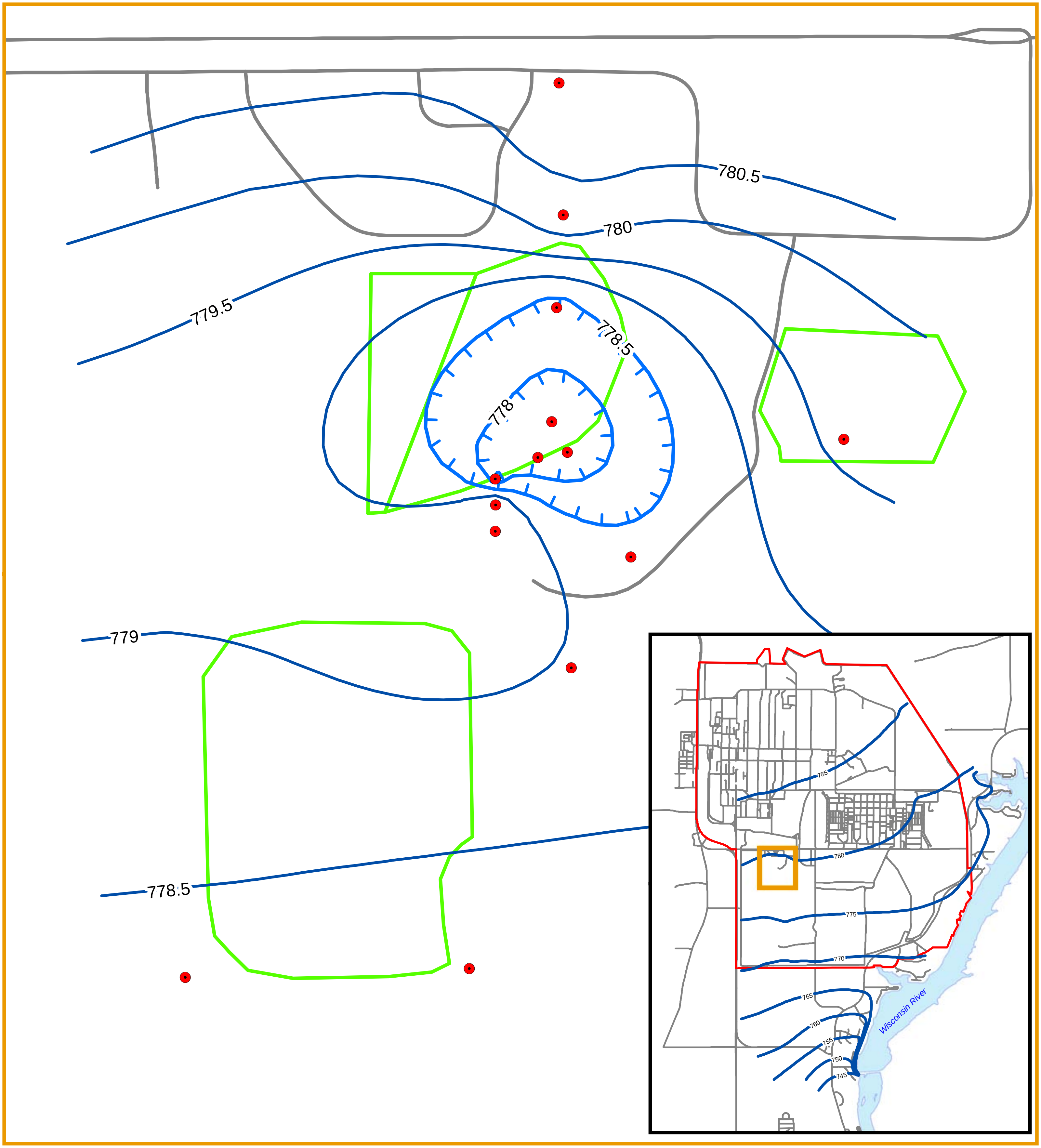
Contour Interval = 5 feet

Figure 16

September 2017 Groundwater Contours
RI/FS
Badger Army Ammunition Plant

1 inch = 3,475 feet

0 5,300 10,600 Feet



Legend

🟥 Badger Army Ammunition Plant Boundary

● Monitoring Well (used to draw contours)

🟩 Source Area

▬ Road

▬ 0.5 feet Groundwater Contour

⊔ 0.5 feet Depression Groundwater Contour

Figure 17

September 2017 Groundwater Contours
Propellant Burning Ground
RI/FS
Badger Army Ammunition Plant

1 inch = 291 feet

0 300 600 Feet

SPS
SPECPRO PROFESSIONAL SERVICES

N

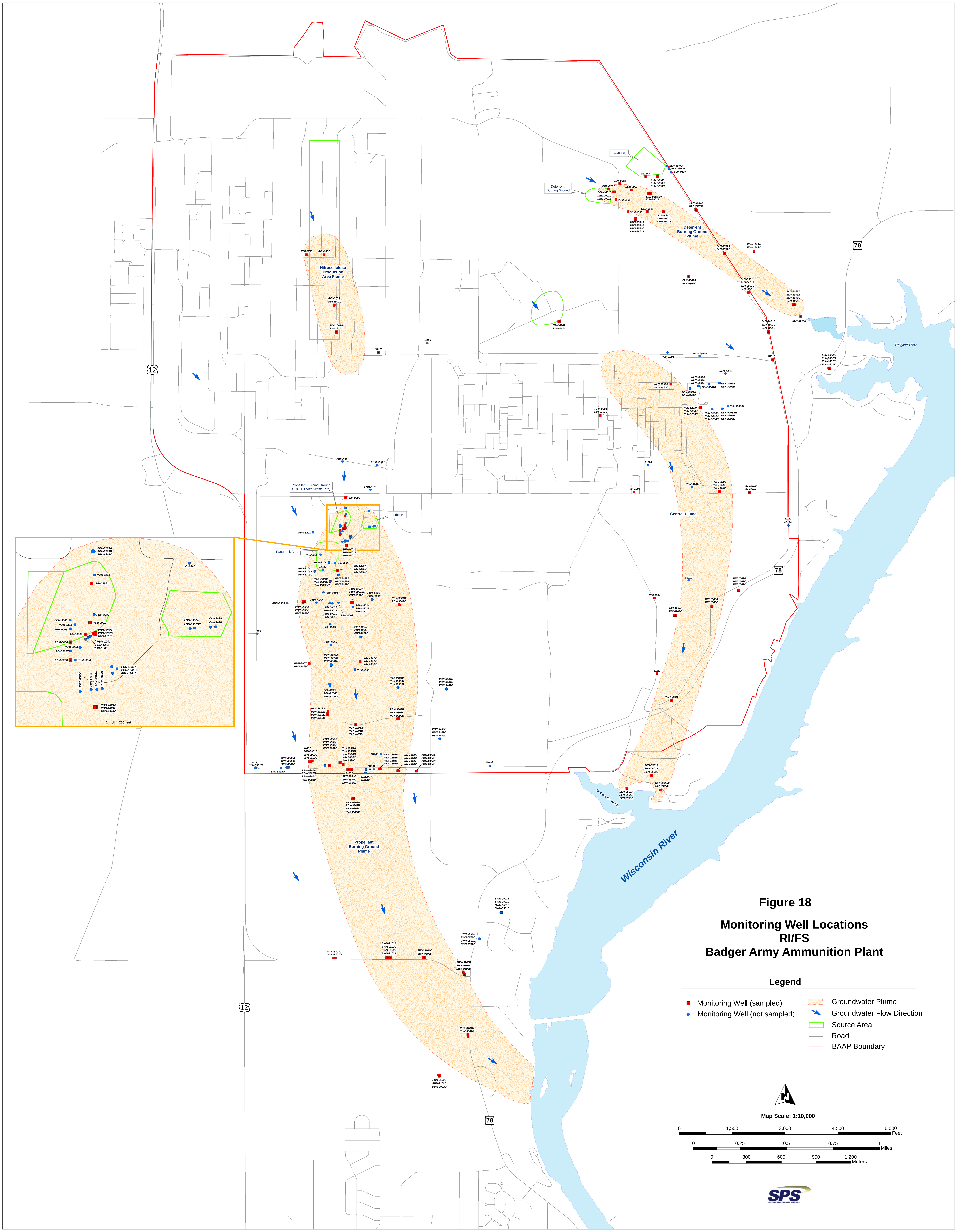
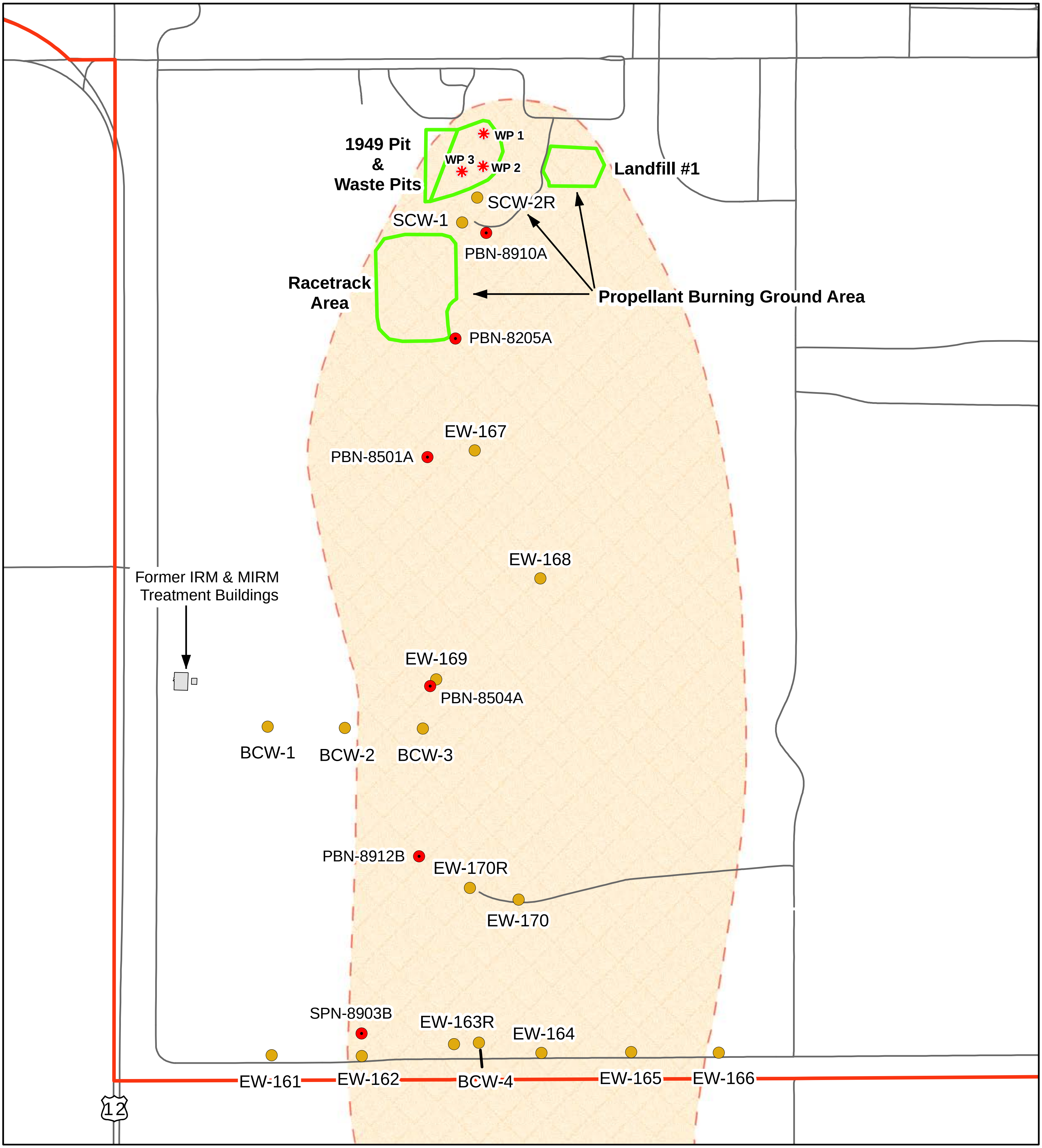


Figure 18

Monitoring Well Locations
RI/FS
Badger Army Ammunition Plant



Legend

- 🟥 Badger Army Ammunition Plant Boundary
- ▨ Groundwater Plume
- ● Abandoned Extraction Well
- ● Monitoring Well
- ✱ Former Waste Pit
- 🟩 Source Area
- ▬ Road

Figure 19

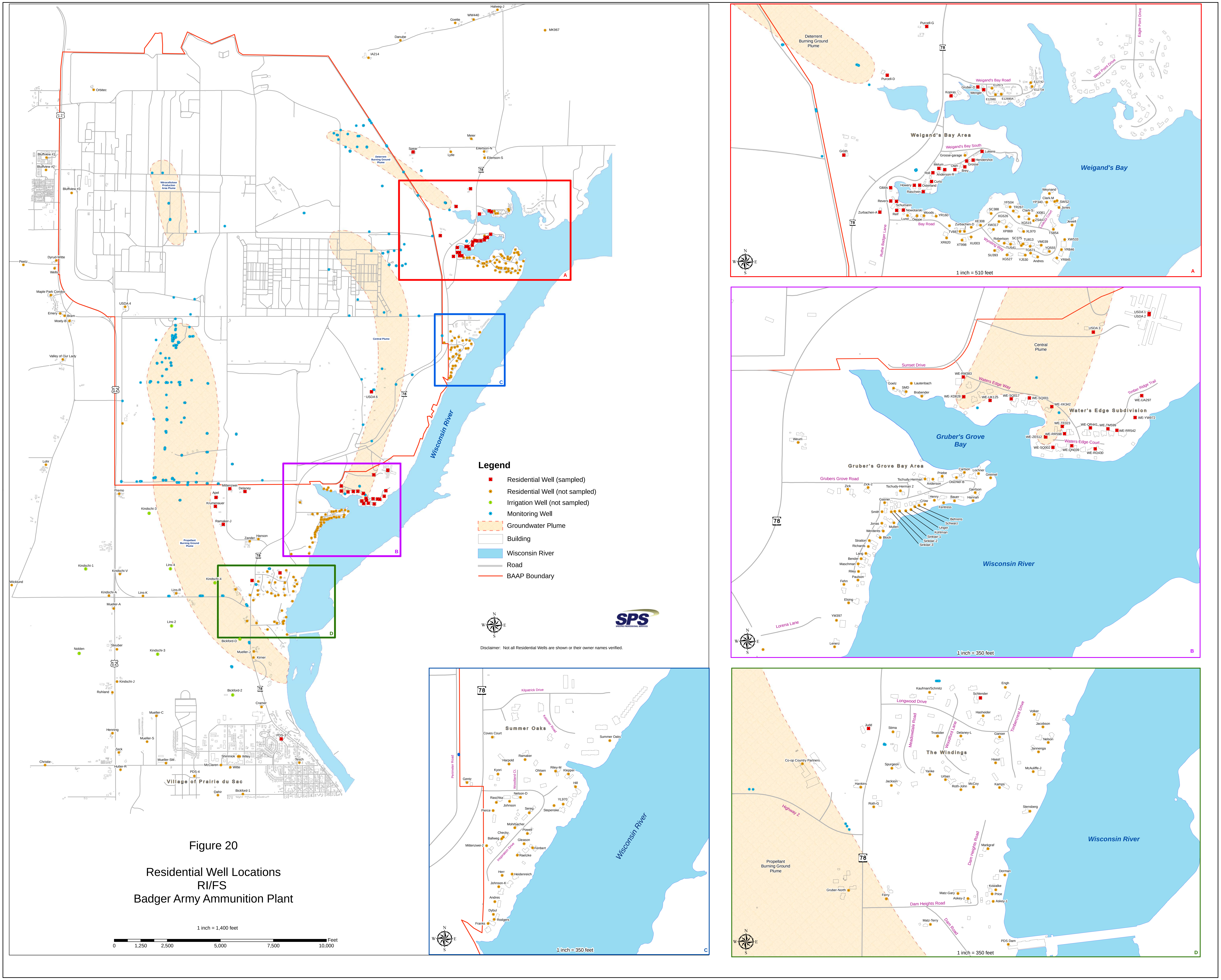
Propellant Burning Ground Layout
RI/FS
Badger Army Ammunition Plant

1 inch = 975 feet

0 1,500 3,000 Feet

N

Note: Only monitoring wells referenced in Section 4.5.1.6 MNA are shown.



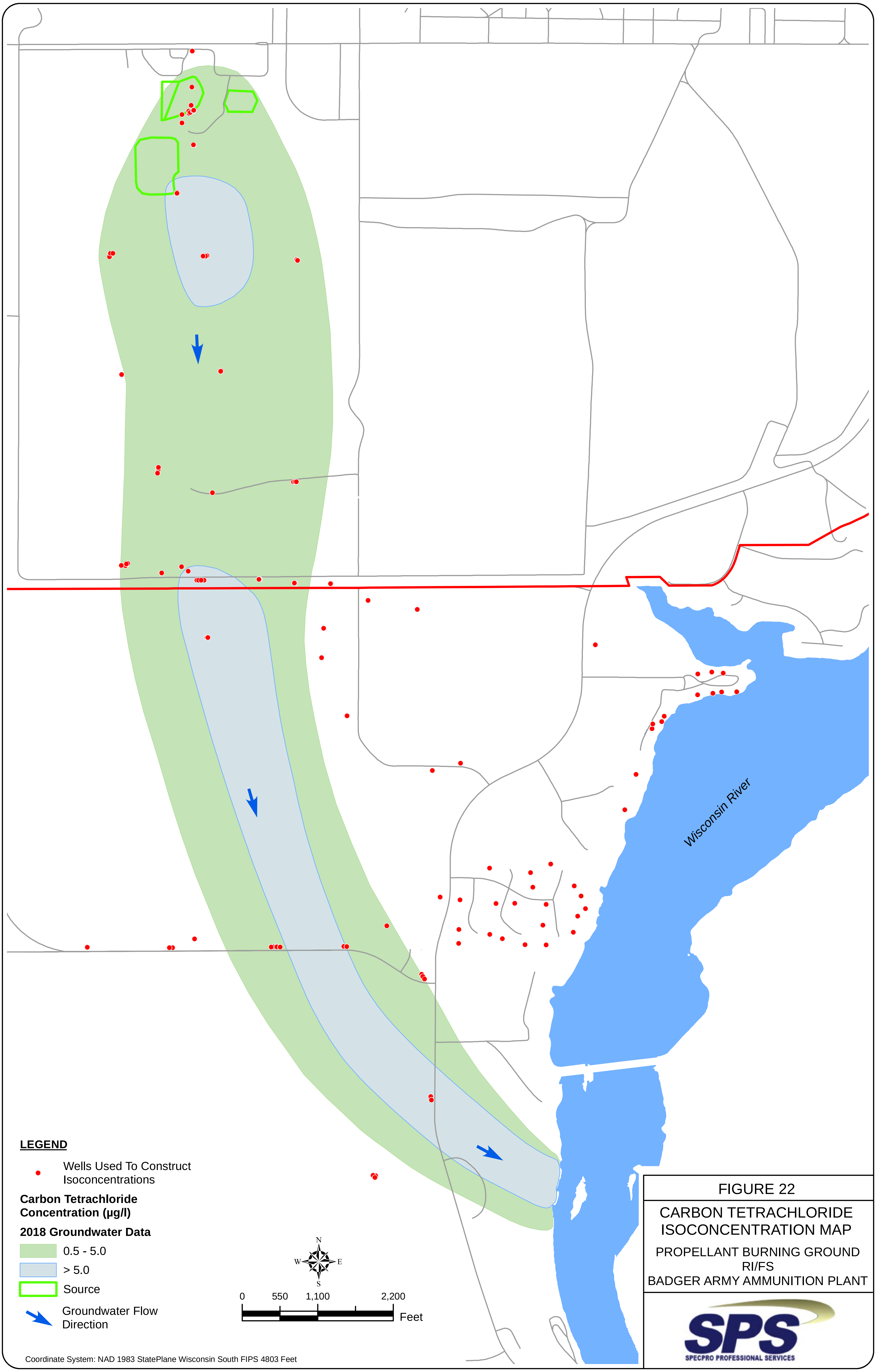
Disclaimer: Not all Residential Wells are shown or their owner names verified.

Figure 20

Residential Well Locations
RI/FS
Badger Army Ammunition Plant

Figure 21

Well Sampling Frequency Map
RI/FS
Badger Army Ammunition Plant



LEGEND

● Wells Used To Construct Isoconcentrations

Carbon Tetrachloride Concentration (µg/l)

2018 Groundwater Data

🟩 0.5 - 5.0

🟦 > 5.0

▭ Source

↘ Groundwater Flow Direction

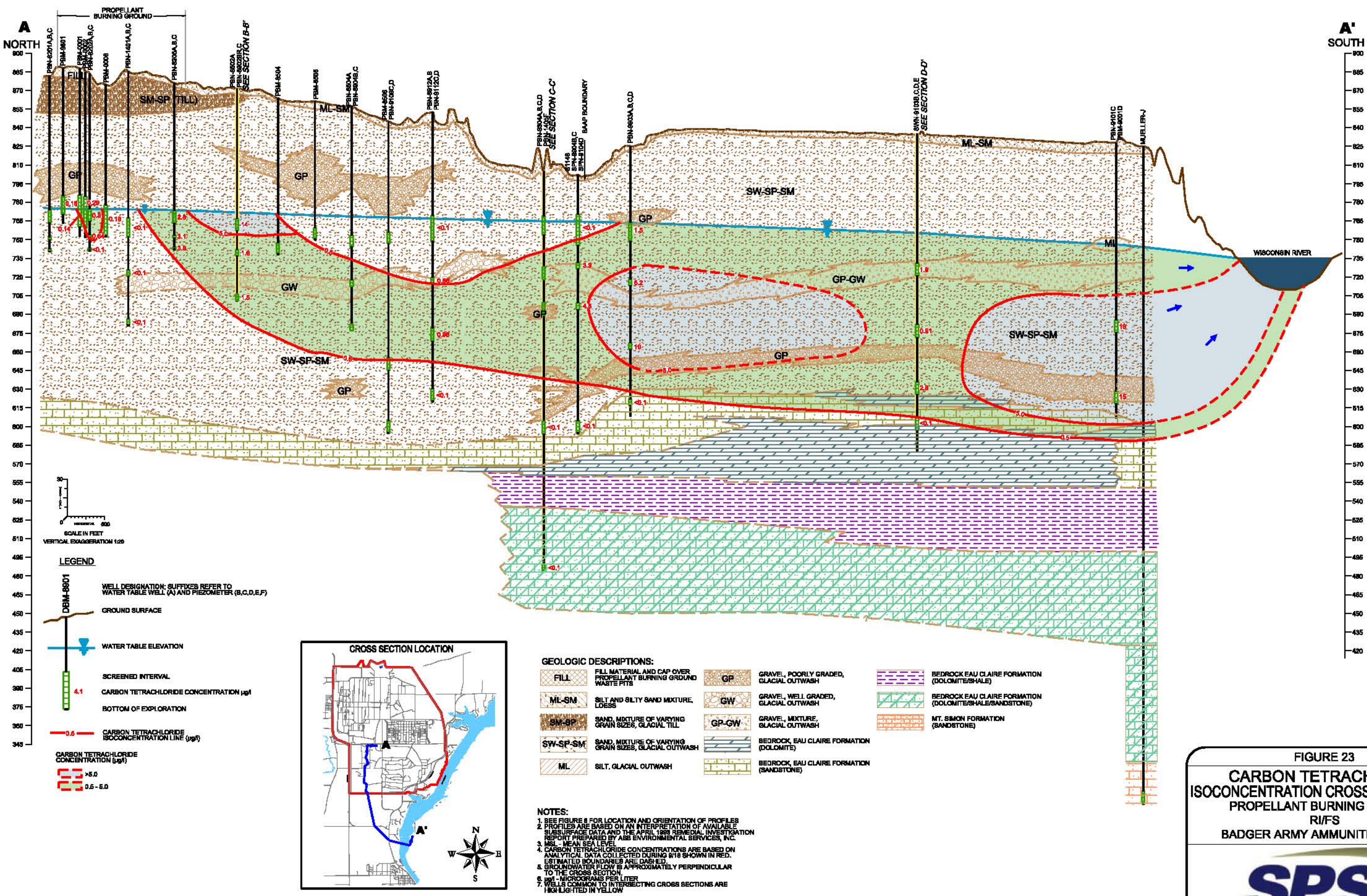
FIGURE 22

CARBON TETRACHLORIDE ISOCONCENTRATION MAP

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet



LEGEND

DBM-8801 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E,F)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

4.1 CARBON TETRACHLORIDE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.5 CARBON TETRACHLORIDE ISOCONCENTRATION LINE (µg/l)

CARBON TETRACHLORIDE CONCENTRATION (µg/l)

- >5.0
- 0.5 - 5.0

GEOLOGIC DESCRIPTIONS:

FILL	FILL MATERIAL AND CAP OVER PROPELLANT BURNING GROUND WASTE PITS
ML-SM	SILT AND SILTY SAND MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
ML	SILT, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GW	GRAVEL, WELL GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▨	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▨	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)
▨	BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE)
▨	BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE/SANDSTONE)
▨	MT. SIMON FORMATION (SANDSTONE)

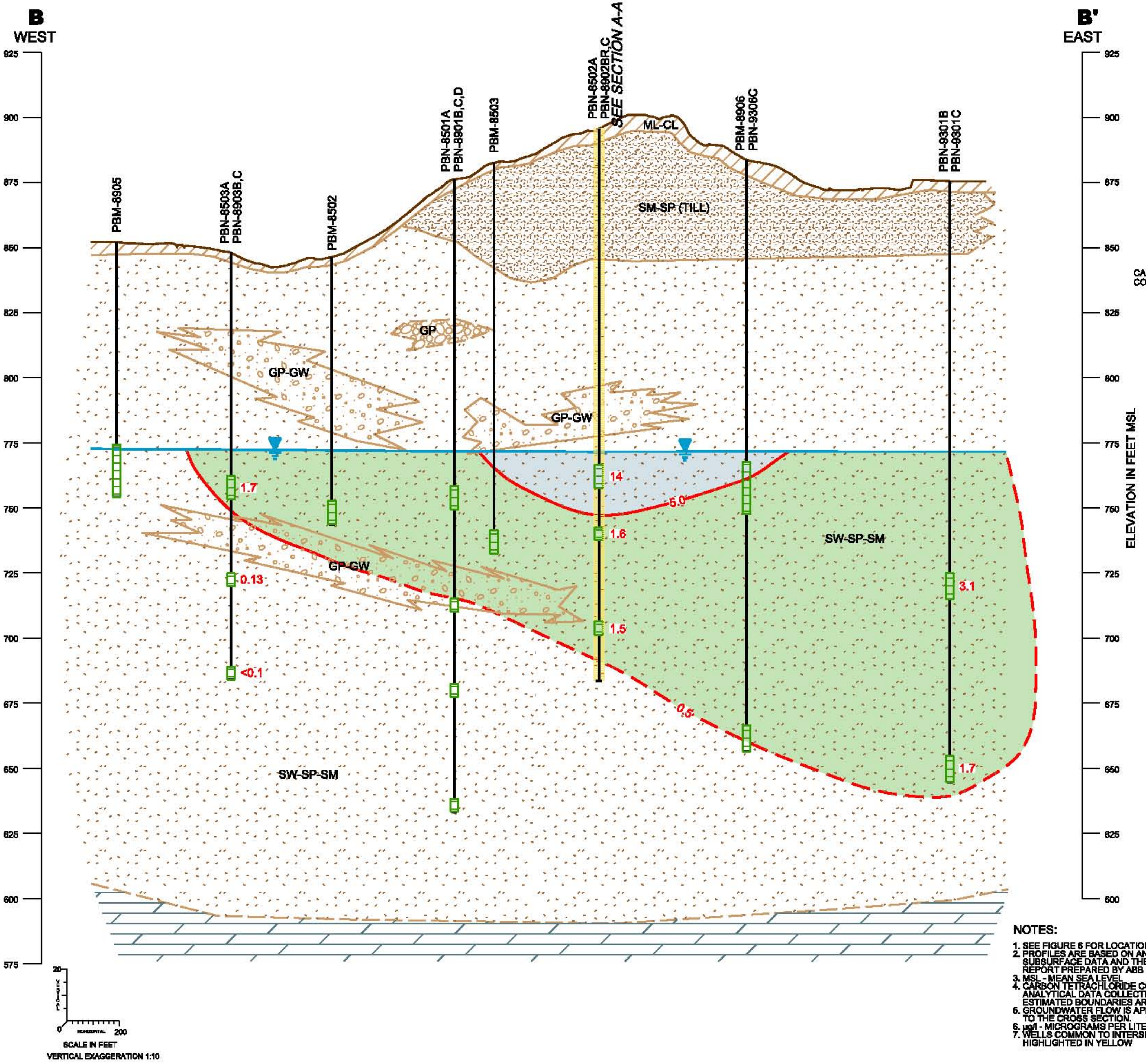
NOTES:

1. SEE FIGURE 8 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. CARBON TETRACHLORIDE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 23

CARBON TETRACHLORIDE ISOCONCENTRATION CROSS SECTION A-A'
PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

2.3 CARBON TETRACHLORIDE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

5.0 CARBON TETRACHLORIDE ISOCONCENTRATION LINE (µg/l)

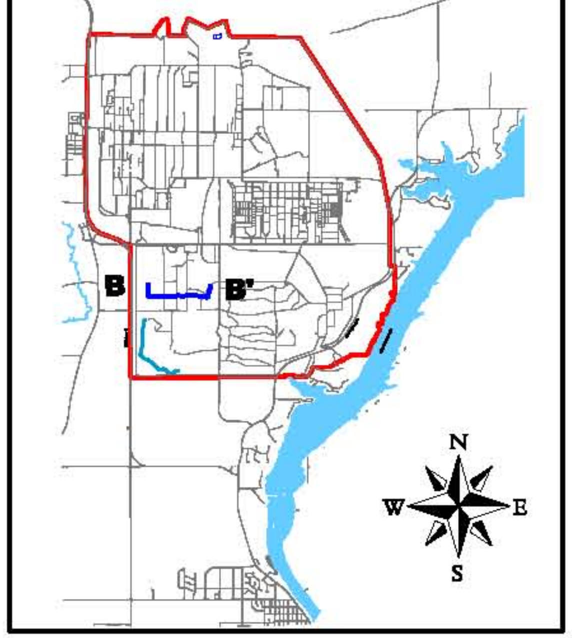
CARBON TETRACHLORIDE CONCENTRATION (µg/l)

⬜	>5.0
🟩	0.5 - 5.0

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▤	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)

CROSS SECTION LOCATION



NOTES:

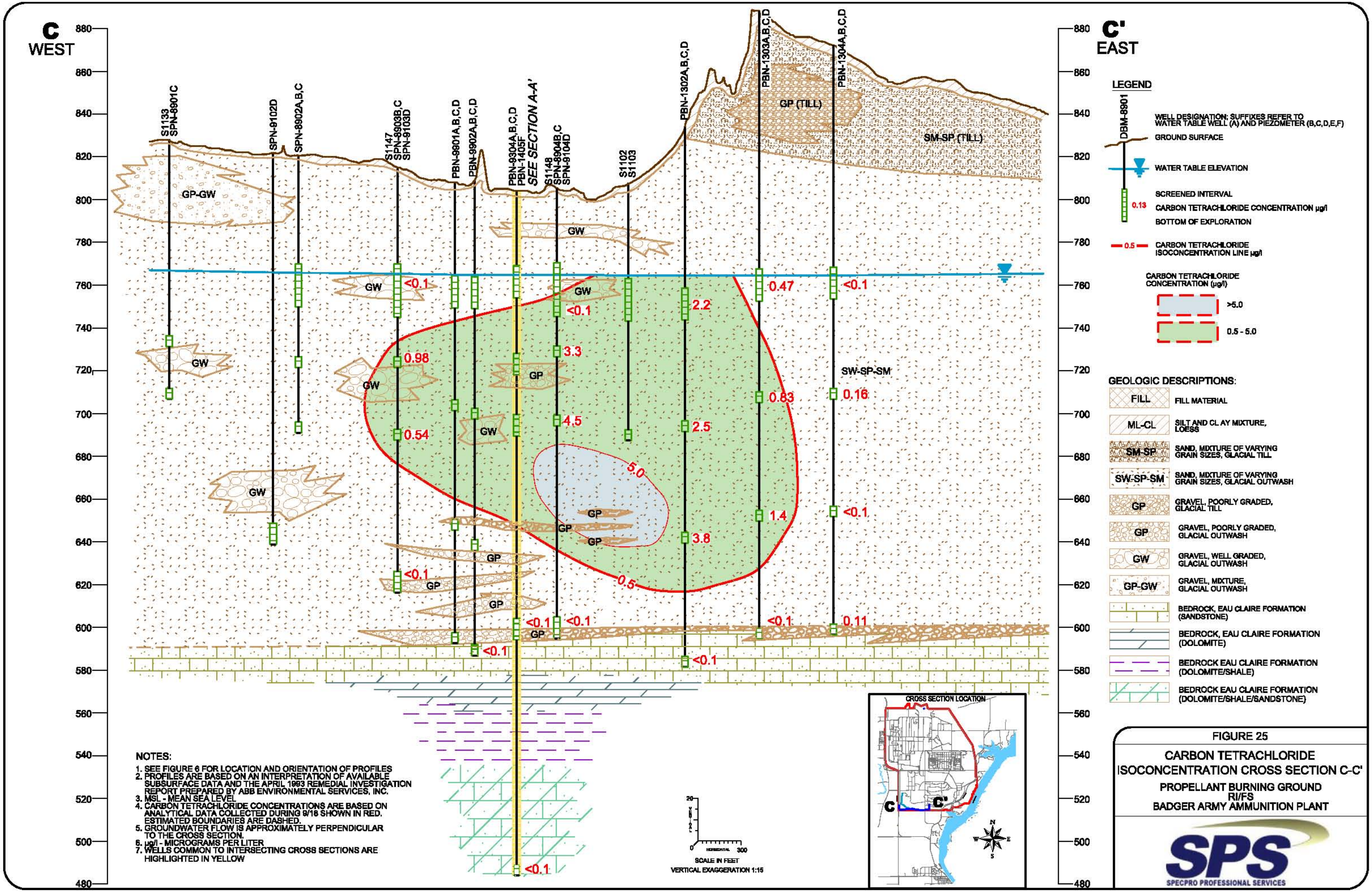
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. CARBON TETRACHLORIDE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 24

CARBON TETRACHLORIDE ISOCONCENTRATION CROSS SECTION B-B'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



NOTES:

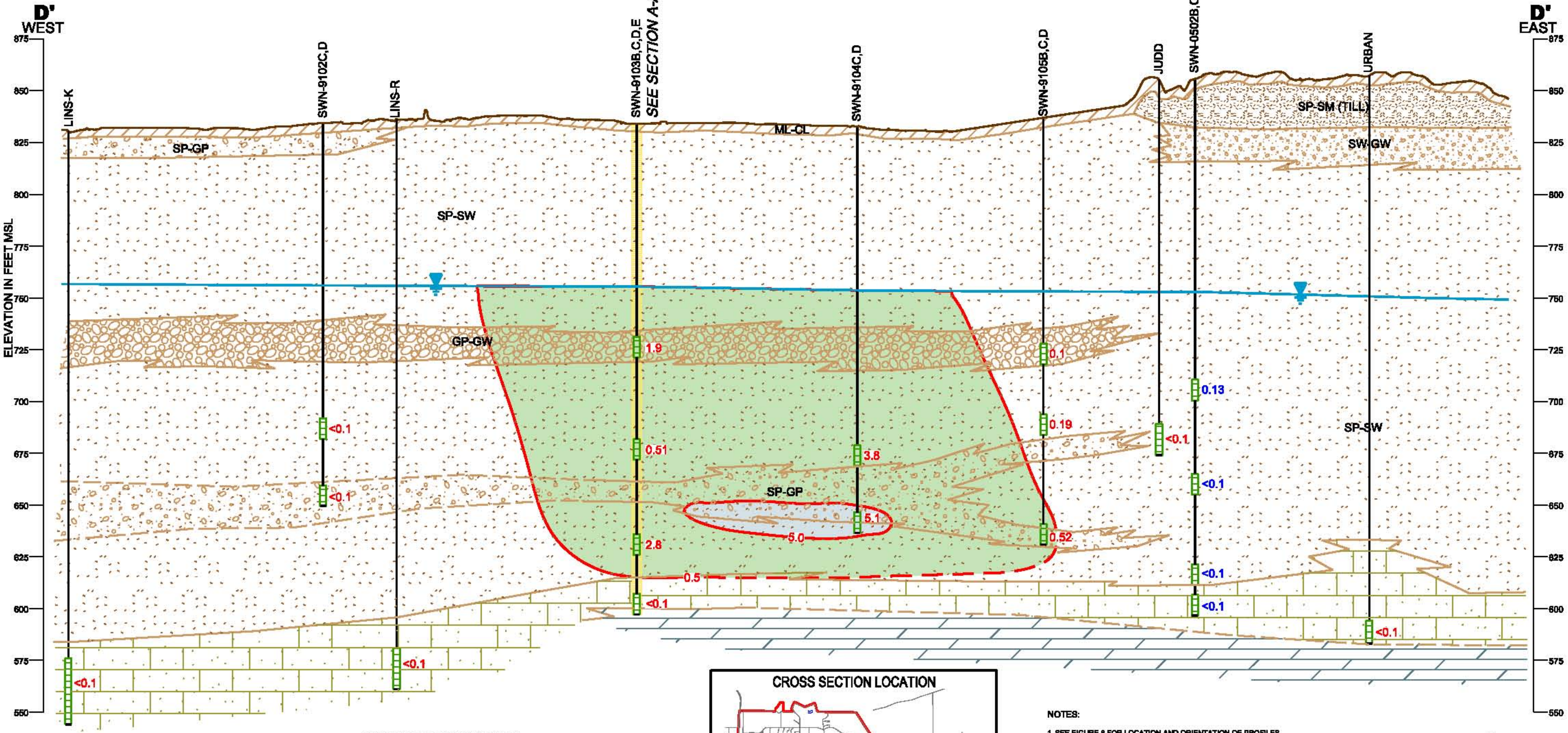
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. CARBON TETRACHLORIDE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 25

CARBON TETRACHLORIDE ISOCONCENTRATION CROSS SECTION C-C'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

3.2
0.13 CARBON TETRACHLORIDE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

— 0.5 — CARBON TETRACHLORIDE ISOCONCENTRATION LINE (µg/l)

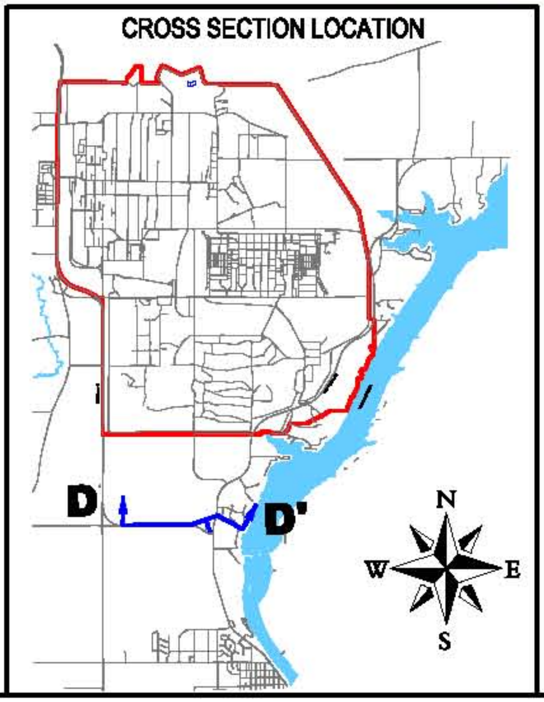
GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SP-GP	SAND AND GRAVEL, GLACIAL OUTWASH
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SP-SW	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▤	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▦	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)

CARBON TETRACHLORIDE CONCENTRATION (µg/l)

🟩 0.5 - 5.0   ⬜ >5.0

CROSS SECTION LOCATION



NOTES:

1. SEE FIGURE 8 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. CARBON TETRACHLORIDE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED AND 11/14 SHOWN IN BLUE. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

SCALE IN FEET
VERTICAL EXAGGERATION 1:10

FIGURE 26

CARBON TETRACHLORIDE ISOCONCENTRATION CROSS SECTION D-D'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

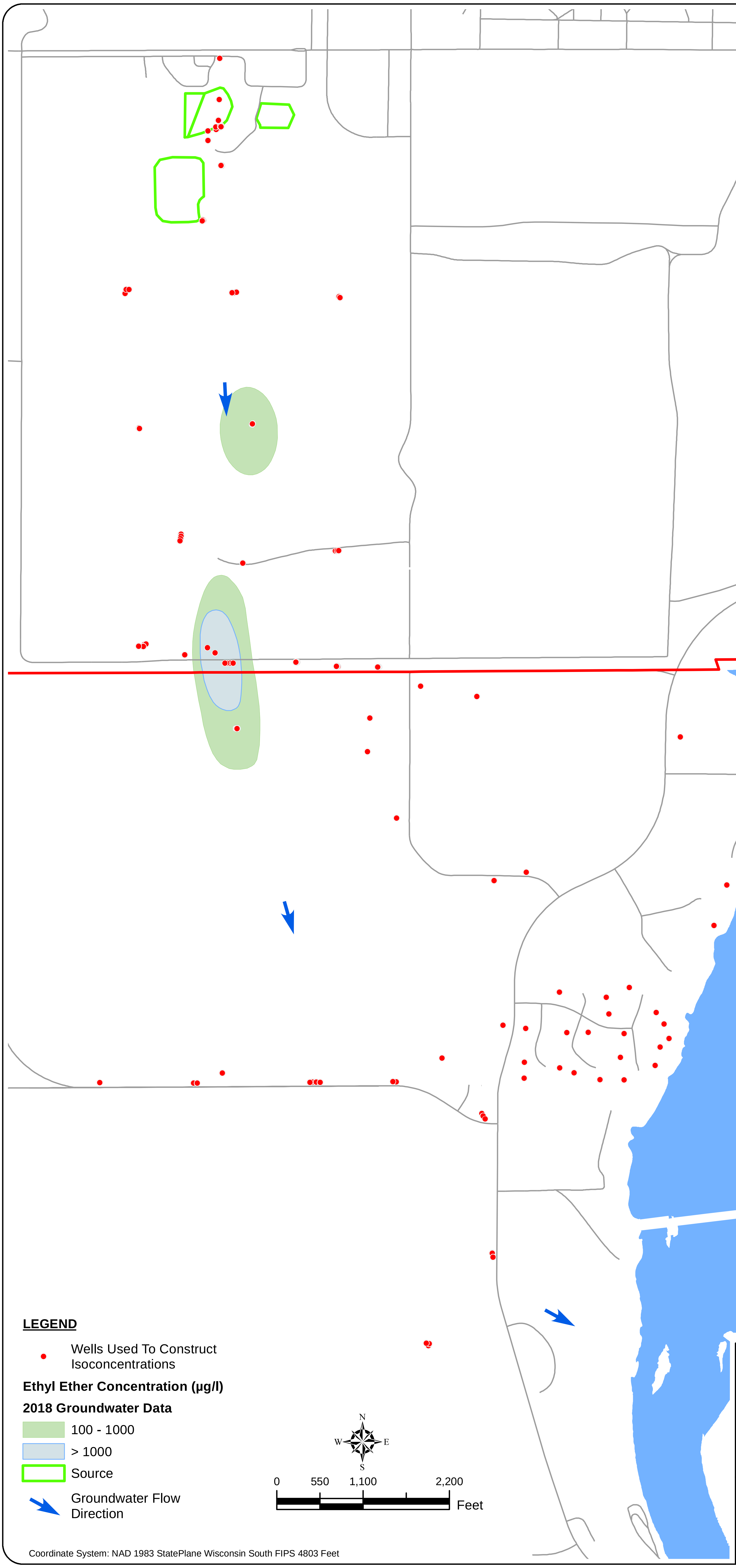
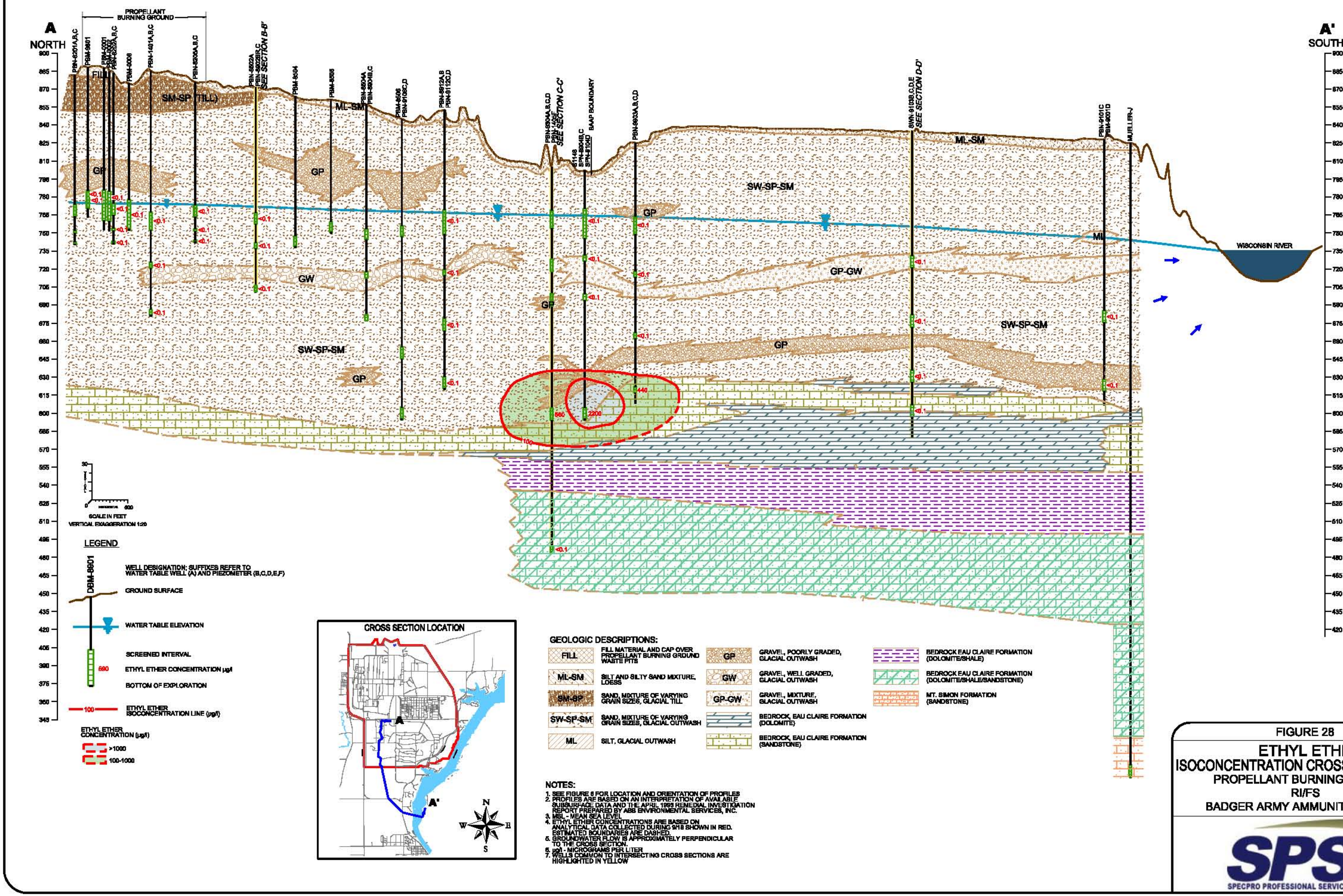


FIGURE 27

ETHYL ETHER ISOCONCENTRATION MAP

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



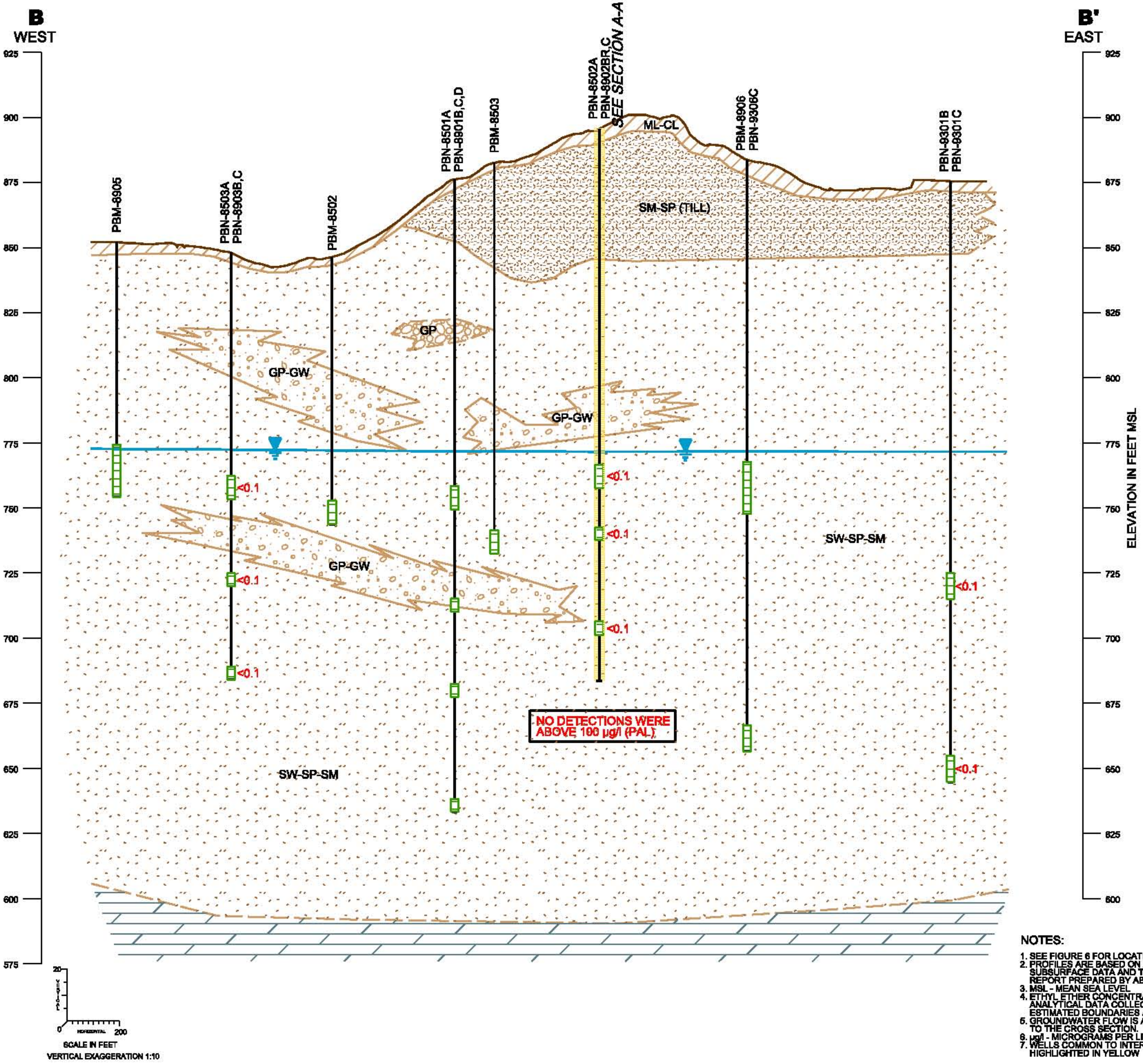
NOTES:

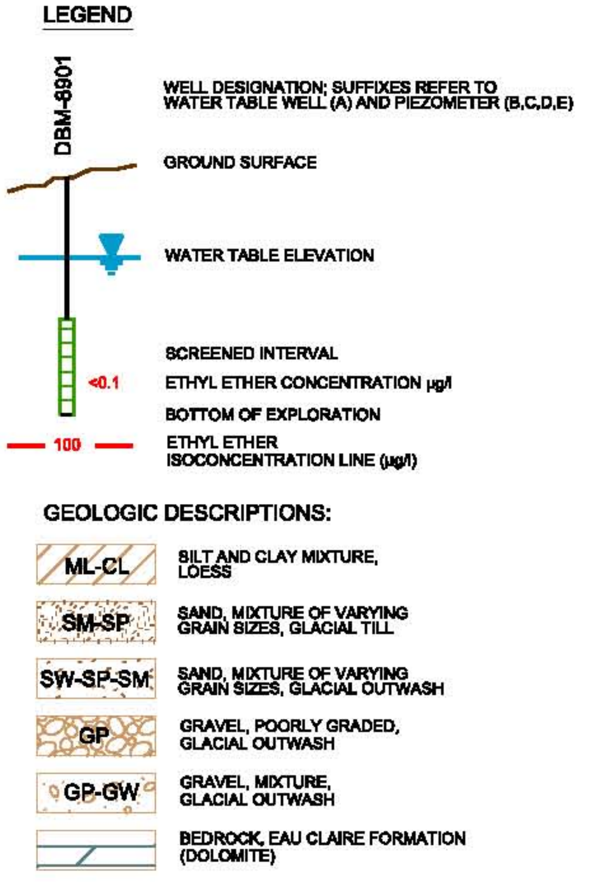
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. ETHYL ETHER CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 28

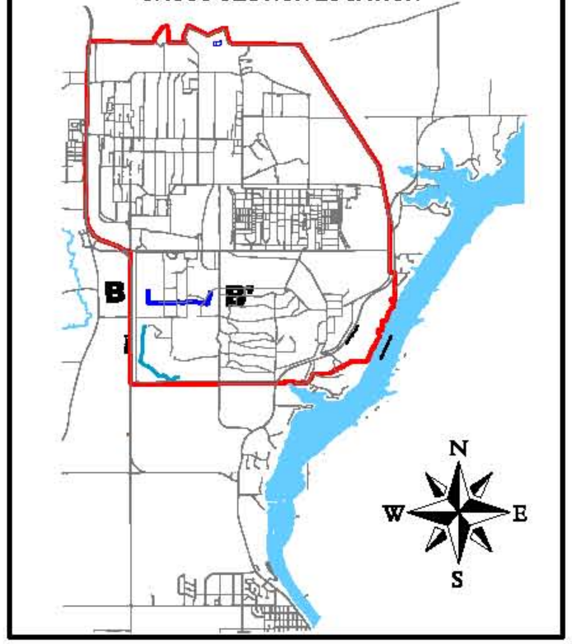
ETHYL ETHER
ISOCONCENTRATION CROSS SECTION A-A'
PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES





CROSS SECTION LOCATION



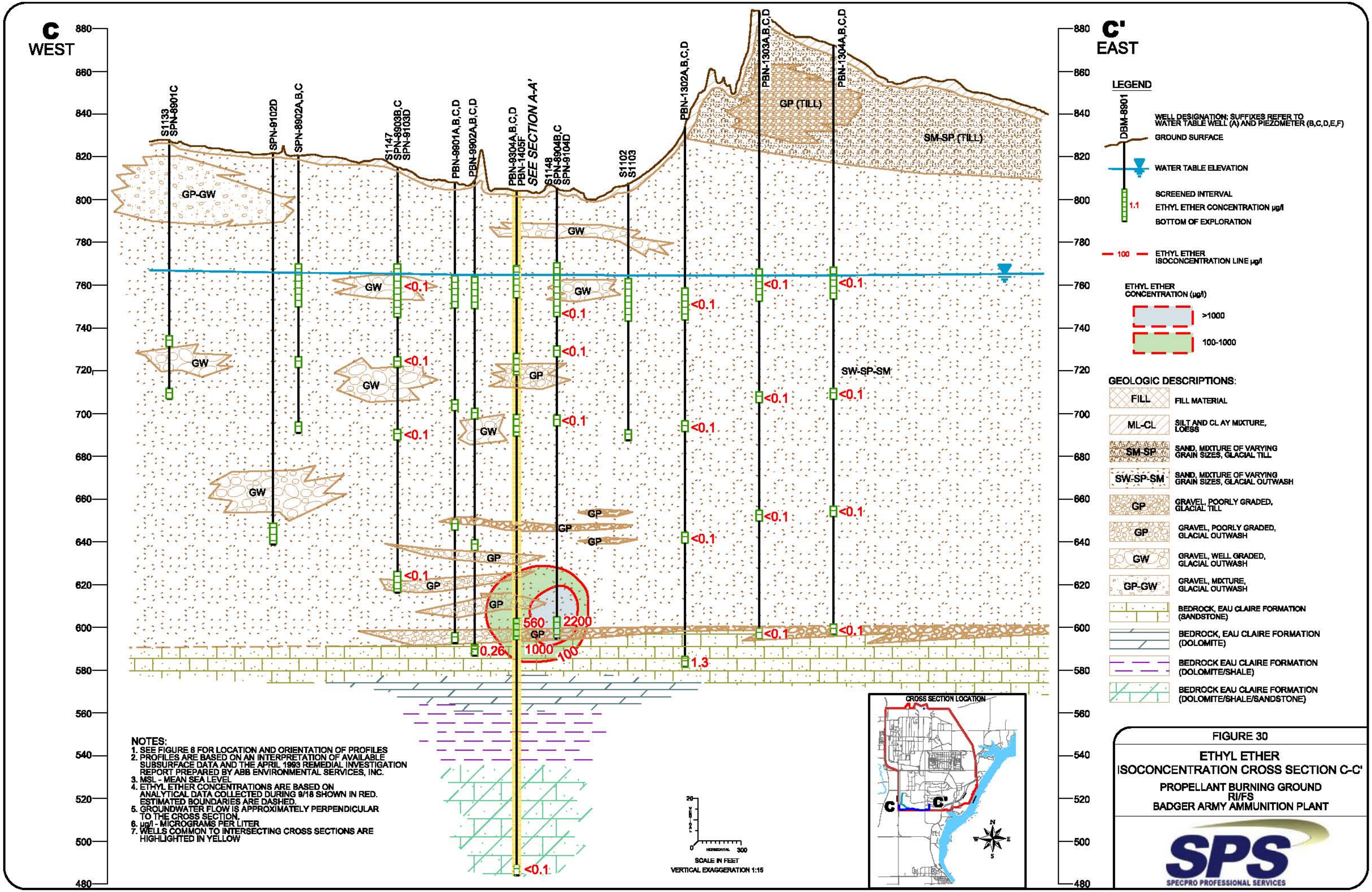
NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. ETHYL ETHER CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 29

ETHYL ETHER
ISOCONCENTRATION CROSS SECTION B-B'
PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



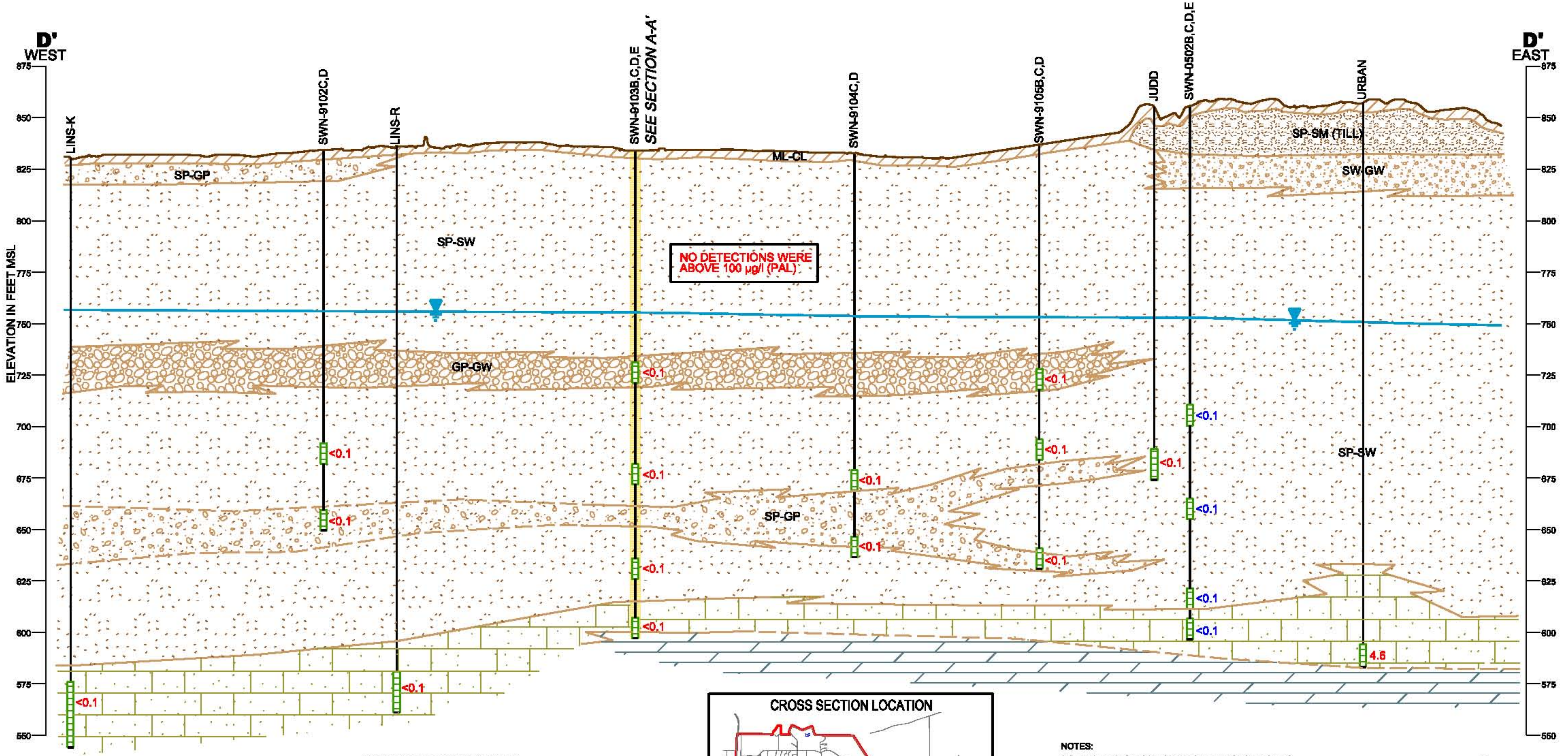
NOTES:
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. ETHYL ETHER CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 30

ETHYL ETHER
ISOCONCENTRATION CROSS SECTION C-C'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

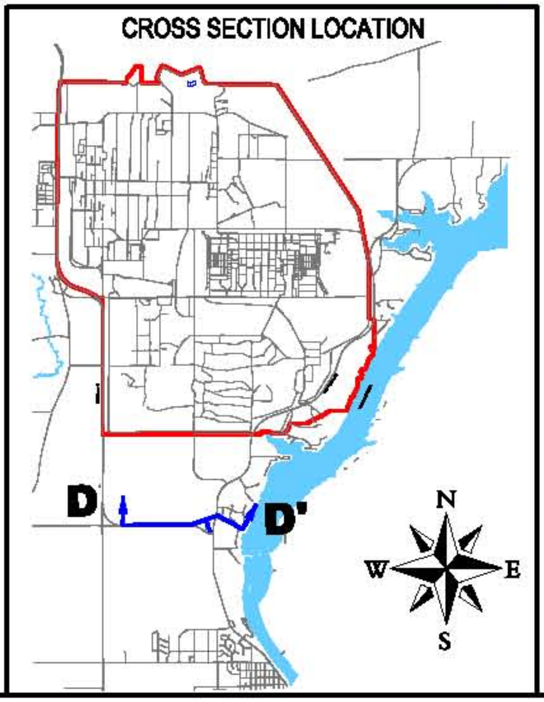
<0.1 ETHYL ETHER CONCENTRATION µg/l

BOTTOM OF EXPLORATION

100 ETHYL ETHER ISOCONCENTRATION LINE (µg/l)

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SP-GP	SAND AND GRAVEL, GLACIAL OUTWASH
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SP-SW	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▨	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▨	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)



NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. ETHYL ETHER CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED AND 11/14 SHOWN IN BLUE.
   ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

25 VERTICAL 0 HORIZONTAL 250

SCALE IN FEET

VERTICAL EXAGGERATION 1:10

FIGURE 31

ETHYL ETHER
ISOCONCENTRATION CROSS SECTION D-D'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

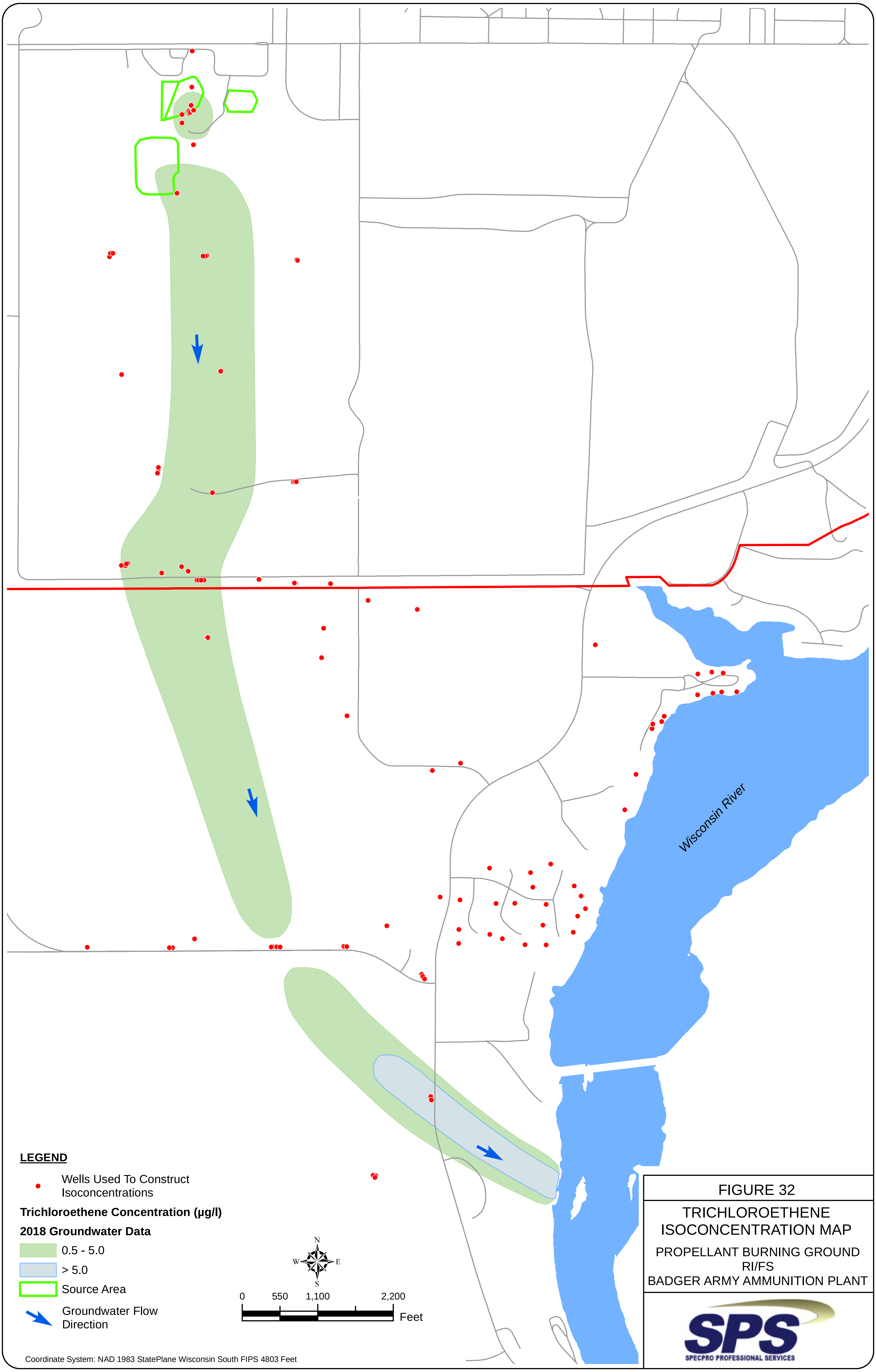
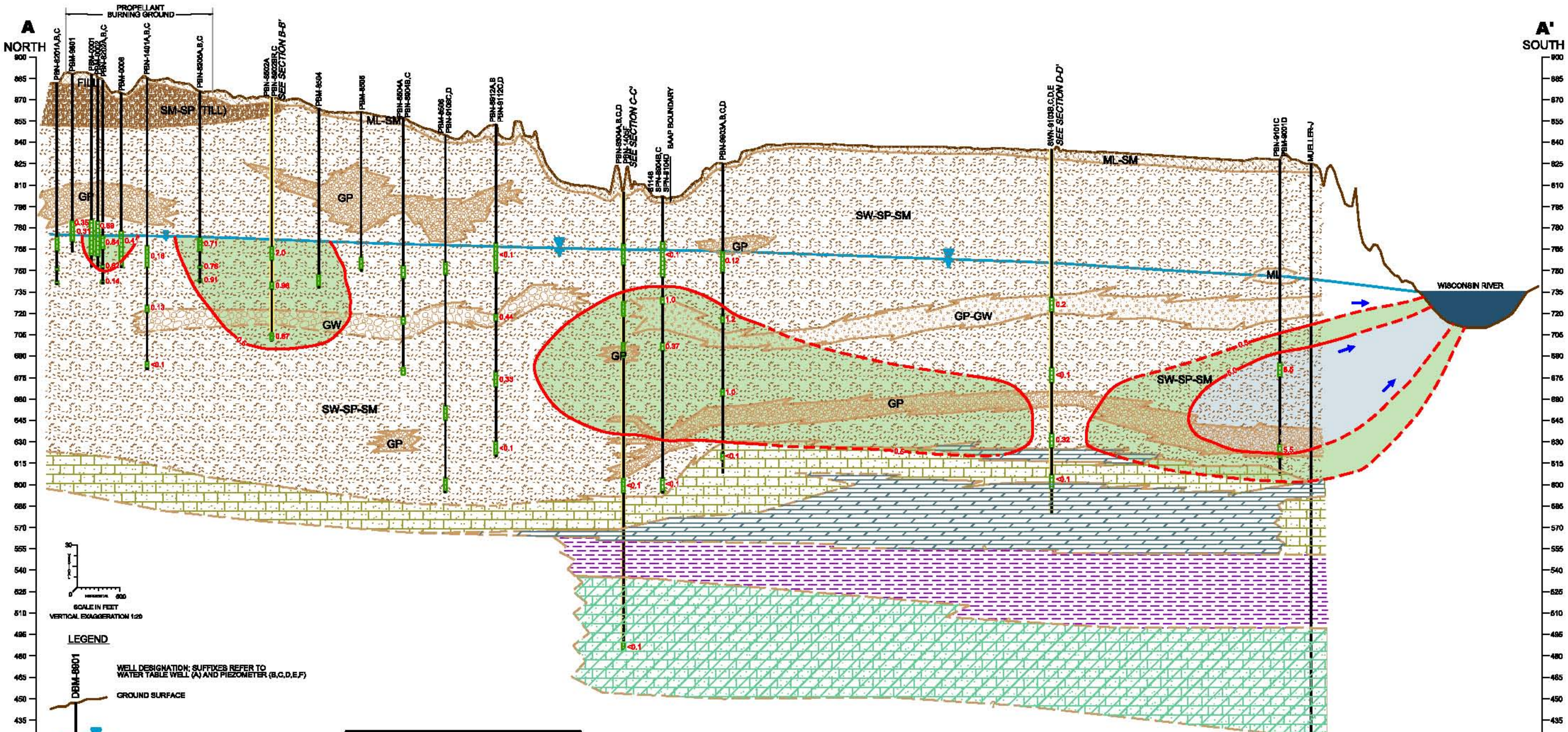


FIGURE 32

TRICHLOROETHENE
ISOCONCENTRATION MAP

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT



LEGEND

DBM-8801 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E,F)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

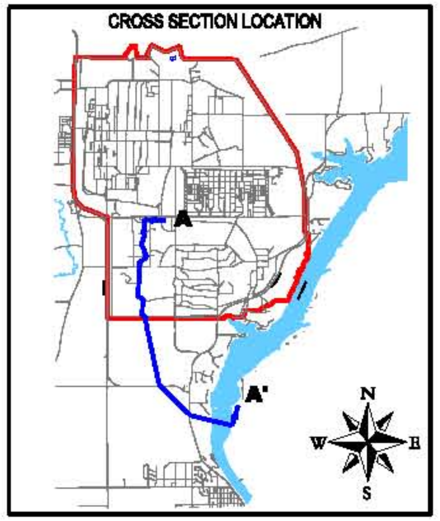
0.47 TRICHLOROETHENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.5 TRICHLOROETHENE ISOCONCENTRATION LINE (µg/l)

TRICHLOROETHENE CONCENTRATION (µg/l)

- >5.0
- 0.5 - 5.0



GEOLOGIC DESCRIPTIONS:

FILL	FILL MATERIAL AND CAP OVER PROPELLANT BURNING GROUND WASTE PITS
ML-SM	SILT AND SILTY SAND MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
ML	SILT, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GW	GRAVEL, WELL GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▤	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▦	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)
▤	BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE)
▨	BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE/SANDSTONE)
▦	MT. SIMON FORMATION (SANDSTONE)

NOTES:

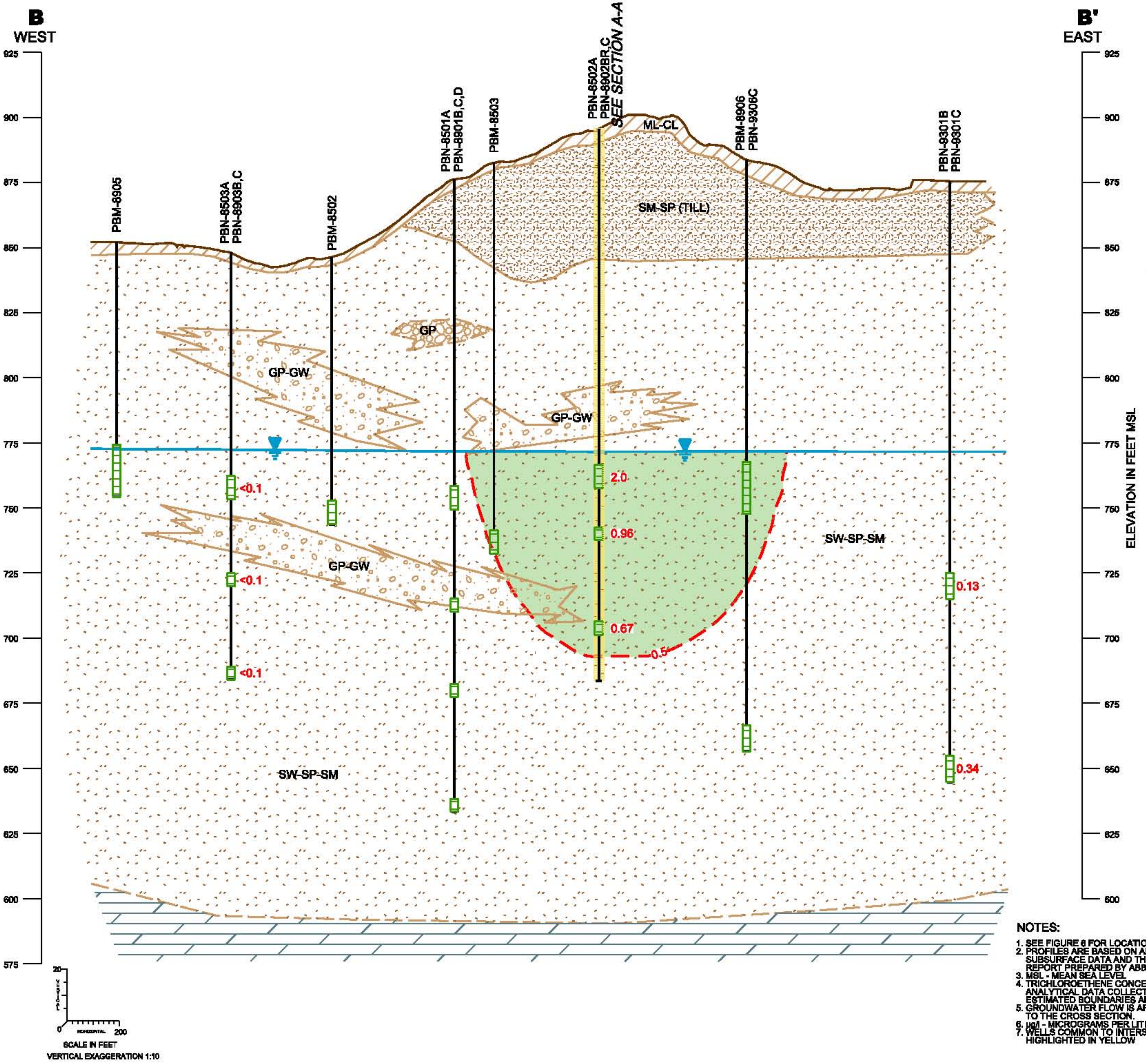
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TRICHLOROETHENE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/16 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 33

TRICHLOROETHENE ISOCONCENTRATION CROSS SECTION A-A'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



TRICHLOROETHENE CONCENTRATION (µg/l)

🟩 0.5 - 5.0

LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

2.4 TRICHLOROETHENE CONCENTRATION µg/l

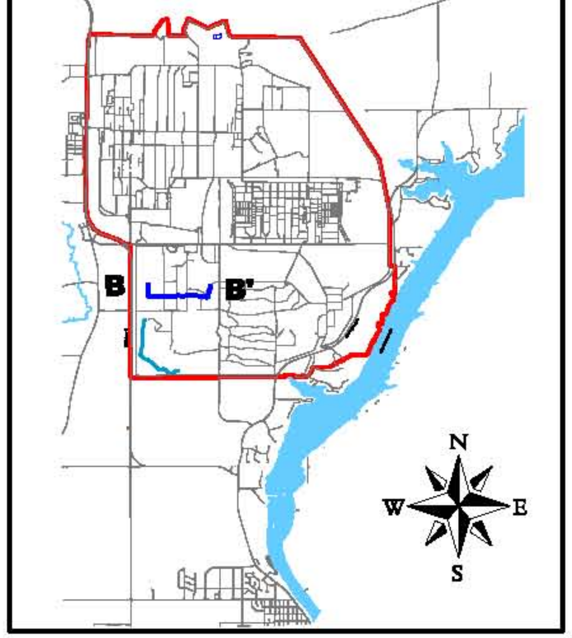
BOTTOM OF EXPLORATION

0.5 TRICHLOROETHENE ISOCONCENTRATION LINE (µg/l)

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
▨	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)

CROSS SECTION LOCATION



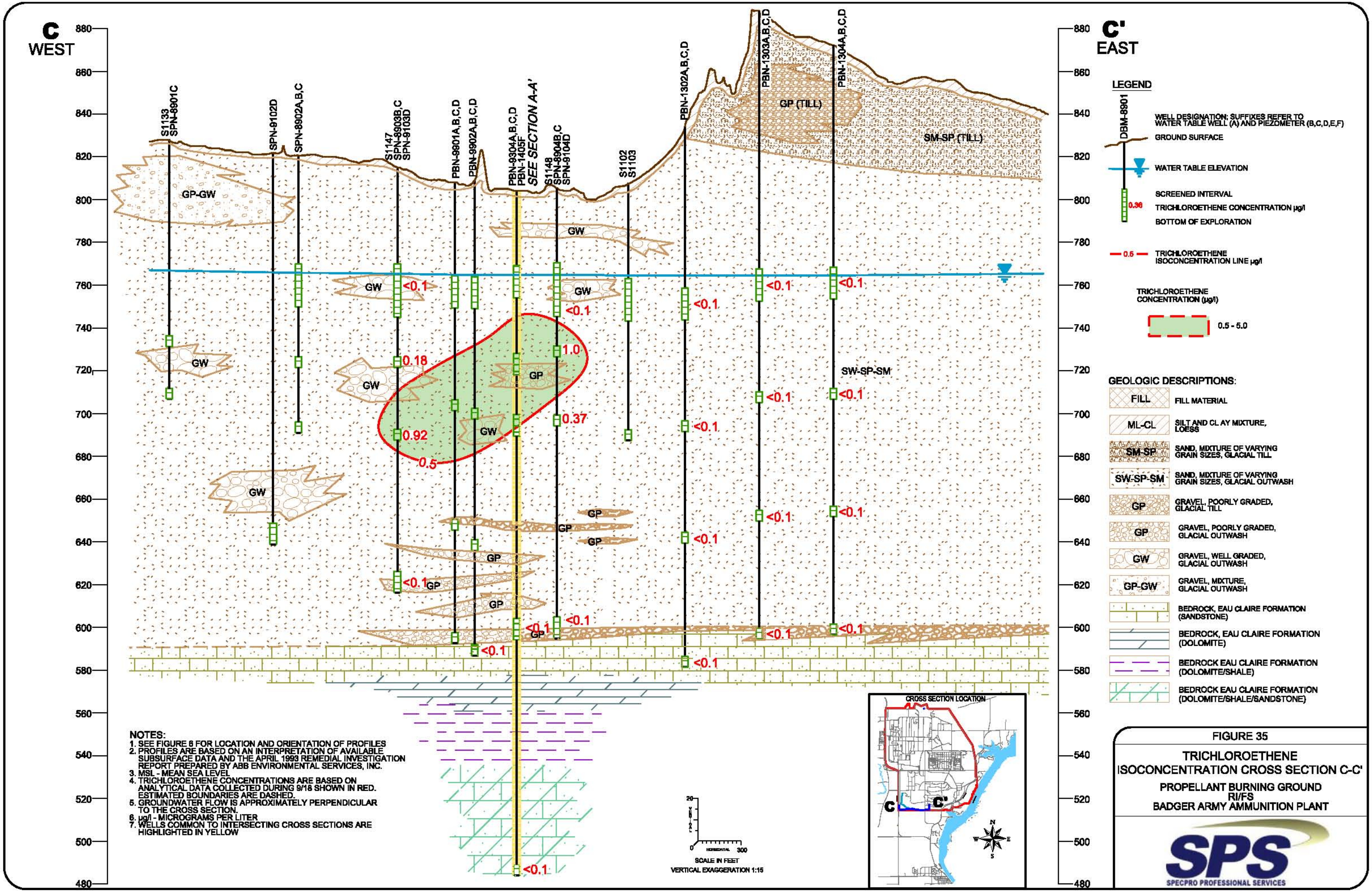
NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TRICHLOROETHENE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 34

TRICHLOROETHENE
ISOCONCENTRATION CROSS SECTION B-B'
PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



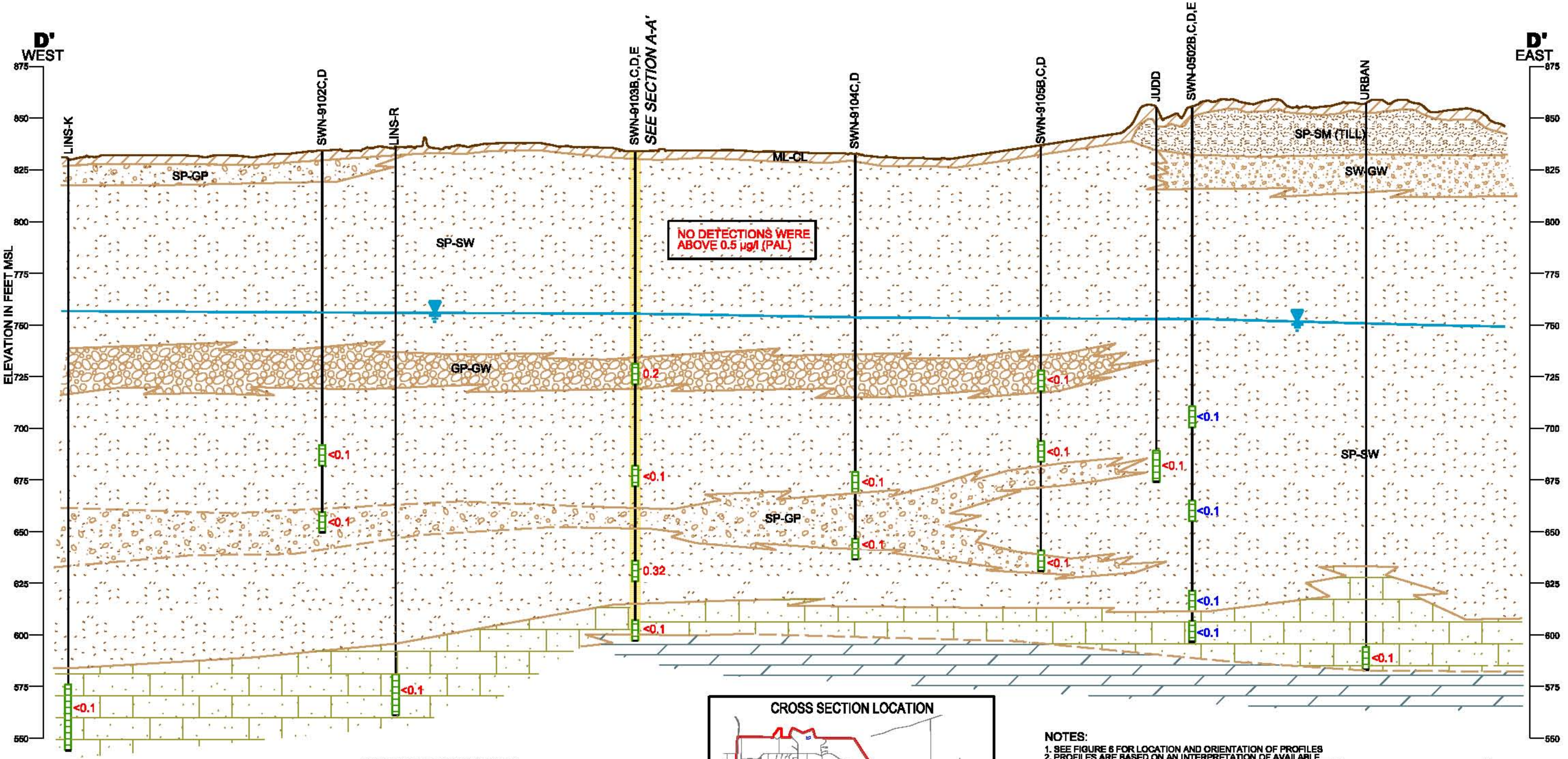
NOTES:
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TRICHLOROETHENE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 SHOWN IN RED. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW

FIGURE 35

TRICHLOROETHENE
ISOCONCENTRATION CROSS SECTION C-C'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-9901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

1.2 TRICHLOROETHENE CONCENTRATION µg/l

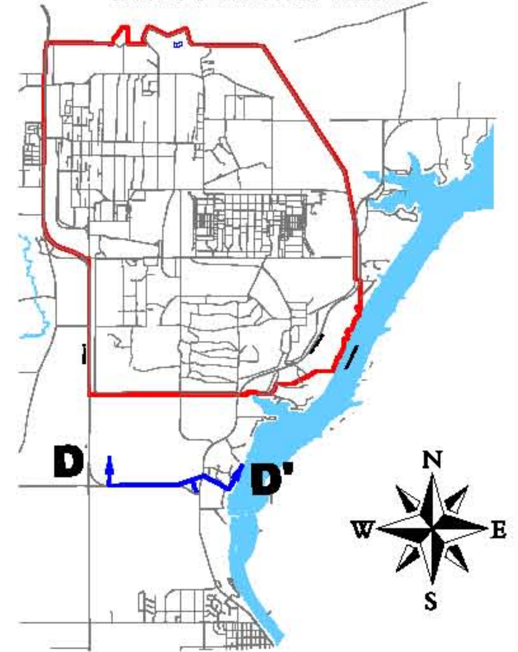
BOTTOM OF EXPLORATION

0.5 TRICHLOROETHENE ISOCONCENTRATION LINE (µg/l)

GEOLOGIC DESCRIPTIONS:

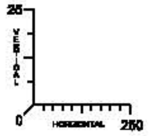
ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SP-GP	SAND AND GRAVEL, GLACIAL OUTWASH
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SP-SW	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▨	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▦	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)

CROSS SECTION LOCATION



NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TRICHLOROETHENE CONCENTRATIONS ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/16 SHOWN IN RED AND 11/14 SHOWN IN BLUE.
   ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO THE CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW



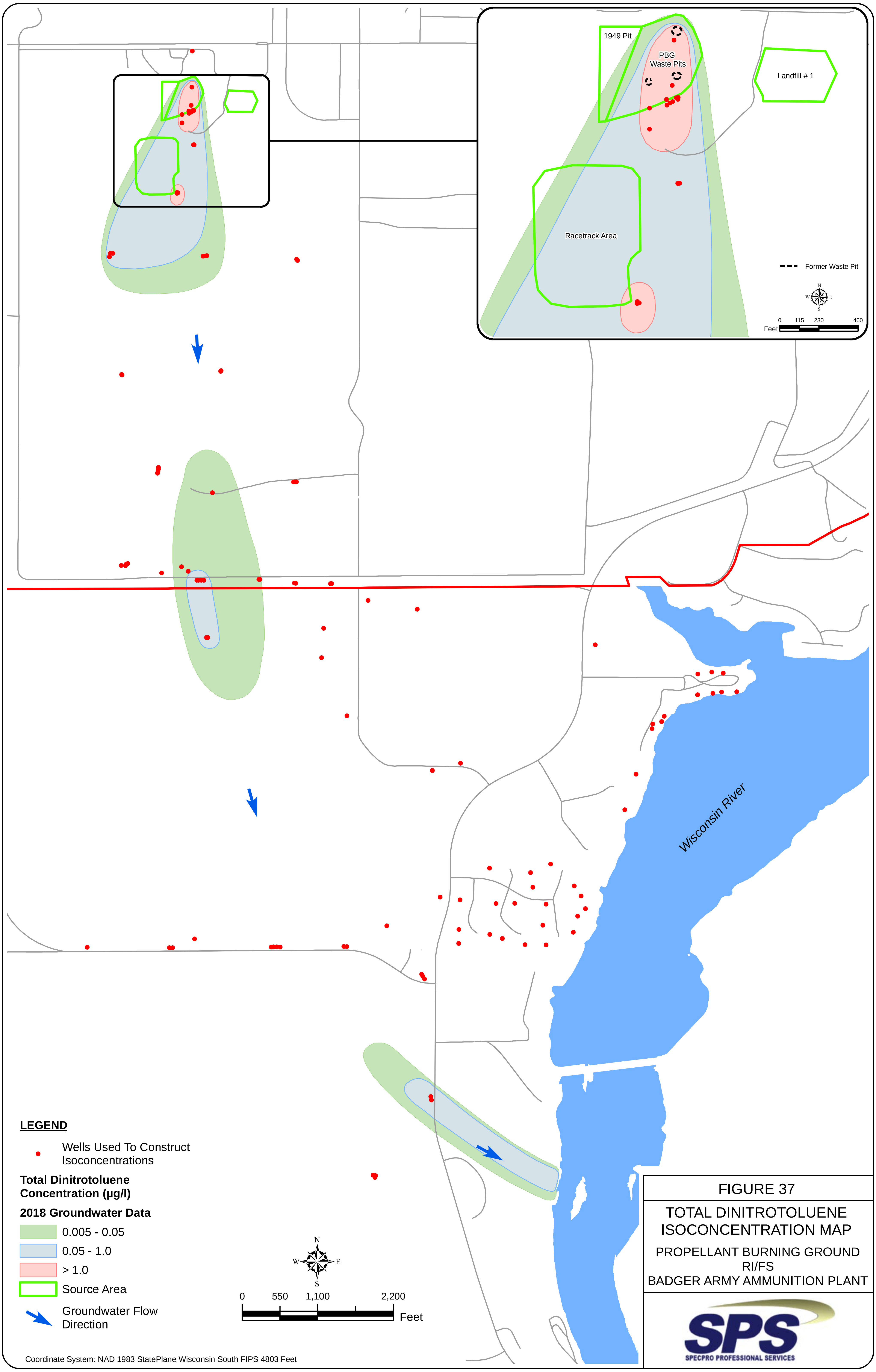
SCALE IN FEET
VERTICAL EXAGGERATION 1:10

FIGURE 36

TRICHLOROETHENE ISOCONCENTRATION CROSS SECTION D-D'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

● Wells Used To Construct Isoconcentrations

Total Dinitrotoluene Concentration (µg/l)

2018 Groundwater Data

🟩 0.005 - 0.05

▨ 0.05 - 1.0

🟥 > 1.0

☐ Source Area

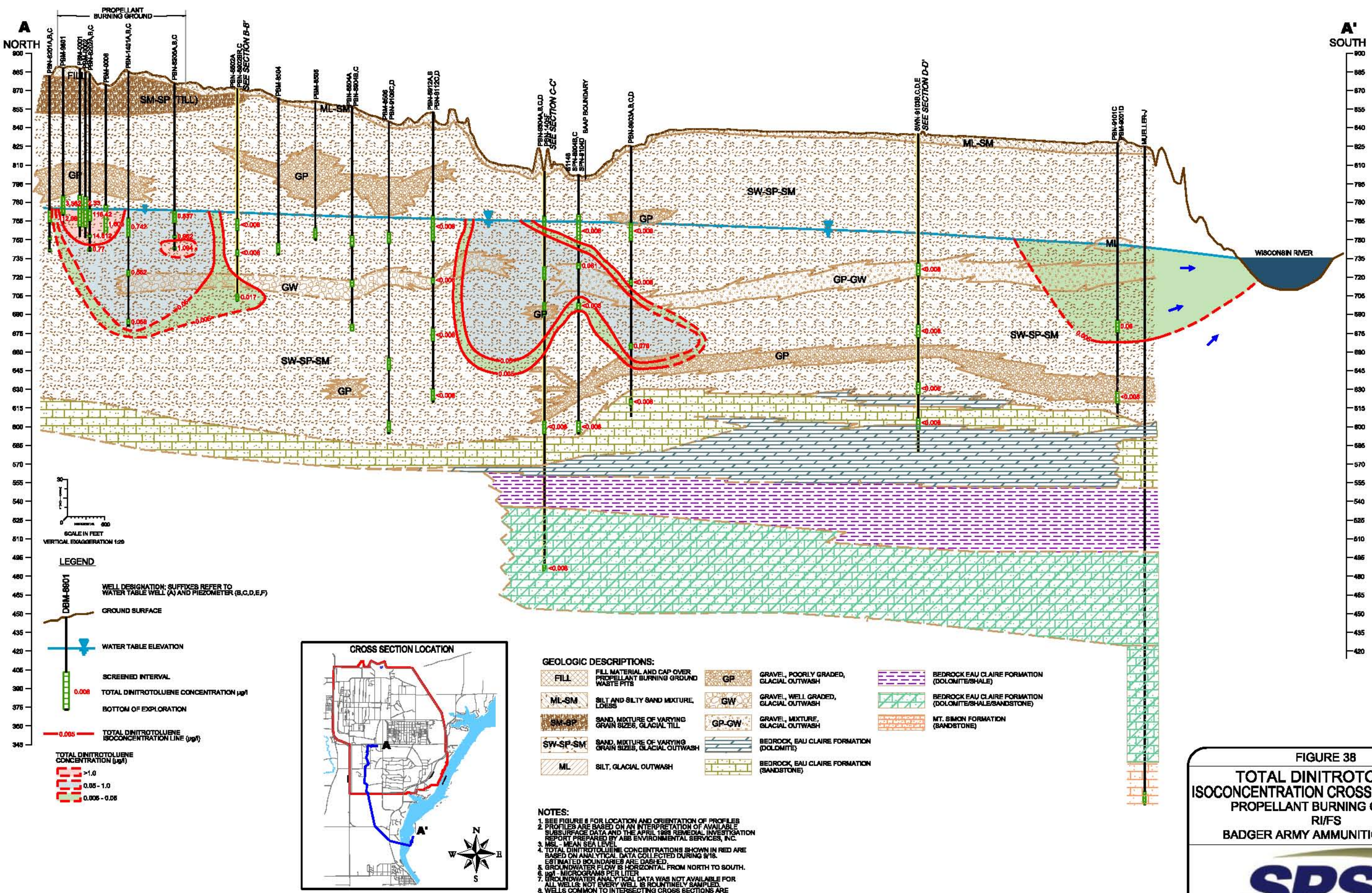
➘ Groundwater Flow Direction

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

FIGURE 37

TOTAL DINITROTOLUENE ISOCONCENTRATION MAP

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT



NOTES:

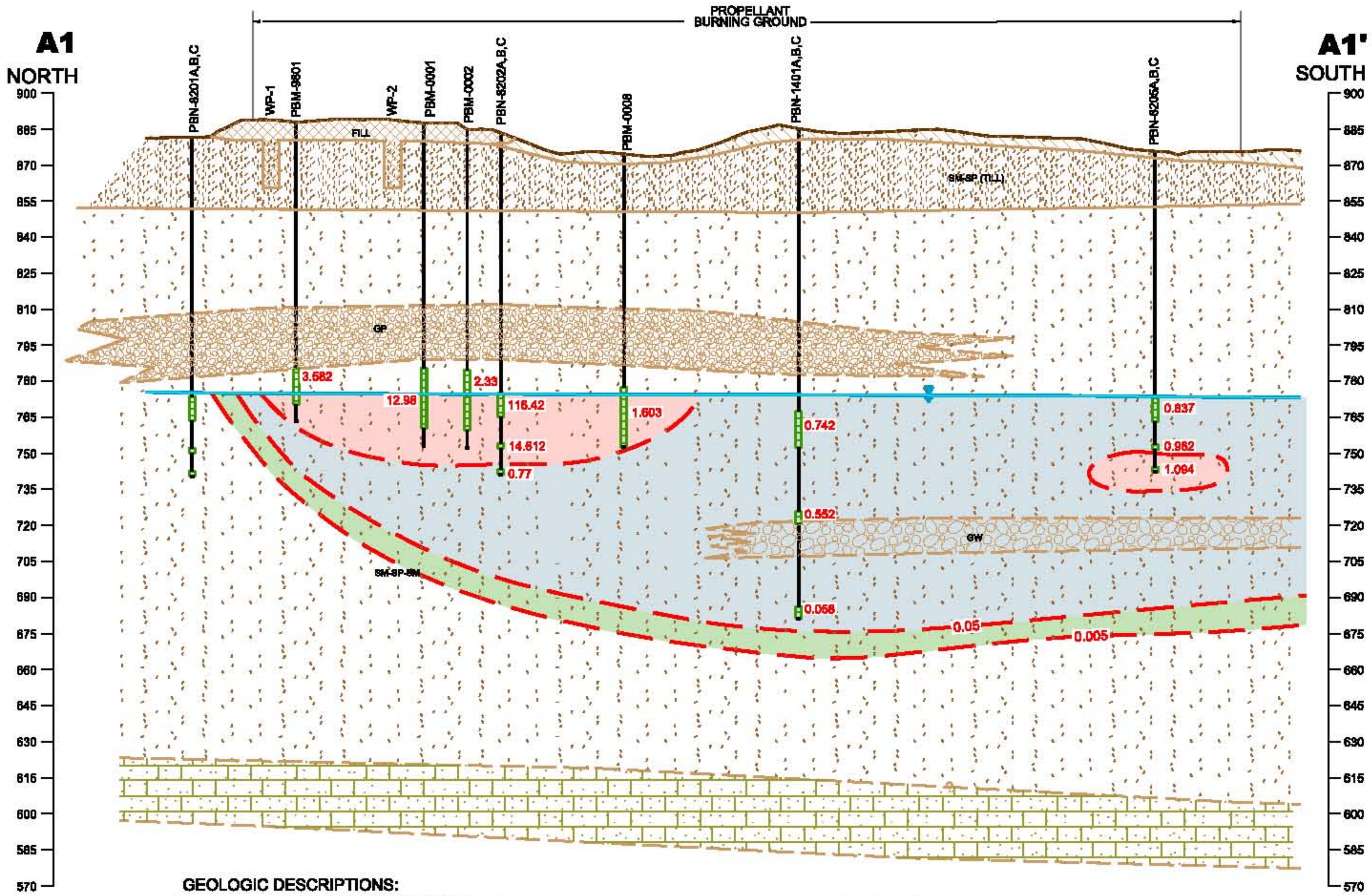
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/16. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS; NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 38

TOTAL DINITROTOLUENE ISOCONCENTRATION CROSS SECTION A-A'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 — WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E,F)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

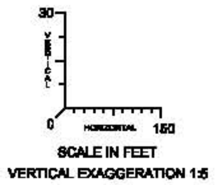
0.008 — TOTAL DINITROTOLUENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.005 — TOTAL DINITROTOLUENE ISOCONCENTRATION LINE (µg/l)

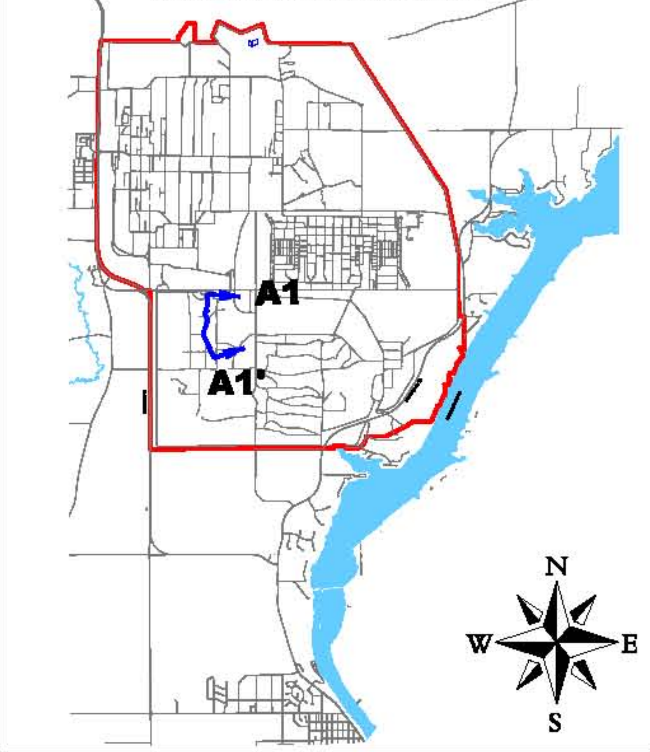
TOTAL DINITROTOLUENE ISOCONCENTRATION (µg/l)

- 🟥 >1.0
- ▨ 0.05 - 1.0
- 🟩 0.005 - 0.05



SCALE IN FEET
VERTICAL EXAGGERATION 1:5

CROSS SECTION LOCATION



GEOLOGIC DESCRIPTIONS:

FILL	FILL MATERIAL AND CAP OVER PROPELLANT BURNING GROUND WASTE PITS	GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH		BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE)
ML-SM	SILT AND SILTY SAND MIXTURE, LOESS	GW	GRAVEL, WELL GRADED, GLACIAL OUTWASH		BEDROCK EAU CLAIRE FORMATION (DOLOMITE/SHALE/SANDSTONE)
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL	GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH		MT. SIMON FORMATION (SANDSTONE)
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH		BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)		
ML	SILT, GLACIAL OUTWASH		BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)		

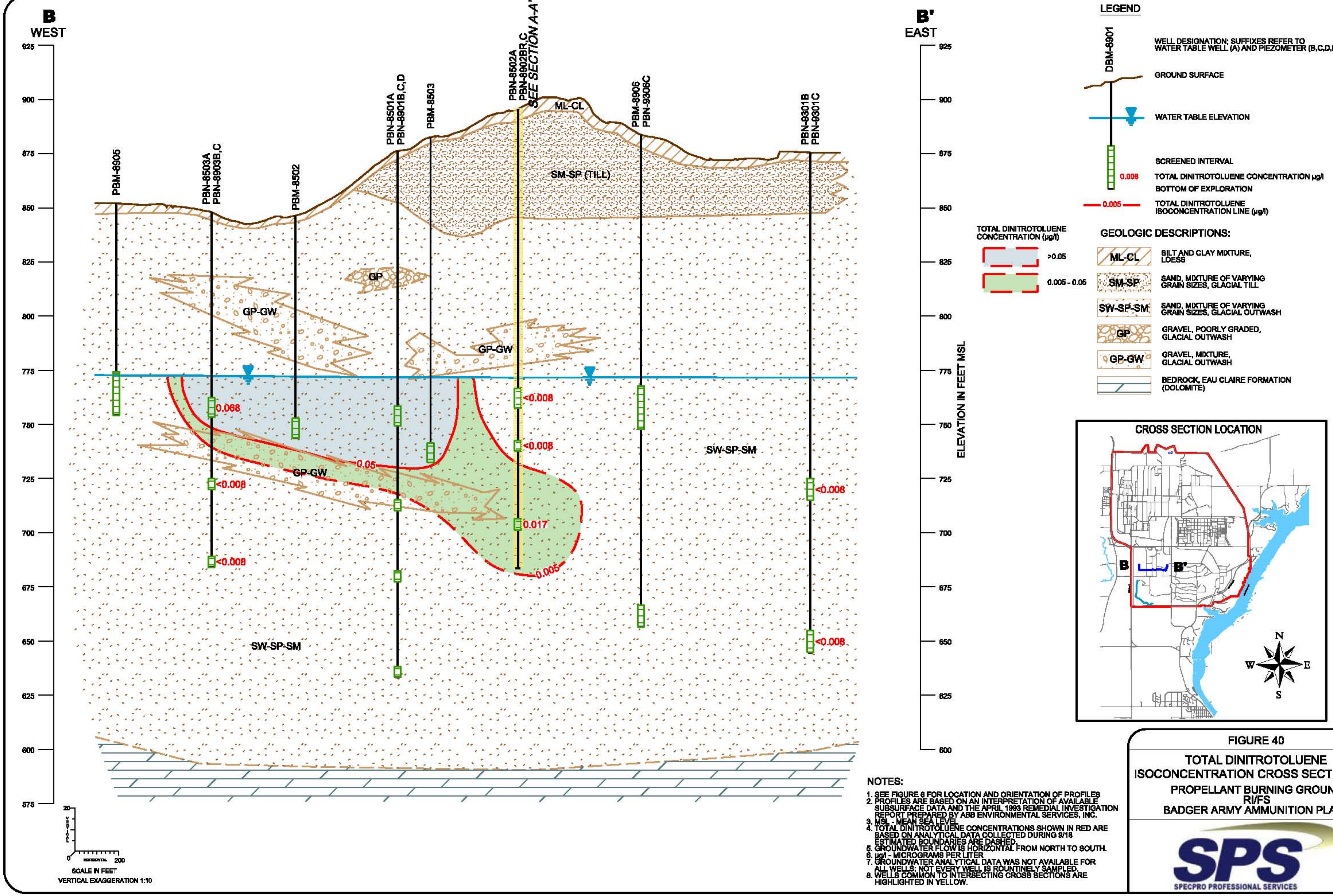
NOTES:
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 39

TOTAL DINITROTOLUENE ISOCONCENTRATION CROSS SECTION A1-A1'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



NOTES:

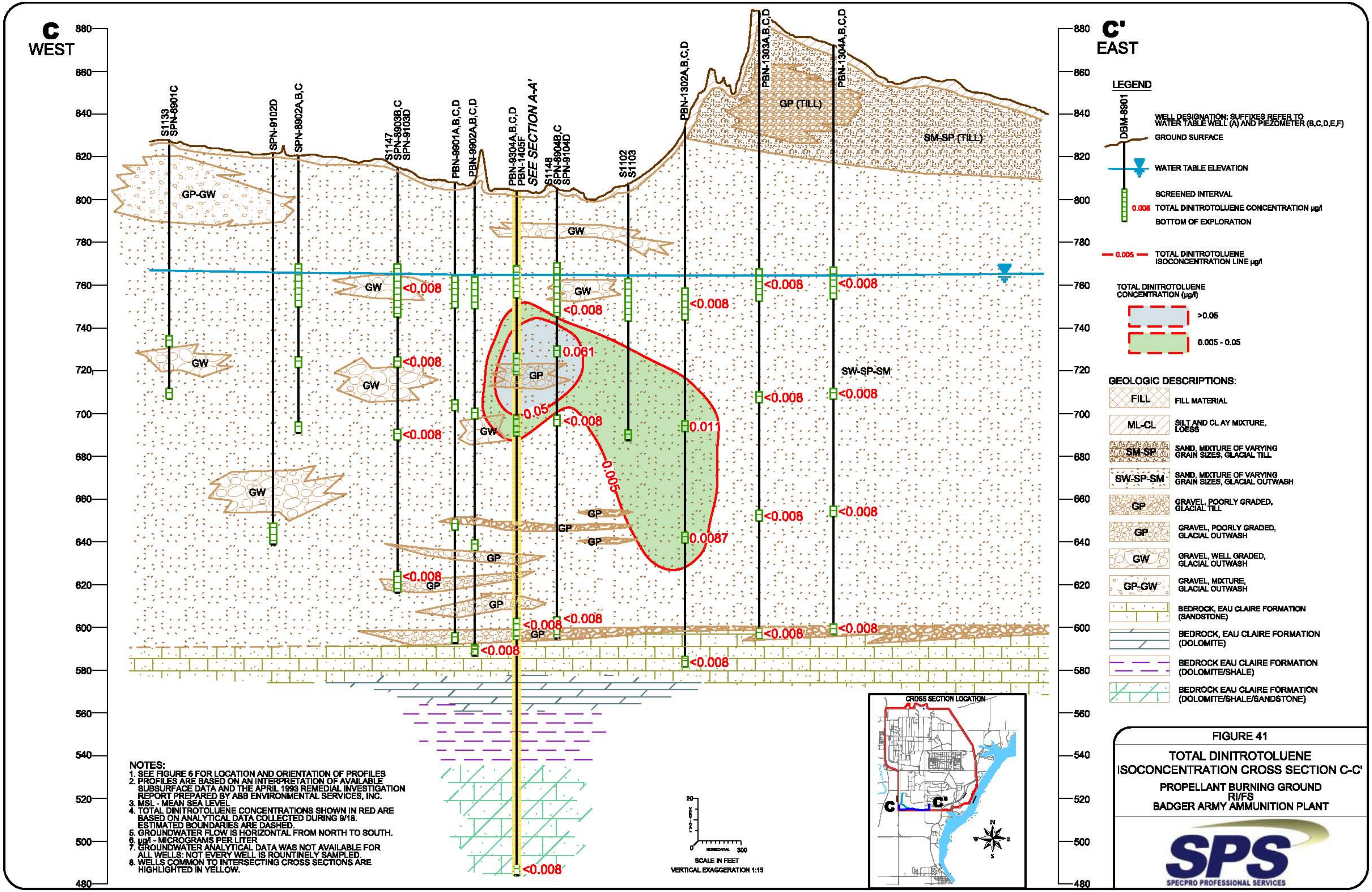
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS; NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 40

TOTAL DINITROTOLUENE
ISOCONCENTRATION CROSS SECTION B-B'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



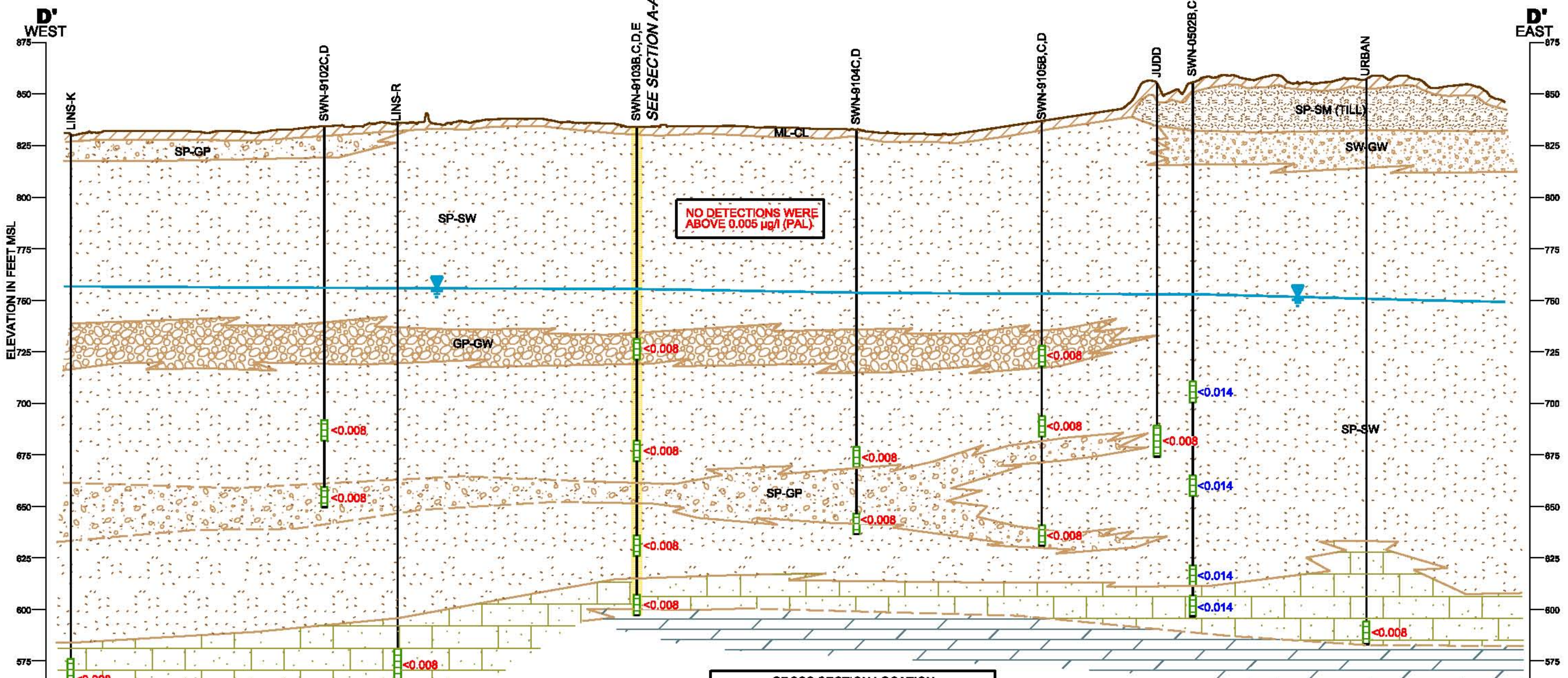
NOTES:
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 41

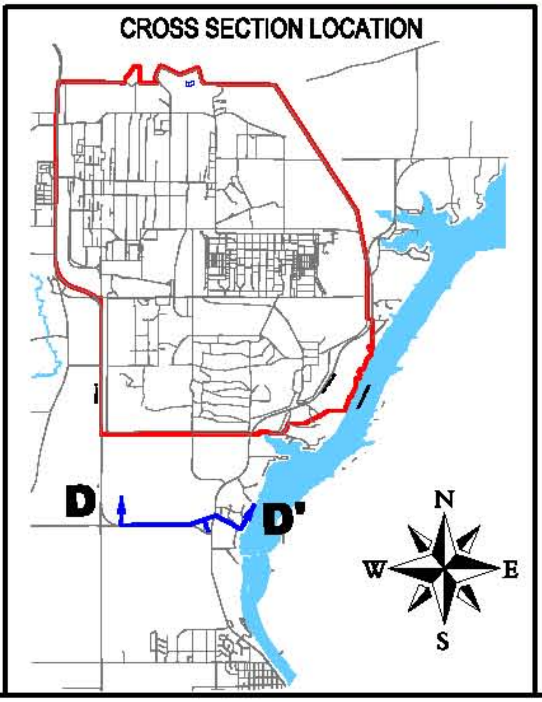
TOTAL DINITROTOLUENE ISOCONCENTRATION CROSS SECTION C-C'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



CROSS SECTION LOCATION



LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

0.008 TOTAL DINITROTOLUENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

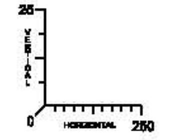
—0.005— TOTAL DINITROTOLUENE ISOCONCENTRATION LINE (µg/l)

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SP-GP	SAND AND GRAVEL, GLACIAL OUTWASH
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SP-SW	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▤	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)
▦	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)

NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18 AND BLUE COLLECTED DURING 11/14
   ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.



SCALE IN FEET
VERTICAL EXAGGERATION 1:10

FIGURE 42

TOTAL DINITROTOLUENE ISOCONCENTRATION CROSS SECTION D-D'

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

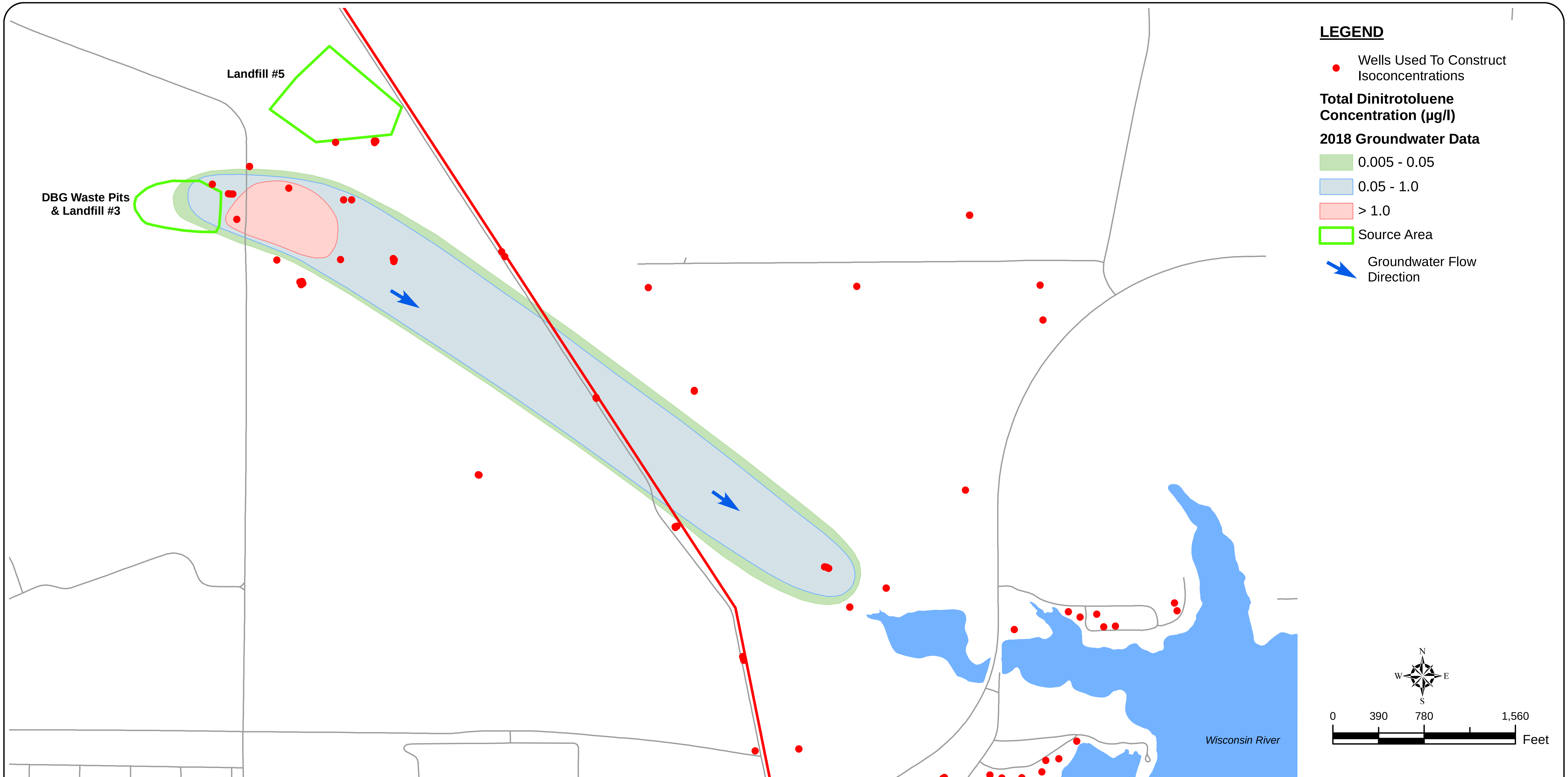
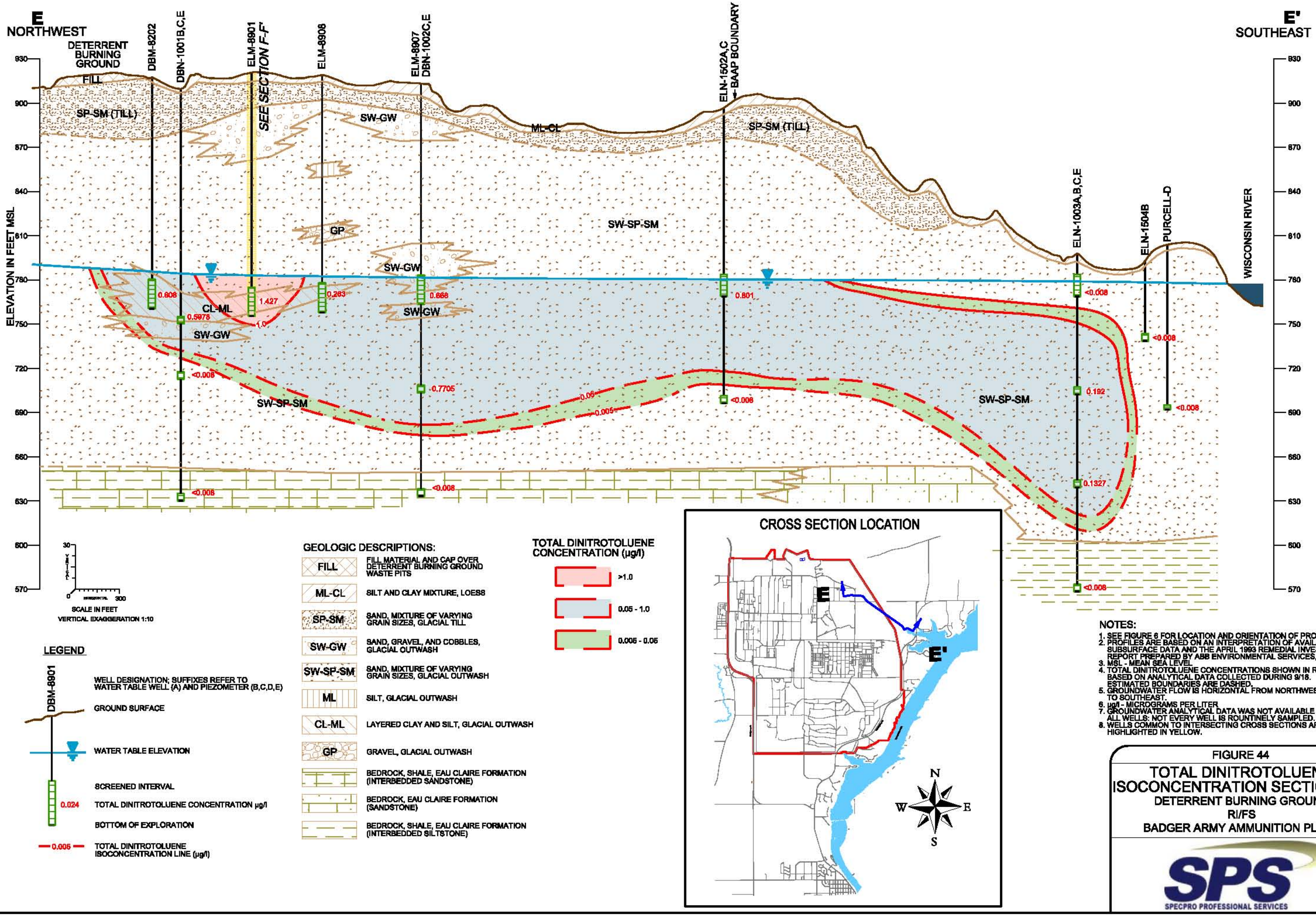


FIGURE 43

TOTAL DINITROTOLUENE ISOCONCENTRATION MAP

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



GEOLOGIC DESCRIPTIONS:

FILL	FILL MATERIAL AND CAP OVER DETERRENT BURNING GROUND WASTE PITS
ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
ML	SILT, GLACIAL OUTWASH
CL-ML	LAYERED CLAY AND SILT, GLACIAL OUTWASH
GP	GRAVEL, GLACIAL OUTWASH
	BEDROCK, SHALE, EAU CLAIRE FORMATION (INTERBEDDED SANDSTONE)
	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)
	BEDROCK, SHALE, EAU CLAIRE FORMATION (INTERBEDDED SILTSTONE)

TOTAL DINITROTOLUENE CONCENTRATION (µg/l)

🟥	>1.0
▨	0.05 - 1.0
🟩	0.005 - 0.05

LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

0.024 TOTAL DINITROTOLUENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.005 TOTAL DINITROTOLUENE ISOCONCENTRATION LINE (µg/l)

NOTES:

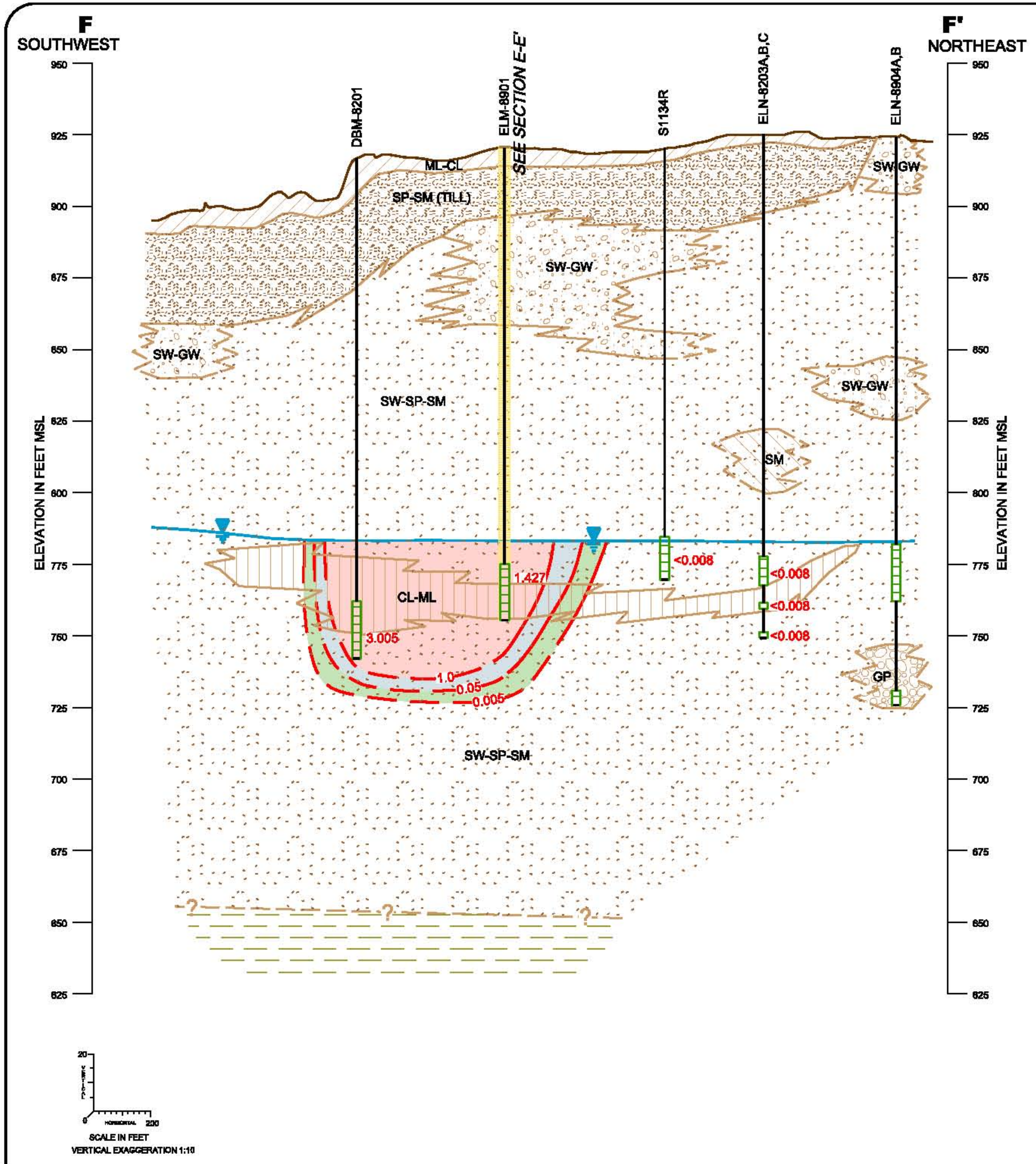
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTHWEST TO SOUTHEAST.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 44

TOTAL DINITROTOLUENE ISOCONCENTRATION SECTION E-E'

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

0.008 TOTAL DINITROTOLUENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.005 TOTAL DINITROTOLUENE ISOCONCENTRATION LINE (µg/l)

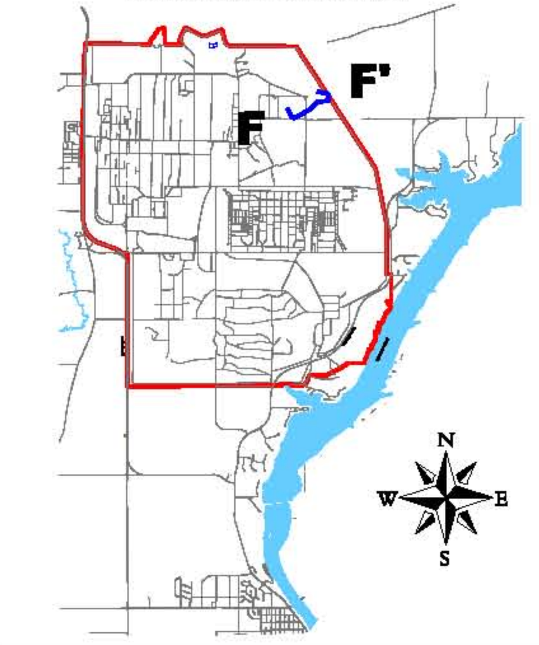
TOTAL DINITROTOLUENE CONCENTRATION (µg/l)

🟥	>1.0
⬜	0.05 - 1.0
🟩	0.005 - 0.05

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
SM	SILTY SAND, GLACIAL OUTWASH
CL-ML	LAYERED CLAY AND SILT, GLACIAL OUTWASH
GP	GRAVEL, GLACIAL OUTWASH
	BEDROCK, EAU CLAIRE FORMATION (SHALE, INTERBEDDED SANDSTONE)

CROSS SECTION LOCATION



NOTES:

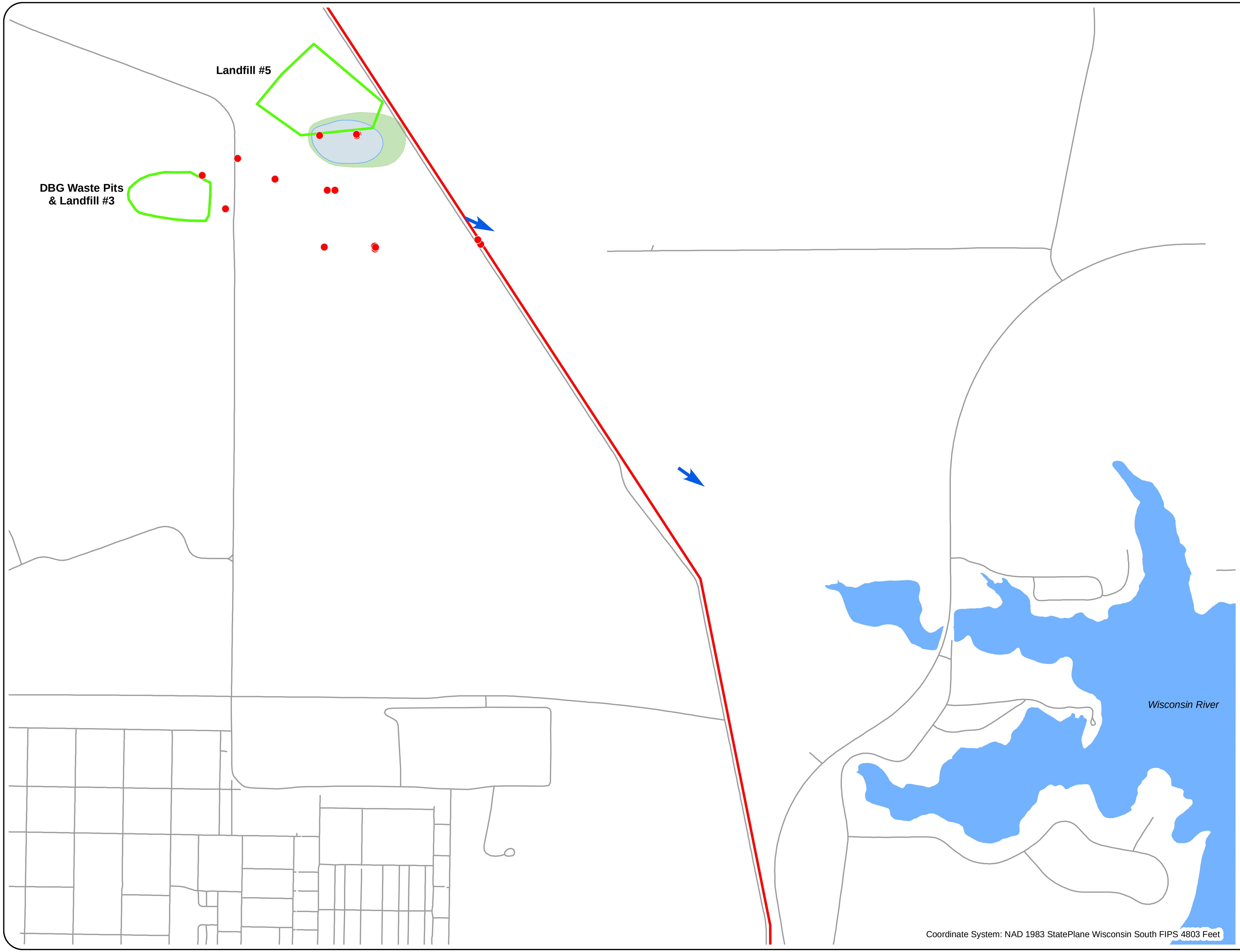
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS APPROXIMATELY PERPENDICULAR TO CROSS SECTION.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 45

TOTAL DINITROTOLUENE ISOCONCENTRATION SECTION F-F'

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

LEGEND

● Wells Used To Construct Isoconcentrations

Sulfate Concentration (mg/l)

April 2018

🟩 125 - 250

▨ > 250

☐ Source Area

Groundwater Flow Direction

Notes: The sulfate isoconcentrations in milligrams per liter (mg/l) are interpreted from groundwater data collected during 2018. Wisconsin has a "secondary" NR 140 Public Welfare Groundwater Quality Standard. The sulfate groundwater standard is based on a taste threshold and not considered to present a risk to human health. The NR 140 Preventive Action Limit is 125 mg/l and Enforcement Standard is 250 mg/l.

FIGURE 46

SULFATE ISOCONCENTRATION MAP

DETERRENT BURNING GROUND
& LANDFILL #5
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

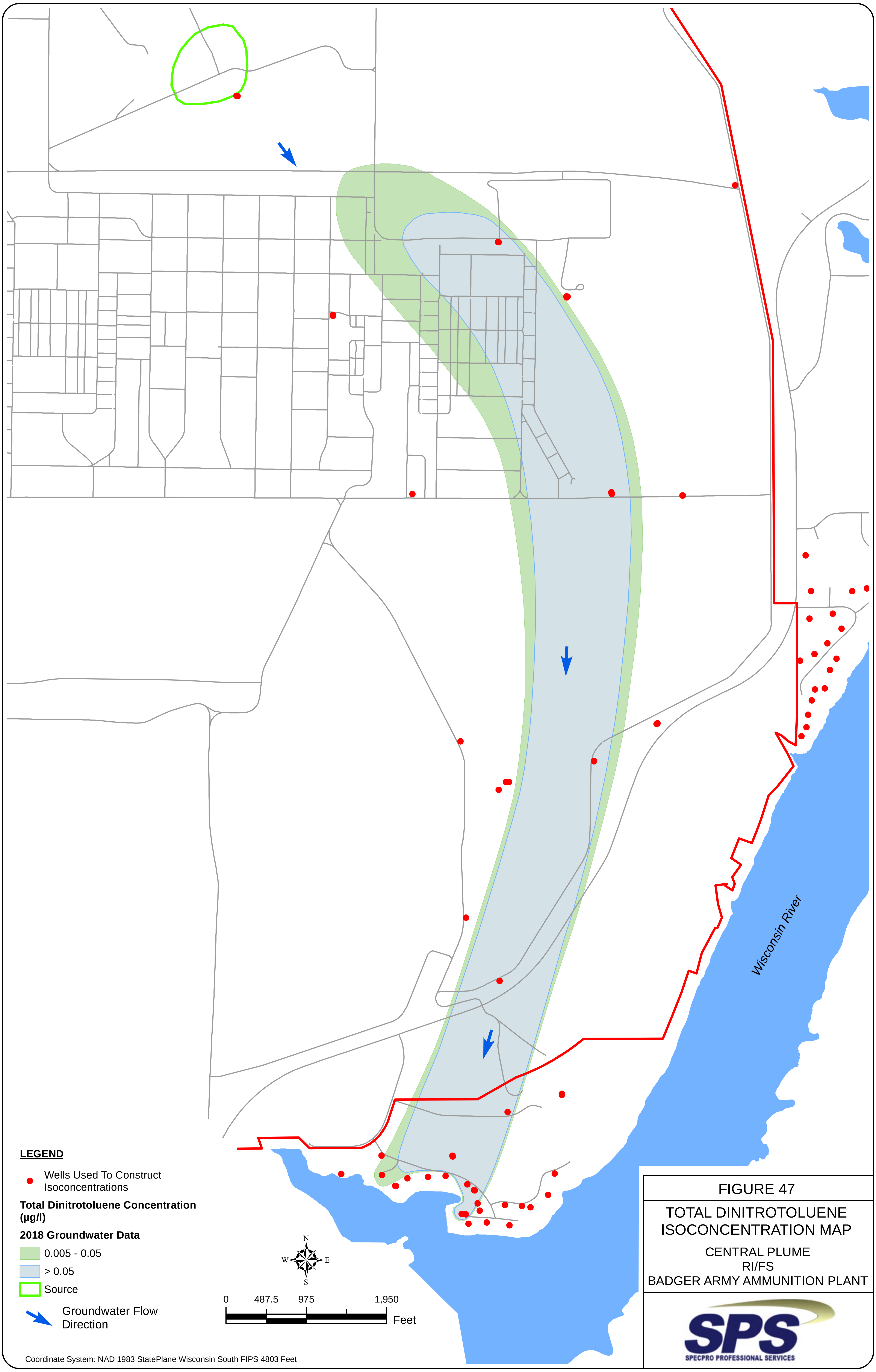
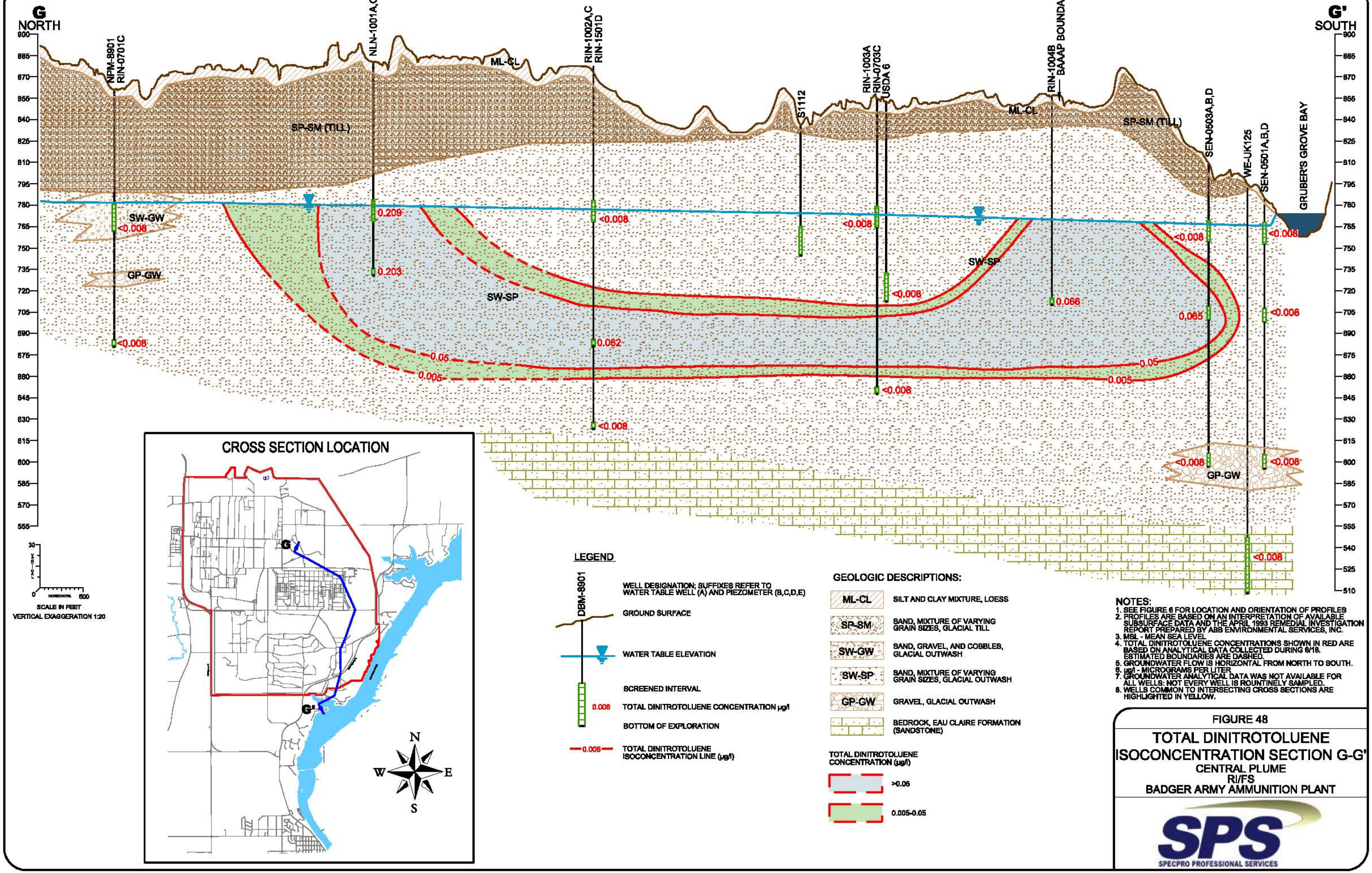


FIGURE 47

TOTAL DINITROTOLUENE ISOCONCENTRATION MAP

CENTRAL PLUME
RI/FS
BADGER ARMY AMMUNITION PLANT

SPECPRO PROFESSIONAL SERVICES



LEGEND

DBM-8901 — WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

0.008 — TOTAL DINITROTOLUENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.005 — TOTAL DINITROTOLUENE ISOCONCENTRATION LINE (µg/l)

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-GW	SAND, GRAVEL, AND COBBLES, GLACIAL OUTWASH
SW-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP-GW	GRAVEL, GLACIAL OUTWASH
▦	BEDROCK, EAU CLAIRE FORMATION (SANDSTONE)

TOTAL DINITROTOLUENE CONCENTRATION (µg/l)

⬜	>0.05
🟩	0.005-0.05

NOTES:

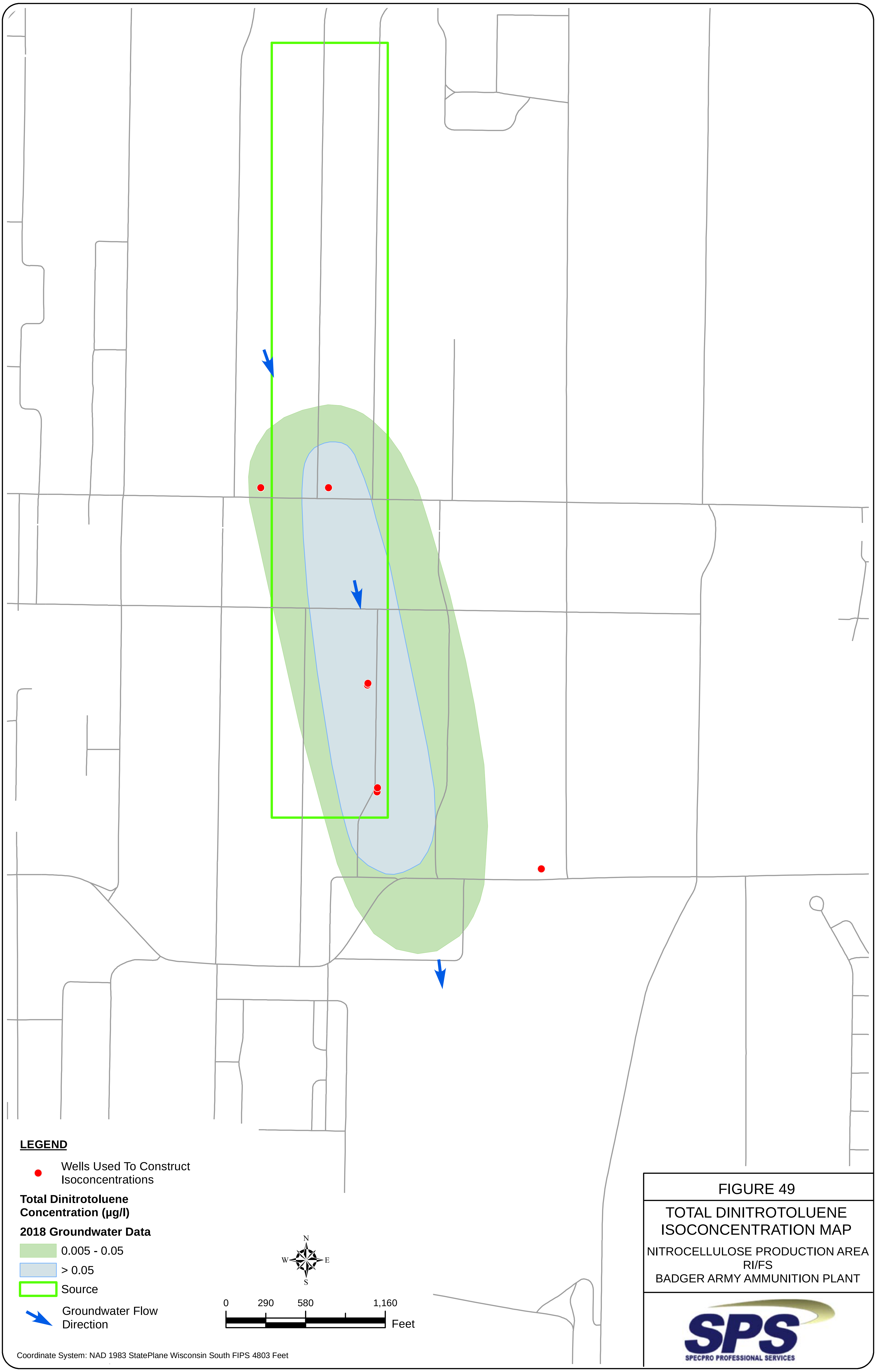
1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 6/18. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 48

TOTAL DINITROTOLUENE ISOCONCENTRATION SECTION G-G'

CENTRAL PLUME
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



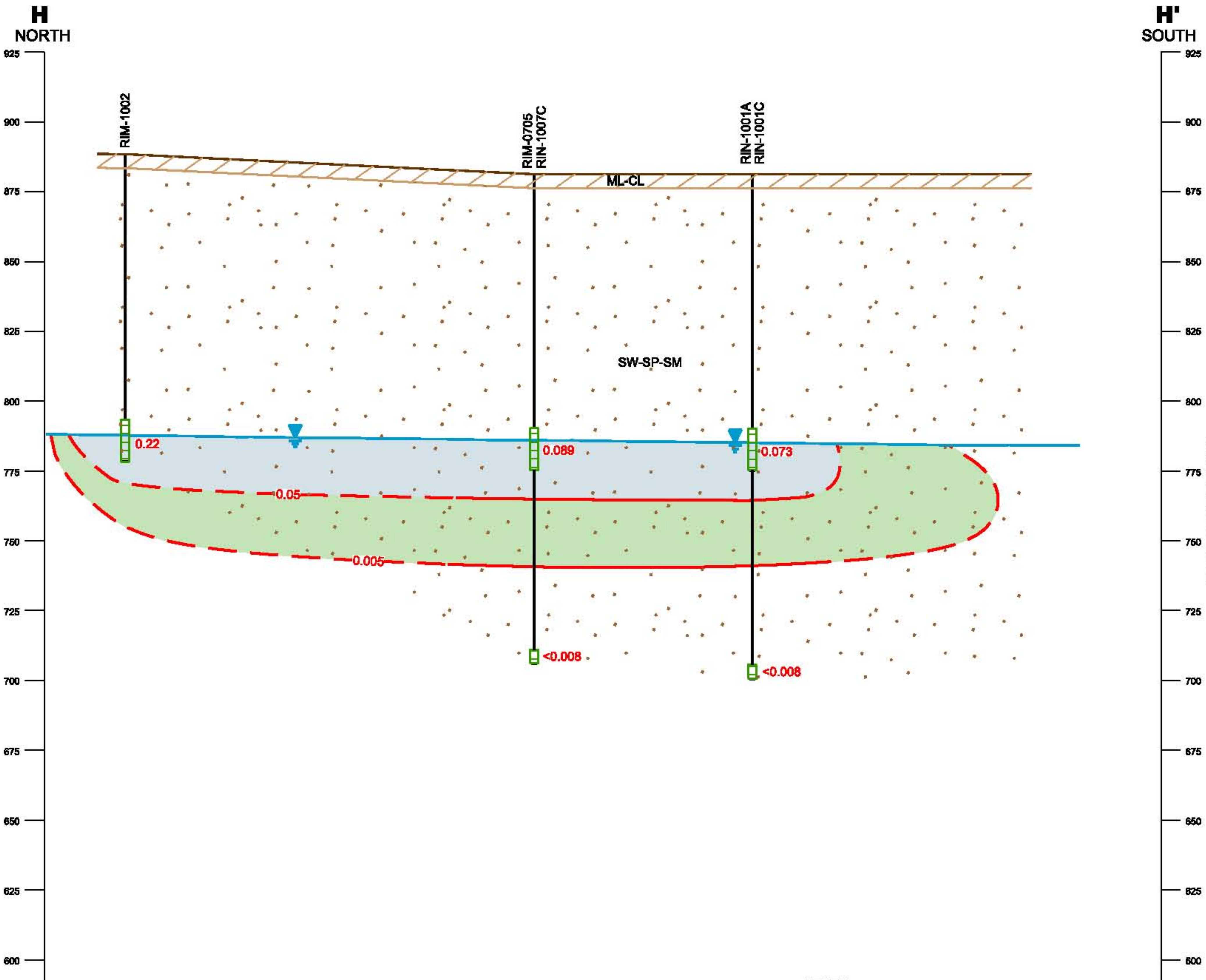
Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

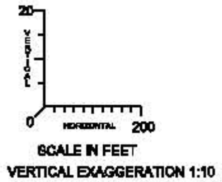
FIGURE 49

TOTAL DINITROTOLUENE ISOCONCENTRATION MAP

NITROCELLULOSE PRODUCTION AREA
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES





LEGEND

DBM-8901 — WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,D,E)

GROUND SURFACE

WATER TABLE ELEVATION

SCREENED INTERVAL

0.008 — TOTAL DINITROTOLUENE CONCENTRATION µg/l

BOTTOM OF EXPLORATION

0.005 — TOTAL DINITROTOLUENE ISOCONCENTRATION LINE (µg/l)

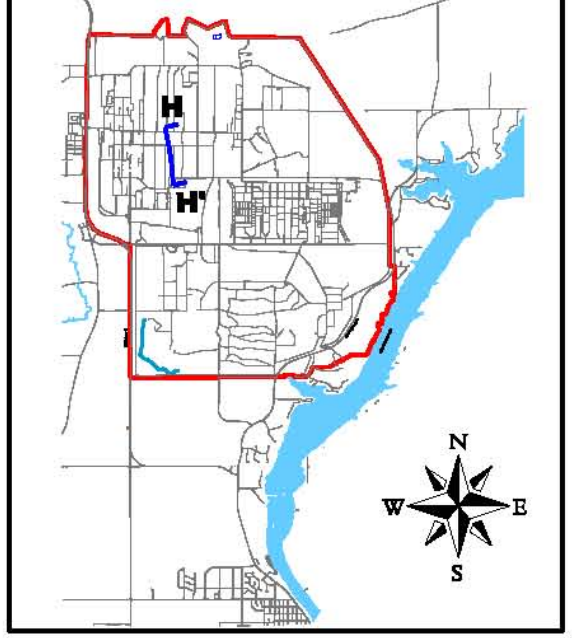
TOTAL DINITROTOLUENE CONCENTRATION (µg/l)

▨	>0.05
🟩	0.005 - 0.05

GEOLOGIC DESCRIPTIONS:

ML-CL	SILT AND CLAY MIXTURE, LOESS
SM-SP	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL
SW-SP-SM	SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH
GP	GRAVEL, POORLY GRADED, GLACIAL OUTWASH
GP-GW	GRAVEL, MIXTURE, GLACIAL OUTWASH
	BEDROCK, EAU CLAIRE FORMATION (DOLOMITE)

CROSS SECTION LOCATION



NOTES:

1. SEE FIGURE 6 FOR LOCATION AND ORIENTATION OF PROFILES
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA AND THE APRIL 1993 REMEDIAL INVESTIGATION REPORT PREPARED BY ABB ENVIRONMENTAL SERVICES, INC.
3. MSL - MEAN SEA LEVEL
4. TOTAL DINITROTOLUENE CONCENTRATIONS SHOWN IN RED ARE BASED ON ANALYTICAL DATA COLLECTED DURING 9/18. ESTIMATED BOUNDARIES ARE DASHED.
5. GROUNDWATER FLOW IS HORIZONTAL FROM NORTH TO SOUTH.
6. µg/l - MICROGRAMS PER LITER
7. GROUNDWATER ANALYTICAL DATA WAS NOT AVAILABLE FOR ALL WELLS: NOT EVERY WELL IS ROUNTINELY SAMPLED.
8. WELLS COMMON TO INTERSECTING CROSS SECTIONS ARE HIGHLIGHTED IN YELLOW.

FIGURE 50

TOTAL DINITROTOLUENE ISOCONCENTRATION SECTION H-H'

NITROCELLULOSE PRODUCTION AREA
RI/FS
BADGER ARMY AMMUNITION PLANT

SPECPRO PROFESSIONAL SERVICES

Appendix A

Summary of WDNR Conditions of Approval

Summary of WDNR Conditions of Approval

The Wisconsin Department of Natural Resources (WDNR) June 28, 2012 Final Determination of Feasibility for an Alternative Groundwater Remedial Strategy approval letter established specific requirements (conditions) to be satisfied by the Army. The Army has addressed these conditions and provided appropriate documentation to the WDNR. The following summarizes the conditions of approval (*italics*) and the Army's subsequent activities (**bold**) to address these conditions.

Conditions of Approval

Condition 1: *The Army shall continue operation of the Interim Remedial Measures (IRM) and Modified Interim Remedial Measures (MIRM) systems, as currently required, to collect and treat contaminated groundwater until modifications are approved by the Department in writing.*

Army Action: **The Army submitted an Interim Remedial Measures (IRM) Shutdown Plan in October 2012 that outlined a systematic approach to restoring natural groundwater conditions so that PBG Plume dynamics and attenuation could be evaluated. Based on the WDNR's December 11, 2012 approval letter, the IRM was shut down on December 17, 2012. The Army's June 17, 2014 letter to the WDNR summarized the monitoring activities conducted during 2013 and 2014 and requested that the IRM system be dismantled. The WDNR's August 4, 2014 letter approved the dismantling of the IRM system. During 2014, the IRM extraction wells were abandoned and the IRM treatment building was demolished.**

The Army submitted a Modified Interim Remedial Measures Shutdown Plan (MIRM) in January 2014 that outlined a systematic approach to restoring natural groundwater conditions so that PBG Plume dynamics and attenuation could be evaluated. Based on the WDNR's August 4, 2014 approval letter, the MIRM was completely shut down on August 31, 2015. The Army's June 27, 2016 letter to the WDNR summarized the monitoring activities conducted between 2014 and 2016 and requested that the MIRM system be dismantled. The WDNR's July 15, 2016 letter approved the dismantling of the MIRM system. During 2016, the MIRM extraction wells were abandoned. Ownership of the MIRM treatment building was transferred from the Army to the Bluffview Sanitary District in July 2016.

Condition 2: *Prior to requesting modification or termination of the operation of the IRM or MIRM systems, the Army shall propose to the Department a process by which the effects of the requested changes can be predicted and evaluated. This proposal will be reviewed by the Department. Written Department approval will be required before any modifications are implemented.*

Army Action: See response to Condition 1. Both the IRM and MIRM Shutdown Plans provided a summary of the groundwater treatment operations, contaminant mass removal data, hydrogeologic conditions, contaminant trends in monitoring wells, and proposed shutdown activities.

Condition 3: As part of the workplan for the phased shutdown of the IRM/MIRM, the Army shall prepare a comprehensive written report evaluating the effectiveness of the MIRM and IRM systems in preventing offsite groundwater contaminant migration. The evaluation shall include, but not be limited to, delineation of hydraulic capture zones, contaminant trends in select on- and off-site monitoring wells, calculations of contaminant travel times, and a concise statement concerning the effectiveness of the remedial systems in preventing offsite contaminant movement. Also included in the report shall be a description of the maintenance activities taken to keep the MIRM and IRM systems operational such as well chlorination and pump replacements.

Army Action: See response to Conditions 1 and 2.

Condition 4: The IRM and MIRM systems and all associated appurtenances shall be maintained in operational condition until such time that the Army obtains written Department approval to abandon or dismantle either or both systems.

Army Action: Routine maintenance of the IRM and MIRM systems was performed prior to obtaining WDNR approval to dismantle each system.

Condition 5: The Army shall propose an investigation and monitoring program to define the degree and extent to which contaminated groundwater is entering the Wisconsin River, Lake Wisconsin and/or other surface waters. This shall include, but not be limited to, installation of additional groundwater monitoring wells in addition to those already being used to monitor the plume(s) and may include the sampling of surface water.

Army Action: On October 31, 2012, the Army provided to the WDNR the Surface Waters Impact Investigation workplan. The WDNR provided verbal approval of the workplan on January 4, 2013. The field investigation was conducted in June 2013 and the results were summarized in the Surface Waters Impact Investigation Report. The report was provided to the WDNR on November 21, 2013. The investigation involved collecting groundwater samples from temporary wells located near Weigand's Bay for the DBG Plume and near the Wisconsin River for the PBG Plume.

Condition 6: The BAAP groundwater monitoring program currently implemented by the Army shall continue until modifications are approved by the Department.

Army Action: The Army has continued their groundwater monitoring efforts consistent will all plan approvals and subsequent modifications.

Condition 7: *By July 1, 2013, the Army shall propose modifications to the groundwater monitoring program with the goal of providing data on the long-term effectiveness of natural attenuation as a remedial alternative. The requested changes in the monitoring program to evaluate natural attenuation shall encompass all three known groundwater contaminant plumes (propellant burning ground (PBG), deterrent burning ground (DBG) and central plumes). The proposal shall include (but not be limited to) a map or maps showing the names and locations of all monitoring wells associated with the property investigation and those that will be included in the groundwater monitored natural attenuation (MNA) network. The Army shall identify any locations where new wells will be installed to address any gaps in data collection to support monitored natural attenuation. The modification proposal shall include cross-sections, a table or tables providing information about the wells (by name or number identifier and/or associated license number) in the network, which plume(s) the wells are associated with, the parameters for which groundwater will be monitored, test methods used, and the frequency of sampling. The Army shall obtain written Department approval prior to implementing the modification to the groundwater monitoring network.*

Army Action: The Army, under separate covers, made three requests related to the groundwater monitoring modifications. The requested modifications related to data validation on April 4, 2013, private well sampling reduction dated May 14, 2013 and monitoring well sampling schedule on June 24, 2013. The WDNR approved these requests in a letter dated September 4, 2013.

Condition 8: *A groundwater narrative summary report similar in format to those submitted in the past several years shall be submitted to the Department annually for each calendar year by May 1 of the following year. Contents of the report shall focus on the results of work performed to evaluate monitored natural attenuation.*

Army Action: Groundwater narrative summary reports are completed annually and submitted to the WDNR.

Condition 9: *The Army shall conduct adequate saturated and unsaturated soil sampling, for all appropriate parameters, within the PBG, DBG and Central plumes to determine the nature and extent of site contaminants adsorbed onto the soil. Because back-diffusion of adsorbed waste constituents appears to be a major contributor to the groundwater plumes' stability, fully characterizing the adsorbed waste mass is necessary to evaluate natural attenuation as a possible remedial alternative.*

Army Action: Sampling within the final cap area associated with the PBG and DBG would compromise the barrier component of these systems. The barrier components of the PBG final cap consist of clay and geomembrane. The barrier components of the DBG final cap consist of geosynthetic clay and

geomembrane. These barrier components would need to be penetrated for samples to be obtained. In addition, the final cap layers above the barrier layer including the sand drainage layer, geotextile filter fabric, frost protection layer, and topsoil would need to be excavated at an angle for adequate access and subsequent cover repair/replacement.

Both the PBG and DBG have conditions of approval that strictly prohibit activities that would impact the integrity of the final cap system. Because of these factors and the conditions of approval for these facilities, the Army has not pursued sampling within the final cap area of the PBG or DBG.

The Army has conducted numerous soil investigations and remedial actions in the potential source areas of the Central Plume. These soil investigations and remedial actions are summarized in multiple reports submitted to the WDNR. The WDNR has provided the Army with multiple site closures related to the source areas for the Central Plume.

Condition 10: In conducting the required descriptions of plume configuration and behavior as well as the impact of past or future remedial efforts (as required in conditions 3, 5, 7 and 9, above) the Army shall consider that the plumes at Badger are three dimensional entities. All investigations and analyses described in this section shall be implemented to fully characterize in three dimensions the characteristics of all flow systems.

Army Action: Investigations and analyses have been completed to characterize plume configurations and tendencies.

Condition 11: Within 30 days of the date of approval, the Army shall provide a proposed schedule of events regarding the efforts to obtain local approval of the municipal water supply system. Inform the Department's Remediation and Redevelopment and Drinking Water and Groundwater programs, in writing, of any unforeseen delays in obtaining local approvals. Updates shall be submitted at least every 60 days.

Army Action: The Army submitted the first proposed schedule of events on July 25, 2012. The Army's final submission was on November 8, 2016. These submissions were ceased in 2017 when the Army choose to not install a municipal water supply system.

Condition 12: The source control action taken at the PBG and DBG shall be maintained as required in past approvals from the Department. Specifically, these approvals are Condition 6 of the October 14, 2002 approval for the PBG and Condition 5 of the March 17, 2008 approval for the DBG.

Army Action: The Army completes annual cap inspections for the PBG and DBG and addresses corrective action as necessary. In addition, the Army controls

vegetation at these waste containment facilities through annual mowing. An annual cap and cover report containing inspection results, corrective actions and annual maintenance is completed and provided to the WDNR in January of each year for the previous year's activities.

Condition 13: If approved by local units of government, the Army shall obtain the Department's approval of plans for the municipal water supply system prior to commencing construction. Please be aware that you will also need approvals from the Public Service Commission of Wisconsin. Please contact them directly.

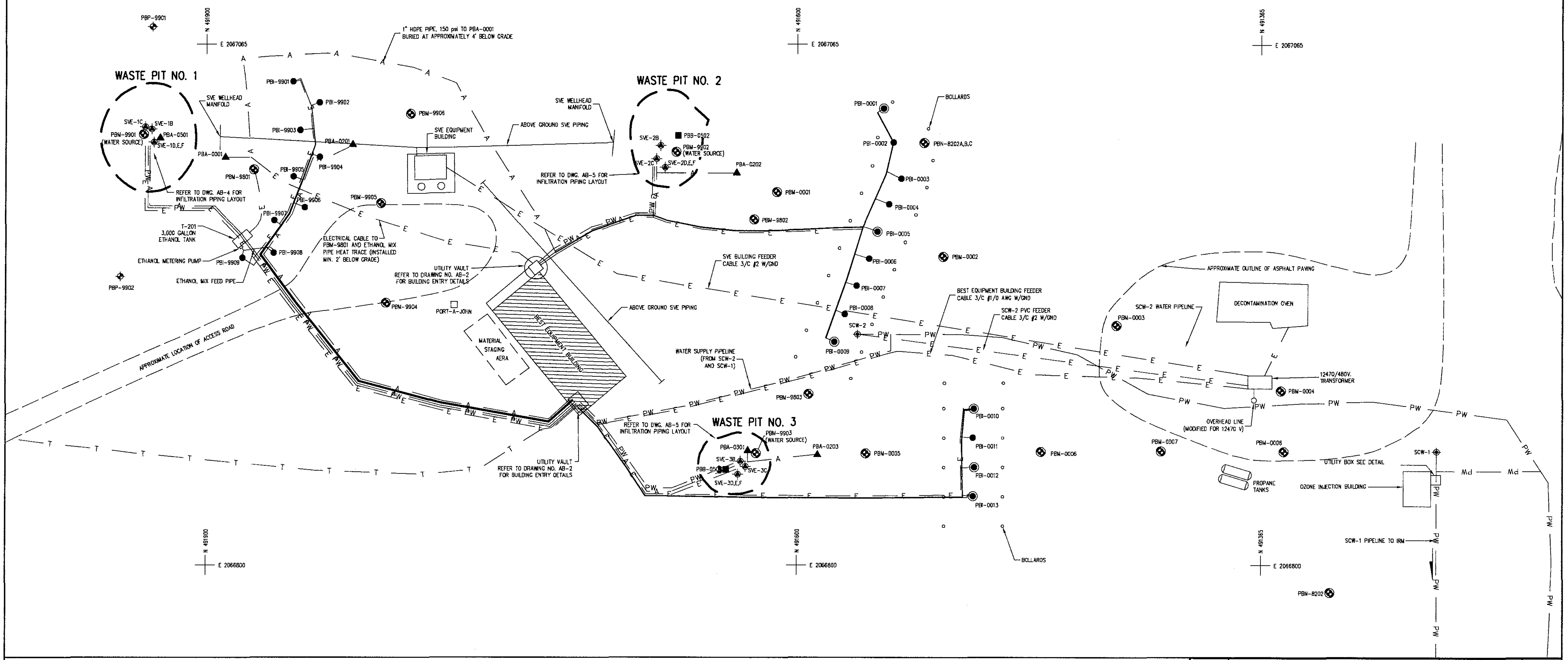
Army Action: The Army has determined that they neither have the legal nor funding authority to authorize a municipal water system. The Army's Supplemental Remedial Investigation/Feasibility Study is being provided within this document to outline remedial alternatives for groundwater contamination.

Condition 14: If the chosen remedy is not effective, the Department has the authority to require the Army to take additional actions to address contamination at the site.

Army Action: No action required.

Appendix B

PBG Waste Pits Soil Investigation Information (2005)



LEGEND

— — — —	TEMPORARY ACCESS ROAD
▬▬ ▬▬	WASTE PIT BOUNDARY
SVE-1A ⌖	SVE WELL/AIR INJECTION WELL
PBP-9902 ⌖	PIEZOMETER
SCW-2 ⌖	SOURCE CONTROL WELL
PBA-0001 ▲	AIR INJECTION WELL
PBM-0005 ⊕	MONITORING WELL
PBI-0001 ◉	CARBOHYDRATE INJECTION AND MONITORING WELL
PBI-0002 ●	CARBOHYDRATE INJECTION WELL
PBB-0502 ■	EVALUATION SOIL BORING
—— A ——	AIR LINE
—— E ——	ELECTRICAL CABLE
—— T ——	TELEPHONE CABLE
—— PW ——	WATER SUPPLY PIPELINE
————	CARBOHYDRATE INJECTION LINE

N

0 25 50

SCALE: 1" = 50'

A	ISSUED TO ARMY	AE	DJR	06/03/05
REVISION	DESCRIPTION	CHECKED	APPROVED	DATE

U.S. ARMY
CORPS OF ENGINEERS
OMAHA DISTRICT

BADGER ARMY AMMUNITION PLANT

FIGURE NUMBER
1

PROPELLANT BURNING GROUND BEST SYSTEM LAYOUT

Shaw™ Environmental, Inc.

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DSND	AE	06/02/05	CHKD	AE	06/02/05	843333.0150	A	3333F04A
DRAWN	MEC	06/02/05	APPR	DJR	06/02/05			

THU, JUN 02, 2005 10:20 A MEC O:\BADGER\843333\F-0150\REV-A\3333F04A.DWG

TABLE 1
WASTE PIT 1 SAMPLE NUMBERS AND ANALYSES

Sample Number	Sample Interval (ft bgs)	Analyses							Comment
		VOC Headspace	VOCs	SVOCs	TOC	Select Metals	Select Anions	pH	
PBB 0501 010	20 - 30	X			X	X	X	X	Duplicate of PBB 0501 030
PBB 0501 022	21 - 22		X	X					
PBB 0501 026	25 - 26		X	X					
PBB 0501 030	20 - 30	X			X	X	X	X	
PBB 0501 031	30 - 31		X	X					
PBB 0501 040	30 - 40	X			X	X	X	X	
PBB 0501 041	40 - 41		X	X					
PBB 0501 050	40 - 50	X			X	X	X	X	
PBB 0501 051	50 - 51		X	X					
PBB 0501 060	50 - 60	X			X	X	X	X	
PBB 0501 061	60 - 61		X	X					
PBB 0501 070	60 -70	X			X	X	X	X	
PBB 0501 071	70 - 71		X	X					
PBB 0501 080	70 - 80	X			X	X	X	X	
PBB 0501 080	90 - 91		X	X					Duplicate of PBB 0501 091 (VOCs & SVOCs only)
PBB 0501 090	80 - 90	X			X	X	X	X	
PBB 0501 091	90 - 91		X	X					
PBB 0501 100	90 - 100	X			X	X	X	X	

Notes:
ft bgs = feet below ground surface
SVOC = semivolatile organic compound
TOC = total organic carbon
VOC = volatile organic compound

TABLE 2
WASTE PIT 2 SAMPLE NUMBERS AND ANALYSES

Sample Number	Sample Interval (ft bgs)	Analyses							Comment
		VOC Headspace	VOCs	SVOCs	TOC	Select Metals	Select Anions	pH	
PBB 0502 010	104 - 105				X	X	X	X	Duplicate of PBB 0502 105
PBB 0502 023	22 - 23		X	X					
PBB 0502 029	28 - 29		X	X					
PBB 0502 030	20 - 30	X			X	X	X	X	
PBB 0502 035	34 - 35		X	X					
PBB 0502 040	30 - 40	X			X	X	X	X	
PBB 0502 050	40 - 50	X			X	X	X	X	
PBB 0502 053	52 - 53		X	X					
PBB 0502 060	50 - 60	X			X	X	X	X	
PBB 0502 070	60 -70	X	X	X	X	X	X	X	
PBB 0502 080	70 - 80	X			X	X	X	X	
PBB 0502 080	80 - 90		X						Duplicate of PBB 0502 090 (VOCs only)
PBB 0502 090	80 - 90	X	X	X	X	X	X	X	
PBB 0502 100	90 - 100	X			X	X	X	X	
PBB 0502 105	104 - 105		X	X	X	X	X	X	

Notes:
ft bgs = feet below ground surface
SVOC = semivolatile organic compound
TOC = total organic carbon
VOC = volatile organic compound

TABLE 3
WASTE PIT 3 SAMPLE NUMBERS AND ANALYSES

Sample Number	Sample Interval (ft bgs)	Analyses							Comment
		VOC Headspace	VOCs	SVOCs	TOC	Select Metals	Select Anions	pH	
PBB-0503 010	60 -70				X	X	X	X	Duplicate of PBB 0503 070
PBB 0503 013	12 - 13		X	X					
PBB 0503 020	10 - 20	X	X	X	X	X	X	X	
PBB 0503 030	20 - 30	X	X	X	X	X	X	X	
PBB 0503 040	30 - 40	X			X	X	X	X	
PBB 0503 050	40 - 50	X			X	X	X	X	
PBB 0503 055	54 - 55		X	X					
PBB 0503 060	50 - 60	X			X	X	X	X	
PBB 0503 070	60 -70	X	X	X	X	X	X	X	
PBB 0503 080	70 - 80	X	X	X	X	X	X	X	Duplicate of PBB 0503 090
PBB 0503 090	80 - 90	X	X	X	X	X	X	X	
PBB 0503 100	90 - 100	X			X	X	X	X	
PBB 0503 105	100 - 105	X			X	X	X	X	

Notes:
ft bgs = feet below ground surface
SVOC = semivolatile organic compound
TOC = total organic carbon
VOC = volatile organic compound

TABLE 4
WASTE PIT 1 SOIL RESULTS COMPARISON

Depth (ft)	Oct-91				Feb-97	Aug-02				Dec-03				Jan-05			
	2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)	2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)	2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)	2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)
20	NA	NA	NA		19,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
22	NA	NA	NA		--	NA	33,000	260	33,260	<340	47,000	<380	47,380	<120	13,000	<140	13,140
26	NA	56,000	ND	56000	--	NA	14,000	160	14,160	120	4,300	290	4,590	<31	5,000	<35	5,035
31	NA	8,200	ND	8200	--	NA	2,200	380	2,580	120	5,900	240	6,140	<30	5,100	<33	5,133
41	NA	5,700	1,000	6700	--	NA	15,000	1,500	16,500	<15	1,500	110	1,610	<0.61	48	4.7	53
51	NA	4,700	1,000	5700	--	NA	39,000	1,400	40,400	<61	8,300	360	8,660	4.4	53	36	89
61	NA	8,500	1,000	9500	--	NA	8,200	200	8,400	350	9,200	2,000	11,200	13	8.2	41	49
71	NA	1,900	830	2730	--	NA	3	28	31	140	4,100	1,100	5,200	2.6	5.2	29	34
91	NA	58	12	70	--	NA	1	20	21	6	130	48	178	0.7	2.2	1.1	3
Total				88,900					115,352				84,958				23,536

Notes:
DNT = dinitrotoluene
ft = feet
mg/kg = milligram(s) per kilogram
NA = not analyzed
ND = not detected
-- = no data

TABLE 5
WASTE PIT 2 SOIL RESULTS COMPARISON

Depth (ft)	Feb-97			Dec-03				Jan-05			
	2,4- & 2,6-DNT (mg/kg)			2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)	2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT
23	--	--	11,000	1.20	35	<0.36	35	<16	2,800	<18	2,818
25	25,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA
29	--	--	20,000	<0.79	130	<0.87	131	52	3,200	1,200	4,400
30	--	3,500	--	NA	NA	NA	NA	NA	NA	NA	NA
35	--	--	--	<6.6	1,200	<7.3	1,207	30	3,700	320	4,020
53	--	--	11,000	<120	10,000	890	10,890	1.90	5	31	36
70	--	--	5,300	15	640	100	740	9	570	160	730
90	--	--	290	3	5.60	33	39	0.23	0.13	0.36	0.5
105	--	--	3	0.23	0.17	0.16	0.33	0.045	0.087	<0.032	0.12
Total	76,093						13,042				12,005

Notes:
DNT = dinitrotoluene
ft = feet
mg/kg = milligram(s) per kilogram
NA = not analyzed
-- = no data

TABLE 6
WASTE PIT 3 SOIL RESULTS COMPARISON

Depth (ft)	Feb-97			Dec-03				Jan-05			
	2,4- & 2,6-DNT (mg/kg)			2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT (mg/kg)	2,3-DNT (mg/kg)	2,4-DNT (mg/kg)	2,6-DNT (mg/kg)	2,4- & 2,6-DNT
13	--	--	64,000	<15	2,800	<17	2,817	<160	16,000	<180	16,180
20	5,300	16,000	39,000	<6.2	1,100	<6.8	1,107	<120	16,000	<130	16,130
30	--	--	6,900	120	3,400	470	3,870	0.17	12	0.74	13
55	--	--	7,200	74	2,500	440	2,940	9.7	4.7	67	72
70	--	--	14,000	14	340	66	406	6.1	<1.1	160	161
80	--	--	--	0.75	17	3.6	20.6	0.29	0.19	1.9	2
90	--	--	2	0.17	0.35	0.18	0.53	0.23	0.24	16	16
Total	131,102						11,161				32,574

Notes:
DNT = dinitrotoluene
ft = feet
mg/kg = milligram(s) per kilogram
-- = no data

Appendix C

Groundwater Quality Regulations

National Primary Drinking Water Regulations

EPA

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
⬡ Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	**zero**
⬡ Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	**zero**
☢ Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	**zero**
⚛ Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	**0.006**
⚛ Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	**0**
⚛ Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	**7 MFL**
⬡ Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	**0.003**
⚛ Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	**2**
⬡ Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	**zero**
⬡ Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	**zero**
⚛ Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	**0.004**
☢ Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	**zero**
⚗ Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	**zero**
⚛ Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	**0.005**
⬡ Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	**0.04**

LEGEND

- 🧴 DISINFECTANT
- ⚗ DISINFECTION BYPRODUCT
- ⚛ INORGANIC CHEMICAL
- 🦠 MICROORGANISM
- ⬡ ORGANIC CHEMICAL
- ☢ RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
⬡ Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	**zero**
🧴 Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	**MRDLG=4[1]**
⬡ Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	**zero**
🧴 Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	**MRDLG=4[1]**
🧴 Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	**MRDLG=0.8[1]**
⚗ Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	**0.8**
⬡ Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	**0.1**
⚛ Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	**0.1**
⚛ Copper	TT[5]; Action Level=1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	**1.3**
🦠 *Cryptosporidium*	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
⚛ Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	**0.2**
⬡ 2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	**0.07**
⬡ Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	**0.2**
⬡ 1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	**zero**
⬡ o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	**0.6**
⬡ p-Dichlorobenzene	0.075	Anemia; liver, kidney, or spleen damage; changes in blood	Discharge from industrial chemical factories	**0.075**
⬡ 1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**

LEGEND

- 🧴 DISINFECTANT
- ⚗ DISINFECTION BYPRODUCT
- ⚛ INORGANIC CHEMICAL
- 🦠 MICROORGANISM
- ⬡ ORGANIC CHEMICAL
- ☢ RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	**0.007**
cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	**0.07**
trans-1,2, Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	**0.1**
Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from industrial chemical factories	**zero**
1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**
Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	**0.4**
Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	**zero**
Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	**0.007**
Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	**zero**
Diquat	0.02	Cataracts	Runoff from herbicide use	**0.02**
Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	**0.1**
Endrin	0.002	Liver problems	Residue of banned insecticide	**0.002**
Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	**zero**
Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	**0.7**
Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	**zero**
Fecal coliform and *E. coli*	MCL[6]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	**zero[6]**

LEGEND

DISINFECTANT

DISINFECTION BYPRODUCT

INORGANIC CHEMICAL

MICROORGANISM

ORGANIC CHEMICAL

RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	**4.0**
Giardia lamblia	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	**0.7**
Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	**zero**
Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	**zero**
Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	**n/a**
Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	**zero**
Hexachloro-cyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	**0.05**
Lead	TT[5]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	**zero**
Legionella	TT[7]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	**zero**
Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, and gardens	**0.0002**
Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	**0.002**
Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, and livestock	**0.04**
Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**10**

LEGEND

- DISINFECTANT
- DISINFECTION BYPRODUCT
- INORGANIC CHEMICAL
- MICROORGANISM
- ORGANIC CHEMICAL
- RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
⚛ Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**1**
⬡ Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	**0.2**
⬡ Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	**zero**
⬡ Picloram	0.5	Liver problems	Herbicide runoff	**0.5**
⬡ Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	**zero**
☢ Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	**zero**
⚛ Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	**0.05**
⬡ Simazine	0.004	Problems with blood	Herbicide runoff	**0.004**
⬡ Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	**0.1**
⬡ Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	**zero**
⚛ Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	**0.0005**
⬡ Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	**1**
🦠 Total Coliforms	5.0 percent[8]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	**zero**
⚗ Total Trihalomethanes (TTHMs)	0.080	Liver, kidney, or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
⬡ Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	**zero**
⬡ 2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	**0.05**
⬡ 1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	**0.07**

LEGEND

🧴 DISINFECTANT
⚗ DISINFECTION BYPRODUCT
⚛ INORGANIC CHEMICAL
🦠 MICROORGANISM
⬡ ORGANIC CHEMICAL
☢ RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
⬡ 1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	**0.2**
⬡ 1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	**0.003**
⬡ Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	**zero**
🦠 Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	**n/a**
☢ Uranium	30μg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	**zero**
⬡ Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	**zero**
🦠 Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
⬡ Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	**10**

LEGEND

🧴	DISINFECTANT
⚗	DISINFECTION BYPRODUCT
⚛	INORGANIC CHEMICAL
🦠	MICROORGANISM
⬡	ORGANIC CHEMICAL
☢	RADIONUCLIDES

NOTES

1 Definitions

- **Maximum Contaminant Level Goal (MCLG):** The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- **Maximum Contaminant Level (MCL):** The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- **Maximum Residual Disinfectant Level Goal (MRDLG):** The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **Maximum Residual Disinfectant Level (MRDL):** The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **Treatment Technique (TT):** A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or E. coli-positive triggers repeat samples--if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or E. coli-negative triggers repeat samples--if any repeat sample is fecal coliform-positive or E. coli-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- ***Cryptosporidium*:** 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- **Giardia lamblia:** 99.9 percent removal/inactivation
- **Viruses:** 99.9 percent removal/inactivation
- ***Legionella*:** No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- **Turbidity:** For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- **HPC:** No more than 500 bacterial colonies per milliliter
- **Long Term 1 Enhanced Surface Water Treatment:** Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- **Long Term 2 Enhanced Surface Water Treatment:** This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional *Cryptosporidium* treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- **Filter Backwash Recycling:** The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli. If two consecutive TC-positive samples, and one is also positive for E. coli or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- **Haloacetic acids:** dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- **Trihalomethanes:** bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

NATIONAL SECONDARY DRINKING WATER REGULATION

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

FOR MORE INFORMATION ON EPA'S SAFE DRINKING WATER:

visit: **epa.gov/safewater**

call: **(800) 426-4791**

ADDITIONAL INFORMATION:

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at: **(800) 490-9198**, or email: **nscep@bps-lmit.com**.

OFFICE OF GROUND WATER
AND DRINKING WATER

Chapter NR 140

GROUNDWATER QUALITY

Subchapter I — General

NR 140.01 Purpose. The purpose of this chapter is to establish groundwater quality standards for substances detected in or having a reasonable probability of entering the groundwater resources of the state; to specify scientifically valid procedures for determining if a numerical standard has been attained or exceeded; to specify procedures for establishing points of standards application, and for evaluating groundwater monitoring data; to establish ranges of responses the department may require if a groundwater standard is attained or exceeded; and to provide for exemptions for facilities, practices and activities regulated by the department.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85.

NR 140.02 Regulatory framework. **(1)** This chapter supplements the regulatory authority elsewhere in the statutes and administrative rules. The department will continue to exercise the powers and duties in those regulatory programs, consistent with the enforcement standards and preventive action limits for substances in groundwater under this chapter. This chapter provides guidelines and procedures for the exercise of regulatory authority which is established elsewhere in the statutes and administrative rules, and does not create independent regulatory authority.

(2) The department may adopt regulations which establish specific design and management criteria for regulated facilities or activities, if the regulations will ensure that the regulated facilities and activities will not cause the concentration of a substance in groundwater affected by the facilities or activities to exceed the enforcement standards and preventive action limits under this chapter at a point of standards application. The department may adopt more stringent regulations under authority elsewhere in the statutes based on the best currently available technology for regulated activities and practices which ensure a greater degree of groundwater protection or when necessary to comply with state or federal laws.

(3) Preventive action limits serve to inform the department of potential groundwater contamination problems, establish the level of groundwater contamination at which the department is required to commence efforts to control the contamination and provide a basis for design and management practice criteria in administrative rules. Preventive action limits are applicable both to controlling new releases of contamination as well as to restoring groundwater quality contaminated by past releases of contaminants. Although a preventive action limit is not intended to always require remedial action, activities affecting groundwater must be regulated to minimize the level of substances to the extent technically and economically feasible, and to maintain compliance with the preventive action limits unless compliance with the preventive action limits is not technically and economically feasible.

(4) The department may take any actions within the context of regulatory programs established in statutes or rules outside of this chapter, if those actions are necessary to protect public health and welfare or prevent a significant damaging effect on groundwater or surface water quality for present or future consumptive or nonconsumptive uses, whether or not an enforcement standard and preventive action limit for a substance have been adopted under this chapter. Nothing in this chapter authorizes an impact on groundwater quality which would cause surface water quality standards contained in chs. NR 102 to 105 to be attained or exceeded.

History: Cr. Register, January, 1992, No. 433, eff. 2−1−92; reprinted to restore dropped copy, Register, March, 1992, No. 435.

NR 140.03 Applicability. This subchapter and subch. II apply to all facilities, practices, and activities which may affect groundwater quality and which are regulated under chs. 85, 93, 94, 101, 145, 281, 283, 287, 289, 291, and 292, Stats., by the department of agriculture, trade and consumer protection, the department of safety and professional services, the department of transportation, or the department of natural resources, as well as to facilities, practices, and activities which may affect groundwater quality which are regulated by other regulatory agencies. Health−related enforcement standards adopted in s. NR 140.10 also apply to bottled drinking water manufactured, bottled, sold, or distributed in this state as required by s. 97.34 (2) (b), Stats., and to determining eligibility for the well compensation program under s. 281.75, Stats. Subchapter III applies to all facilities, practices, and activities which may affect groundwater quality and which are regulated by the department under ch. 281, 283, 287, 289, 291, 292, 295, or 299, Stats. This chapter applies to ferrous metallic mining operations and mining sites, including mining waste sites, as defined in s. 295.41 (31), Stats., but only to the extent that it does not conflict with subch. III of ch. 295, Stats. Groundwater quality standards, consisting of enforcement standards and preventive action limits contained in ss. NR 140.10 and 140.12, and preventive action limits for indicator parameters identified under s. NR 140.20 (2), apply to ferrous metallic mining operations and mining sites, as defined in s. 295.41 (31), Stats., including mining waste sites, regulated under subch. III of ch. 295, Stats. This chapter does not apply to any facilities, practices, or activities on a nonferrous metallic mining prospecting site or mining site regulated under ch. 293, Stats., because those facilities, practices, and activities are subject to the groundwater quality requirements of chs. NR 131, 132, and 182. The department may promulgate new rules or amend rules governing facilities, practices or activities regulated under ch. 293, Stats., if the department determines that the amendment or promulgation of rules is necessary to protect public health, safety, or welfare. The requirements of this chapter are in addition to the requirements of any other statutes and rules, except as provided in s. 295.645 (9), Stats.

Note: The groundwater standards in this chapter do not replace the maximum contaminant levels applicable to public water systems contained in ch. NR 809. Drinking water maximum contaminant levels and health advisory levels may take into account such factors as treatment costs and feasibility for public water systems.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. Register, December, 1998, No. 516, eff. 1−1−99; correction made under s. 13.93 (2m) (b) 7., Stats., Register, March, 2000, No. 531; correction made under s. 13.92 (4) (b) 6., Stats., Register January 2012 No. 673; CR 13−057: am. Register July 2015 No. 715, eff. 8−1−15.

NR 140.05 Definitions. (1) "Accuracy" means the closeness of a measured value to its generally accepted value or its value based upon an accepted reference standard.

(1m) "Alternative concentration limit" means the concentration of a substance in groundwater established by the department for a site to replace a preventive action limit or enforcement standard or both, from Table 1 or 2, when an exemption is granted in accordance with s. NR 140.28.

(1s) "Approval" means written acceptance by the department of a plan, report or other document that has been submitted to the department for review.

(1u) "Aquifer storage recovery" or "ASR" means placement of treated drinking water underground through a well for the purpose of storing and later recovering the water through the same well for potable use.

Note: Underground placement of water for the purpose of restoring an aquifer is not included in the definition of "aquifer storage recovery" or "ASR".

(1w) "ASR displacement zone" means the 3−dimensional subsurface region surrounding an aquifer storage recovery well into which treated drinking water is placed for storage and later recovery.

(1y) "ASR system" means all of the ASR wells, ASR monitoring wells and related appurtenances within a municipal well system and any interconnected public water system served by the municipal water system.

(2) "Attain or exceed" means that the concentration of a substance is determined to be equal to or greater than the preventive action limit or enforcement standard for that substance.

(3) "Background water quality" or "background concentration" means groundwater quality at or near a facility, practice or activity which has not been affected by that facility, practice or activity.

(4) "Certified laboratory" means a laboratory which performs tests for hire in connection with a covered program and which receives certification under s. 299.11 (7), Stats., or receives reciprocal recognition under s. 299.11 (5), Stats.

(5) "Department" means the department of natural resources.

(6) "Design management zone" means a 3−dimensional boundary surrounding each regulated facility, practice or activity established under s. NR 140.22 (3).

(7) "Enforcement standard" means a numerical value expressing the concentration of a substance in groundwater which is adopted under s. 160.07, Stats., and s. NR 140.10 or s. 160.09, Stats., and s. NR 140.12.

(8) "Facility, practice or activity" means any source or potential source of a substance which is detected in or has a reasonable probability of entering the groundwater resources of the state.

(9) "Groundwater" means any of the waters of the state, as defined in s. 281.01 (18), Stats., occurring in a saturated subsurface geological formation of rock or soil.

(10) "Indicator parameter" means a substance for which a preventive action limit has been established under s. NR 140.20, which is used to indicate the potential for a preventive action limit established under s. NR 140.10 or 140.12 to be attained or exceeded and for which an enforcement standard has not been established under s. NR 140.10 or 140.12.

(10e) "Infiltration" means the underground emplacement of substances or remedial material, or both, into an excavation that is wider than deep so as to percolate or move through unsaturated material to groundwater.

(10s) "Injection" means the underground emplacement of substances or remedial material, or both, into a borehole or other excavation that is deeper than wide so as to percolate or move through unsaturated material to groundwater or to enter groundwater directly.

(11) "Land disposal system" means a facility for disposing of liquid wastes consisting of:

(a) An absorption or seepage pond system,

(b) A ridge and furrow system;

(c) A spray irrigation system,

(d) An overland flow system,

(e) A subsurface field absorption system,

(f) A land spreading system, or

(g) Any other land area receiving liquid waste discharges.

(12) "Limit of detection" means the lowest concentration level that can be determined to be statistically different from a blank.

(13) "Limit of quantitation" means the level above which quantitative results may be obtained with a specified degree of confidence.

Note: The limit of quantitation is 10/3 or 3.333 times the limit of detection.

(14) "Monitoring" means all procedures used to collect data on groundwater, surface water or soils.

(14m) "Natural attenuation" means the reduction in the concentration and mass of a substance and its breakdown products in groundwater, due to naturally occurring physical, chemical, and biological processes without human intervention or enhancement. These processes include, but are not limited to, dispersion, diffusion, sorption and retardation, and degradation processes such as biodegradation, abiotic degradation and radioactive decay.

(15) "Point of standards application" means the specific location, depth or distance from a facility, activity or practice at which the concentration of a substance in groundwater is measured for purposes of determining whether a preventive action limit or an enforcement standard has been attained or exceeded.

(16) "Precision" means the closeness of repeated measurements of the same parameter within a sample.

(17) "Preventive action limit" means a numerical value expressing the concentration of a substance in groundwater which is adopted under s. 160.15, Stats., and s. NR 140.10, 140.12 or 140.20.

(18) "Property boundary" means the boundary of the total contiguous parcel of land owned or leased by a common owner or lessor, regardless of whether public or private roads run through the parcel.

(19) "Registered laboratory" means a laboratory which is registered under s. 299.11 (8), Stats., or receives reciprocal recognition under s. 299.11 (5), Stats.

(20) "Regulatory agency" means the department of agriculture, trade and consumer protection, the department of safety and professional services, the department of transportation, the department of natural resources and other state agencies which regulate activities, facilities or practices which are related to substances which have been detected in or have reasonable probability of entering the groundwater resources of the state.

(20h) "Remedial action" means a response which is taken to achieve compliance with groundwater quality standards established under this chapter. This term includes, but is not limited to, actions designed to prevent or minimize the further discharge or release of substances to groundwater and actions designed to renovate or restore groundwater quality.

(20k) "Remedial material" means any solid, liquid, semi−solid or gaseous material, either naturally occurring or manmade, in its original form or as a metabolite or degradation product, or naturally occurring non−pathogenic biological organisms which have not undergone human induced genetic alteration, which enhances the restoration of soil or groundwater quality, or both.

(20m) "Response" means any action taken to respond to an attainment or exceedance of a preventive action limit or enforcement standard as required by s. NR 140.24 or 140.26.

Note: A response may include a remedial action.

(20s) "Specified substance" means one of the following: chloroform, bromodichloromethane, dibromochloromethane or bromoform.

(21) "Substance" means any solid, liquid, semisolid, dissolved solid or gaseous material, naturally occurring or man−made chemical, parameter for measurement of water quality or biological organism which, in its original form, or as a metabolite or a degradation or waste product, may decrease the quality of groundwater.

(22) "Wastewater and sludge storage or treatment lagoon" means a natural or man−made containment structure, constructed primarily of earthen materials for the treatment or storage of wastewater or sludge, which is not a land disposal system.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; cr. (1m), am. (7), (17) and (18), Register, October, 1988, No. 394, eff. 11−1−88; am. (6), cr. (20h) and (20m), Register, March, 1994, No. 459, eff. 4−1−94; cr. (1s), (10e), (10s), (20k), r. and recr. (12), (13), Register, August, 1995, No. 476, eff. 9−1−95; cr. (14m), Register, October, 1996, No. 490, eff. 11−1−96; am. (20), Register, December, 1998, No. 516, eff. 1−1−99; correction in (9) made under s. 13.93 (2m) (b) 7., Stats., Register, April, 2001, No. 544; CR 02−134: cr. (1u), (1w), (1y) and (20s) Register June 2003 No. 570, eff. 7−1−03; correction in (20) made under s. 13.92 (4) (b) 6., Stats., Register January 2012 No. 673.

Subchapter II — Groundwater Quality Standards

NR 140.10 Public health related groundwater standards. The groundwater quality standards for substances of public health concern are listed in Table 1.

Note: For all substances that have carcinogenic, mutagenic or teratogenic properties or interactive effects, the preventive action limit is 10% of the enforcement standard. The preventive action limit is 20% of the enforcement standard for all other substances that are of public health concern. Enforcement standards and preventive action limits for additional substances will be added to Table I as recommendations are developed pursuant to ss. 160.07, 160.13 and 160.15, Stats.

Table 1
Public Health Groundwater Quality Standards

Substance[1]	Enforcement Standard (micrograms per liter − except as noted)	Preventive Action Limit (micrograms per liter − except as noted)
Acetochlor	7	0.7
Acetochlor ethane sulfonic acid + oxanilic acid (Acetochlor − ESA + OXA)	230	46
Acetone	9 mg/1	1.8 mg/1
Alachlor	2	0.2
Alachlor ethane sulfonic acid (Alachlor − ESA)	20	4
Aldicarb	10	2
Aluminum	200	40
Ammonia (as N)	9.7 mg/l	0.97 mg/l
Antimony	6	1.2
Anthracene	3000	600
Arsenic	10	1
Asbestos	7 million fibers per liter (MFL)	0.7 MFL
Atrazine, total chlorinated residues	3[2]	0.3[2]
Bacteria, Total Coliform	0[3]	0[3]
Barium	2 milligrams/liter (mg/l)	0.4 mg/l
Bentazon	300	60
Benzene	5	0.5
Benzo(b)fluoranthene	0.2	0.02
Benzo(a)pyrene	0.2	0.02
Beryllium	4	0.4
Boron	1000	200
Bromodichloromethane	0.6	0.06
Bromoform	4.4	0.44
Bromomethane	10	1
Butylate	400	80
Cadmium	5	0.5
Carbaryl	40	4
Carbofuran	40	8
Carbon disulfide	1000	200
Carbon tetrachloride	5	0.5
Chloramben	150	30
Chlordane	2	0.2
Chlorodifluoromethane	7 mg/l	0.7 mg/l
Chloroethane	400	80
Chloroform	6	0.6
Chlorpyrifos	2	0.4
Chloromethane	30	3
Chromium (total)	100	10
Chrysene	0.2	0.02

Table 1 − Continued
Public Health Groundwater Quality Standards

Substance[1]	**Enforcement Standard (micrograms per liter − except as noted)**	**Preventive Action Limit (micrograms per liter − except as noted)**
Cobalt	40	8
Copper	1300	130
Cyanazine	1	0.1
Cyanide, free[4]	200	40
Dacthal	70	14
1,2−Dibromoethane (EDB)	0.05	0.005
Dibromochloromethane	60	6
1,2−Dibromo−3−chloropropane (DBCP)	0.2	0.02
Dibutyl phthalate	1000	100
Dicamba	300	60
1,2−Dichlorobenzene	600	60
1,3−Dichlorobenzene	600	120
1,4−Dichlorobenzene	75	15
Dichlorodifluoromethane	1000	200
1,1−Dichloroethane	850	85
1,2−Dichloroethane	5	0.5
1,1−Dichloroethylene	7	0.7
1,2−Dichloroethylene (cis)	70	7
1,2−Dichloroethylene (trans)	100	20
2,4−Dichlorophenoxyacetic Acid (2,4−D)	70	7
1,2−Dichloropropane	5	0.5
1,3−Dichloropropene (cis/trans)	0.4	0.04
Di (2−ethylhexyl) phthalate	6	0.6
Dimethenamid/Dimethenamid−P	50	5
Dimethoate	2	0.4
2,4−Dinitrotoluene	0.05	0.005
2,6−Dinitrotoluene	0.05	0.005
Dinitrotoluene, Total Residues[5]	0.05	0.005
Dinoseb	7	1.4
1,4−Dioxane	3	0.3
Dioxin (2, 3, 7, 8−TCDD)	0.00003	0.000003
Endrin	2	0.4
EPTC	250	50
Ethylbenzene	700	140
Ethyl ether	1000	100
Ethylene glycol	14 mg/l	2.8 mg/l
Fluoranthene	400	80
Fluorene	400	80
Fluoride	4 mg/l	0.8 mg/l
Fluorotrichloromethane	3490	698
Formaldehyde	1000	100
Heptachlor	0.4	0.04
Heptachlor epoxide	0.2	0.02
Hexachlorobenzene	1	0.1
N−Hexane	600	120
Hydrogen sulfide	30	6
Lead	15	1.5
Lindane	0.2	0.02
Manganese	300	60
Mercury	2	0.2

Table 1 − Continued
Public Health Groundwater Quality Standards

Substance[1]	Enforcement Standard (micrograms per liter − except as noted)	Preventive Action Limit (micrograms per liter − except as noted)
Methanol	5000	1000
Methoxychlor	40	4
Methylene chloride	5	0.5
Methyl ethyl ketone (MEK)	4 mg/l	0.8 mg/l
Methyl isobutyl ketone (MIBK)	500	50
Methyl tert−butyl ether (MTBE)	60	12
Metolachlor/s−Metolachlor	100	10
Metolachlor ethane sulfonic acid + oxanilic acid (Metolachlor − ESA + OXA)	1.3 mg/l	0.26 mg/l
Metribuzin	70	14
Molybdenum	40	8
Monochlorobenzene	100	20
Naphthalene	100	10
Nickel	100	20
Nitrate (as N)	10 mg/l	2 mg/l
Nitrate + Nitrite (as N)	10 mg/l	2 mg/l
Nitrite (as N)	1 mg/1	0.2 mg/l
N−Nitrosodiphenylamine	7	0.7
Pentachlorophenol (PCP)	1	0.1
Perchlorate	1	0.1
Phenol	2 mg/l	0.4 mg/l
Picloram	500	100
Polychlorinated biphenyls (PCBs)	0.03	0.003
Prometon	100	20
Propazine	10	2
Pyrene	250	50
Pyridine	10	2
Selenium	50	10
Silver	50	10
Simazine	4	0.4
Styrene	100	10
Tertiary Butyl Alcohol (TBA)	12	1.2
1,1,1,2−Tetrachloroethane	70	7
1,1,2,2−Tetrachloroethane	0.2	0.02
Tetrachloroethylene	5	0.5
Tetrahydrofuran	50	10
Thallium	2	0.4
Toluene	800	160
Toxaphene	3	0.3
1,2,4−Trichlorobenzene	70	14
1,1,1−Trichloroethane	200	40
1,1,2−Trichloroethane	5	0.5
Trichloroethylene (TCE)	5	0.5
2,4,5−Trichlorophenoxy−propionic acid (2,4,5−TP)	50	5
1,2,3−Trichloropropane	60	12
Trifluralin	7.5	0.75
Trimethylbenzenes	480	96
(1,2,4− and 1,3,5− combined)		
Vanadium	30	6

Table 1 − Continued
Public Health Groundwater Quality Standards

Substance[1]	Enforcement Standard (micrograms per liter − except as noted)	Preventive Action Limit (micrograms per liter − except as noted)
Vinyl chloride	0.2	0.02
Xylene[6]	2 mg/l	0.4 mg/l

[1] Appendix I contains Chemical Abstract Service (CAS) registry numbers, common synonyms and trade names for most substances listed in Table 1.

[2] Total chlorinated atrazine residues includes parent compound and the following metabolites of health concern: 2−chloro−4−amino−6−isopropylamino−s−triazine (formerly deethylatrazine), 2−chloro−4−amino−6−ethylamino−s−triazine (formerly deisopropylatrazine) and 2−chloro−4,6−diamino−s−triazine (formerly diaminoatrazine).

[3] Total coliform bacteria may not be present in any 100 ml sample using either the membrane filter (MF) technique, the presence−absence (P−A) coliform test, the minimal medium ONPG−MUG (MMO−MUG) test or not present in any 10 ml portion of the 10−tube multiple tube fermentation (MTF) technique.

[4] "Cyanide, free" refers to the simple cyanides (HCN, CN^-) and /or readily dissociable metal−cyanide complexes. Free cyanide is regulatorily equivalent to cyanide quantified by approved analytical methods for "amenable cyanide" or "available cyanide".

[5] Dinitrotoluene, Total Residues includes the dinitrotoluene (DNT) isomers: 2,3−DNT, 2,4−DNT, 2,5−DNT, 2,6−DNT, 3,4−DNT and 3,5−DNT.

[6] Xylene includes meta−, ortho−, and para−xylene combined.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. table 1, Register, October, 1988, No. 394, eff. 11−1−88; am. table 1, Register, September, 1990, No. 417, eff. 10−1−90; am. Register, January, 1992, No. 433, eff. 2−1−92; am. Table 1, Register, March, 1994, No. 459, eff. 4−1−94; am. Table 1, Register, August, 1995, No. 476, eff. 9−1−95; am. Table 1, Register, December, 1998, No. 516, eff. 1−1−99; am. Table 1, boron, Register, December, 1998, No. 516, eff. 12−31−99; am. Table 1, Register, March, 2000, No. 531, eff. 4−1−00; CR 03−063: am Table 1, Register February 2004 No. 578, eff. 3−1−04; CR 02−095: am. Table 1, Register November 2006 No. 611, eff. 12−1−06; reprinted to correct errors in Table 1, Register January 2007 No. 613; CR 07−034: am. Table 1 Register January 2008 No. 625, eff. 2−1−08; CR 09−102: am. Table 1 Register December 2010 No. 660, eff. 1−1−11.

NR 140.12 Public welfare related groundwater standards. The groundwater quality standards for substances of public welfare concern are listed in Table 2.

Note: For each substance of public welfare concern, the preventive action limit is 50% of the established enforcement standard.

Table 2
Public Welfare Groundwater Quality Standards

Substance	Enforcement Standard (milligrams per liter − except as noted)	Preventive Action Limit (milligrams per liter − except as noted)
Chloride	250	125
Color	15 color units	7.5 color units
Foaming agents MBAS (Methylene−Blue Active Substances)	0.5	0.25
Iron	0.3	0.15
Manganese	0.05	0.025
Odor	3 (Threshold Odor No.)	1.5 (Threshold Odor No.)
Sulfate	250	125
Zinc	5	2.5

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. table 2, Register, October, 1990, No. 418, eff. 11−1−90; am. Table 2, Register, March, 1994, No. 459, eff. 4−1−94.

NR 140.14 Statistical procedures. (1) If a preventive action limit or an enforcement standard for a substance listed in Table 1 or 2, an alternative concentration limit issued in accordance with s. NR 140.28 or a preventive action limit for an indicator parameter established according to s. NR 140.20 (2) is attained or exceeded at a point of standards application:

(a) The owner or operator of the facility, practice or activity at which a standard is attained or exceeded shall notify the appropriate regulatory agency that a standard has been attained or exceeded; and

(b) The regulatory agency shall require a response in accordance with the rules promulgated under s. 160.21, Stats. No response shall be required if it is demonstrated to the satisfaction of the appropriate regulatory agency that a scientifically valid determination cannot be made that the preventive action limit or enforcement standard for a substance in Table 1 or 2 has been attained or exceeded based on consideration of sampling procedures or laboratory precision and accuracy, at a significance level of 0.05.

(2) The regulatory agency shall use one or more valid statistical procedures to determine if a change in the concentration of a substance has occurred. A significance level of 0.05 shall be used for all tests.

(3) In addition to sub. (2), the following applies when a preventive action limit or enforcement standard is equal to or less than the limit of quantitation:

(a) If a substance is not detected in a sample, the regulatory agency may not consider the preventive action limit or enforcement standard to have been attained or exceeded.

(b) If the preventive action limit or enforcement standard is less than the limit of detection, and the concentration of a substance is reported between the limit of detection and the limit of quantitation, the regulatory agency shall consider the preventive action limit or enforcement standard to be attained or exceeded only if:

1. The substance has been analytically confirmed to be present in the same sample using an equivalently sensitive analytical method or the same analytical method, and

2. The substance has been statistically confirmed to be present above the preventive action limit or enforcement standard, determined by an appropriate statistical test with sufficient samples at a significance level of 0.05.

(c) If the preventive action limit or enforcement standard is between the limit of detection and the limit of quantitation, the regulatory agency shall consider the preventive action limit or enforcement standard to be attained or exceeded if the concentration of a substance is reported at or above the limit of quantitation.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. (1) (intro.) and (b), r. and recr. (2), Register, October, 1988, No. 394, eff. 11−1−88; am. (1) (b), (2) and (3) (b), Register, September, 1990, No. 417, eff. 10−1−90; am. (1) (b), Register, March, 1994, No. 459, eff. 4−1−94; r. and recr. (3) (intro.), (a), (b), renum. (3) (c) to be 140.16 (5) and am., Register, August, 1995, No. 476, eff. 9−1−95.

NR 140.16 Monitoring and laboratory data requirements. (1) (a) All groundwater quality samples collected to determine compliance with ch. 160, Stats., shall comply with this section except as noted.

(b) *Groundwater sampling requirements.* All groundwater quality samples shall be collected and handled in accordance with procedures specified by the applicable regulatory agency or, where no sampling procedures are specified by that agency, in accordance with the sampling procedures referenced in par. (c). The sampling procedures specified by a regulatory agency may include requirements for field filtration.

(c) *Department groundwater sampling procedures.* 1. If sampling procedures are not specified by the applicable regulatory agency pursuant to par. (b), all groundwater quality samples shall be collected and handled in accordance with the sampling procedures contained in the following publications:

a. Groundwater Sampling Desk Reference. Wisconsin Department of Natural Resources, PUBL−DG−037−96, September, 1996.

b. Groundwater Sampling Field Manual. Wisconsin Department of Natural Resources, PUBL−DG−038−96, September, 1996.

Note: Copies of these publications may be purchased from:

Wisconsin Department of Administration
Document Sales Unit
4622 University Avenue
Madison, WI 53705−2156

These publications are available for inspection at the offices of the department, the secretary of state and the legislative reference bureau.

2. Where no procedure for collecting a particular groundwater quality sample is specified by the appropriate regulatory agency or in the publications referenced in subd. 1., other published scientifically valid groundwater sampling procedures may be used.

(d) *Laboratory requirements.* All groundwater quality samples, except samples collected for total coliform bacteria analysis and field analyses for pH, specific conductance and temperature, shall be analyzed in accordance with provisions of ch. NR 149 by a laboratory certified or registered under ch. NR 149. Samples for total coliform bacteria analysis shall be analyzed by the state laboratory of hygiene or at a laboratory approved or certified by the department of agriculture, trade and consumer protection.

Note: Refer to s. NR 149.46 for sample preservation procedures and holding times.

(e) *Data submittal.* The results of the analysis of groundwater quality samples shall be submitted to the department and any applicable regulatory agency. Except as provided in s. NR 205.07 (3) (c) for wastewater permittees, this section does not require the submission of groundwater monitoring data which is collected voluntarily and is not required to be collected to determine compliance with this chapter or another rule or statute.

(2) The laboratory shall select the analytical methodology which:

(a) Is specified in rules or approved by the regulatory agency, and

(b) Is appropriate for the concentration of the sample, and

(c) Is one of the following:

1. Has a limit of detection and limit of quantitation below the preventive action limit, or

2. Produces the lowest available limit of detection and limit of quantitation if the limit of detection and limit of quantitation are above the preventive action limit.

(3) If the owner or operator of a facility, practice or activity believes that a sample result does not represent groundwater quality in the vicinity of the facility, practice or activity, the owner or operator shall resample the appropriate well or wells to obtain a representative sample at the earliest possible time. All sample results shall be submitted to the department and the appropriate regulatory agency with an explanation of why the owner or operator believes that all or some of the results are invalid.

(4) The department may reject groundwater quality data that does not meet the requirements of the approved or designated analytical methods.

(5) The owner or operator of the facility, practice or activity shall report the limit of detection and the limit of quantitation with the sample results. If a substance is detected below the limit of quantitation, the owner or operator shall report the detected value with the appropriate qualifier to the regulatory agency.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. (1), Register, September, 1990, No. 417, eff. 10−1−90; am. (1), r. and recr. (2), Register, March, 1994, No. 459, eff. 4−1−94; (5) renum. from NR 140.14 (3) (c), cr. (4), Register, August, 1995, No. 476, eff. 9−1−95; r. and recr. (1), Register, December, 1998, No. 516, eff. 1−1−99.

Subchapter III — Evaluation and Response Procedures

NR 140.20 Indicator parameter groundwater standards. (1) ESTABLISHING BACKGROUND WATER QUALITY. Background water quality at a facility, practice or activity at which monitoring is required shall be established by sampling one or more monitoring points at locations and depths sufficient to yield groundwater samples that are representative of background water quality at or near the facility, practice or activity. Background water quality shall be determined for indicator parameters specified by the department. Background water quality for indicator parameters shall be established by averaging a minimum of 8 sample results from each well. The department may exclude any sample result which is nonrepresentative of background water quality. In making the calculations required in this section, the department may use as many representative sample points as are available.

(2) ESTABLISHING PREVENTIVE ACTION LIMITS FOR INDICATOR PARAMETERS. For each indicator parameter for which groundwater monitoring is required by the department, the preventive action limit shall be established based upon a change of water quality with respect to background water quality according to the methodology specified in pars. (a) to (c) and in Table 3.

(a) For field pH, the preventive action limit shall be one pH unit above or below the pH of the background water quality.

(b) For field temperature, the preventive action limit shall be 3 standard deviations or 10ºF (5.6ºC), whichever is greater, above or below the temperature of the background water quality.

(c) For all other indicator parameters, the preventive action limit shall be the background water quality for that parameter plus 3 standard deviations or the background water quality plus the increase of that parameter listed in Table 3, whichever is greater.

Note: The standard deviation for a group of samples is equal to the square root of: the value of the sum of the squares of the difference between each sample in the sample group and the mean for that sample group divided by the number of samples in the sample group where the sample group has 30 or more samples and by one less than the number of samples in the sample group where the sample group has less than 30 samples.

Table 3
Methodology for Establishing Preventive Action Limit for Indicator Parameters

Parameter	*Minimum Increase (mg/l)*
Alkalinity	100
Biochemical oxygen demand (BOD_5)	25
Calcium	25
Chemical oxygen demand (COD)	25
Magnesium	25
Nitrogen series	
Ammonia nitrogen	2
Organic nitrogen	2
Total nitrogen	5
Potassium	5
Sodium	10
Field specific conductance	200 microSiemens/cm
Total dissolved solids (TDS)	200
Total hardness	100
Total organic carbon (TOC)	1
Total organic halogen (TOX)	0.25

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. table 3, Register, October, 1990, No. 418, eff. 11−1−90; am. Table 3, Register, December, 1998, No. 516, eff. 1−1−99; CR 09−102: am. Table 3 Register December 2010 No. 660, eff. 1−1−11.

NR 140.22 Point of standards application for design and compliance. **(1)** DESIGN. Except as specified in sub. (1m), facilities, practices or activities regulated by the department, including remedial actions, shall be designed to minimize the level of substances in groundwater and to comply with the preventive action limits to the extent technically and economically feasible at all the following locations:

(a) Any point of present groundwater use.

(b) Any point beyond the boundary of the property on which the facility, practice or activity is located.

(c) Any point within the property boundaries beyond the 3−dimensional design management zone if one is established by the department at each facility, practice or activity under sub. (3).

(d) Every point at which groundwater is monitored to determine if a preventive action limit or enforcement standard has been attained or exceeded for sites identified under s. NR 140.22 (2) (c).

(1m) DESIGN OF ASR SYSTEMS; SPECIFIED SUBSTANCES. The point of standards application to determine if the design of an aquifer storage recovery system, regulated under ch. 280 or 281, Stats., complies with the preventive action limits for a specified substance is 1,200 feet from an aquifer storage and recovery well and at any other well that is not part of the ASR system and that is within 1,200 feet of an aquifer storage recovery well.

(2) COMPLIANCE. (a) Except as specified in par. (d), the point of standards application to determine if a preventive action limit has been attained or exceeded is any point at which groundwater is monitored.

(b) Except as specified in par. (d), the point of standards application to determine whether an enforcement standard has been attained or exceeded shall be the following locations:

1. Any point of present groundwater use;

2. Any point beyond the boundary of the property on which the facility, practice or activity is located;

3. Any point within the property boundaries beyond the 3 dimensional design management zone if one is established by the department at each facility, practice or activity under sub. (3).

Note: The boundary beyond which the enforcement standards apply is the closer of the property boundary or the design management zone boundary to the waste boundary for the facility, practice or activity.

(c) For discharges, releases, sites or facilities regulated under s. 292.11, 291.29 or 291.37, Stats., or s. NR 600.07, for which a design management zone has not been established in sub. (3), Table 4, the point of standards application shall be every point at which groundwater is monitored to determine if a preventive action limit or enforcement standard has been attained or exceeded.

Note: Section NR 600.07 no longer exists.

(d) The point of standards application to determine if a preventive action limit or enforcement standard for a specified substance has been attained or exceeded at an aquifer storage recovery well, regulated under ch. 280 or 281, Stats., is 1,200 feet from the aquifer storage and recovery well and at any other well that is not part of the ASR system and that is within 1,200 feet of the aquifer storage recovery well.

(3) DESIGN MANAGEMENT ZONE. (a) The design management zone for facilities, practices or activities subject to regulation by the department shall be an area enclosed by vertical boundaries which extend from the land surface downward through all saturated geological formations. The design management zone shall extend horizontally beyond the waste boundary or ASR displacement zone to the distance indicated in Table 4 for the specific type of facility, practice or activity. The waste boundary shall be the outermost limit at which waste from a facility, practice or activity has been stored, applied or disposed of, or permitted or approved for storage, application or disposal. For hazardous waste facilities regulated under ch. 291, Stats., the waste boundary shall include the horizontal space taken up by any liner, dike or other barrier to contain waste.

(b) In issuing or reissuing a permit, license or approval, the department may consider an expansion or reduction of the design management zone at a regulated or proposed facility, practice or activity by a horizontal distance not to exceed 50% of the distance listed in Table 4.

(c) The department shall consider the following factors in determining whether to expand or reduce the design management zone:

1. Nature, thickness and permeability of unconsolidated materials, including topography;

2. Nature and permeability of bedrock;

3. Groundwater depth, flow direction and velocity;

4. Waste volume, waste type and characteristics, including waste loading;

5. Contaminant mobility;

6. Distances to property boundary and surface waters;

7. Engineering design of the facility, practice or activity;

8. Life span of the facility, practice or activity;

9. Present and anticipated uses of land and groundwater; and

10. Potential abatement options if an enforcement standard is exceeded.

(d) The design management zone may not be expanded or reduced unless it has been demonstrated to the satisfaction of the department that the preventive action limits and enforcement standards will be met at the adjusted design management zone.

The design management zone may not be expanded unless it has been demonstrated to the satisfaction of the department that the preventive action limits and enforcement standards cannot be met at the design management zone specified in Table 4.

Table 4

Type of Facility, Practice or Activity	*Horizontal Distances for the Design Management Zone*
Land disposal systems regulated under ch. 283, Stats.	250 feet
Wastewater and sludge storage or treatment lagoons regulated under ch. 281 or 283, Stats.	100 feet
Solid waste disposal facilities regulated under ch. 289, Stats., which have feasibility reports approved after October 1, 1985.	150 feet
All other solid waste disposal facilities regulated under ch. 289, Stats.	300 feet
Hazardous waste disposal facilities, waste piles, landfills and surface impoundments subject to regulation under ss. NR 665.0090 to 665.0094	300 feet
Hazardous waste disposal facilities, waste piles, landfills and surface impoundments subject to regulation under ss. NR 664.0090 to 664.0100.	0 feet
Aquifer storage recovery systems regulated under ch. 280 or 281, Stats.	0 feet

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. (1) (b), Register, October, 1988, No. 394, eff. 11−1−88; am. (4) and table 4, Register, January, 1992, No. 433, eff. 2−1−92; am. (1), cr. (1) (d), renum. (2) to (5) to be (2) (a), (b), (c) and (3) and am. (2) (b) 3., Register, March, 1994, No. 459, eff. 4−1−94; CR 02−134: am. (1) (intro.), (2) (a), (b) (intro.), (3) (a) and Table 4, cr. (1m) and (2) (d) Register June 2003 No. 570, eff. 7−1−03; correction in Table 4 made under s. 13.93 (2m) (b) 7., Stats., Register November 2006 No. 611.

NR 140.24 Responses when a preventive action limit is attained or exceeded. (1) NOTIFICATION AND ASSESSMENT. If the concentration of a substance, including indicator parameters, in groundwater attains or exceeds a preventive action limit at a point of standards application as described in s. NR 140.22 (2):

(a) The owner or operator of the facility, practice or activity shall notify the department in writing when monitoring data is submitted that a preventive action limit has been attained or exceeded in accordance with any deadlines in applicable statutes, rules, permits or plan approvals. Where no deadlines are imposed, the owner or operator shall notify the department as soon as practical after the results are received. When the results of any private well sampling attain or exceed a preventive action limit, the owner or operator of the facility, practice or activity shall notify the department within 10 days after the results are received. The notification shall provide a preliminary analysis of the cause and significance of the concentration.

Note: Section 292.11 (2) (a), Stats., requires that the department be notified immediately of hazardous substance discharges.

Note: See s. NR 140.27.

(b) Upon receipt of the notice under par. (a), the department shall evaluate the information and, if further information is required to make the assessment under par. (c), direct the owner or operator to prepare and submit a report by a specified deadline. The report shall assess the cause and significance of the increased concentration based on a consideration of the factors identified in par. (c) and shall propose a response to meet the objectives of sub. (2).

(c) The department shall assess the cause and significance of the concentration of the substance in determining the appropriate response to meet the objectives of sub. (2). In addition to all other relevant information, the department shall consider the information submitted under par. (b) and the following factors where applicable:

1. Background water quality. a. The department shall compare background water quality data and monitoring data from wells downgradient of the facility, practice or activity to determine if downgradient water quality is adversely affected. If the background water quality at a facility, practice or activity is not known or is inadequately defined, the department may require additional sampling of existing wells, or installation and sampling of additional wells, or both.

b. Except for substances which are carcinogenic, teratogenic or mutagenic in humans, before requiring a response at a site where the background concentration of a substance is determined to be equal to or greater than the preventive action limit, the department shall determine that the proposed remedial action will protect or substantially improve groundwater quality notwithstanding the background concentrations of naturally occurring substances.

2. Reliability of sampling data. As part of its review of the quality of the sampling data, the department shall evaluate the sampling procedures, precision and accuracy of the analytical test, size of the data set, and the quality control and quality assurance procedures used. If there is insufficient information to evaluate the reliability of the sampling data, the department may require additional samples or other changes in the monitoring program at the facility, practice or activity.

3. Public health, welfare and environmental effects of the substance. The department shall consider the public health, welfare and environmental effects of the substance, including but not limited to its mobility in the subsurface, environmental fate, the risks considered when the standard was adopted and whether it is carcinogenic, mutagenic, teratogenic or has interactive effects with other substances.

4. Probability that a preventive action limit or an enforcement standard may be attained or exceeded outside the design management zone. In evaluating the probability that a preventive action limit or an enforcement standard may be attained or exceeded outside the design management zone, the department shall consider, at a minimum, geologic conditions, groundwater flow rate and direction, contaminant mobility in the subsurface and environmental fate.

5. Performance of the facility, practice or activity. The department shall consider whether the facility, practice or activity is performing as designed in accordance with the design requirements in s. NR 140.22 (1). The department shall consider the type, age and size of the facility, practice or activity; the type of design, if applicable; the operational history; and other factors related to performance of the facility, practice or activity as appropriate.

6. Location of the monitoring point. The department shall consider the location of the monitoring point in relation to the facility, practice or activity and the design management zone in assessing the appropriate response.

7. Other known or suspected sources of the substance in the area. If other known or suspected sources are present in the vicinity of a facility, practice or activity of concern, the department shall evaluate the probability of contributions from other sources of the substance. The department shall consider, at a minimum, the number, size, type and age of nearby sources; the groundwater flow patterns; and the substances involved.

8. Hydrogeologic conditions. The department shall consider the geologic and groundwater conditions, including but not limited to the nature, thickness and permeability of the unconsolidated materials; the nature and permeability of bedrock; the depth

to the water table; groundwater flow gradients, both vertical and horizontal; the position of the facility, practice or activity within the groundwater flow system; and the present and potential groundwater use in the vicinity of the facility, practice or activity at which an exceedance occurs. If there is insufficient hydrogeologic information, the department may require additional information.

9. Extent of groundwater contamination. The department shall consider the current and anticipated future extent of groundwater contamination in 3 dimensions. If water supplies are affected or threatened, the department shall evaluate the existing effects and potential risks of the substance on the potable water supplies. If the extent of contamination is not known, the department may require further documentation of the extent of contamination.

10. Alternate responses. The department shall evaluate alternate responses, including consideration of the technical and economic feasibility of alternate responses from Table 5 or 6 or both, the practicality of stopping the further release of the substance and the risks and benefits of continued operation of the facility, practice or activity and the ability of a response to meet other applicable environmental protection laws.

(2) RESPONSE OBJECTIVES. Based on its evaluation of the report required under sub. (1), and the assessment criteria of sub. (1) (c), the department shall specify the responses to be implemented by the owner or operator of the facility, practice or activity designed to the extent technically and economically feasible to prevent any new releases of the substance from traveling beyond the design management zone or other applicable points of standards application described in s. NR 140.22 and restore contaminated groundwater within a reasonable period of time, considering the criteria specified in s. NR 722.07. Both the source control and the groundwater restoration components of the response shall be designed and implemented to:

(a) Minimize the concentration of the substance in groundwater at the point of standards application where technically and economically feasible;

(b) Regain and maintain compliance with the preventive action limit. If the department determines that compliance with the preventive action limit is either not technically or economically feasible, the owner or operator shall achieve compliance with the lowest possible concentration which is technically and economically feasible; and

(c) Ensure that the enforcement standard is not attained or exceeded at the point of standards application.

(3) RANGE OF RESPONSES FOR INDICATOR PARAMETERS. Except as otherwise provided in this subsection, the range of responses which the department may take or may require if a preventive action limit for an indicator parameter identified in Table 3 has been attained or exceeded, is one or more of the responses in items 1 to 4 in Table 5. The range of responses is one or more of the responses in items 1 to 6 of Table 5 in the event the department determines that:

(a) There is a threat to public health or welfare as a result of a preventive action limit for an indicator parameter being attained or exceeded; or

(b) The results demonstrate a significant design flaw or failure of the facility to contain substances, such that the facility can be expected to emit one or more of the substances on Table 1 or 2 in excess of a preventive action limit at a point of standards application.

(4) RANGE OF RESPONSES FOR SUBSTANCES OF PUBLIC HEALTH OR WELFARE CONCERN. The range of responses which the department may take or may require the owner or operator of a facility, practice or activity to take if a preventive action limit for a substance of health or welfare concern has been attained or exceeded are listed in Table 5. More than one response may be taken or required by the department.

Table 5

Range of Responses for Exceedances of a Preventive Action Limit for Indicator Parameters and Substances of Health or Welfare Concern

1. No action pursuant to s. NR 140.24 (5) and consistent with s. 160.23, Stats.
2. Require the installation and sampling of groundwater monitoring wells.
3. Require a change in the monitoring program, including increased monitoring.
4. Require an investigation of the extent of groundwater contamination.
5. Require a revision of the operational procedures at the facility, practice or activity.
6. Require a change in the design or construction of the facility, practice or activity.
7. Require an alternate method of waste treatment or disposal.
8. Require prohibition or closure and abandonment of a facility, practice or activity in accordance with sub. (6).
9. Require remedial action to renovate or restore groundwater quality.
10. Require remedial action to prevent or minimize the further discharge or release of the substance to groundwater.
11. Revise rules or criteria on facility design, location or management practices.
12. Require the collection and evaluation of data to determine whether natural attenuation can be effective to restore groundwater quality within a reasonable period of time, considering applicable criteria specified in ss. NR 140.24, 722.07 and 722.09 or 722.11, and require monitoring to determine whether or not natural attenuation is occurring in compliance with the response objectives in s. NR 140.24 (2).

(5) NO ACTION RESPONSE CRITERIA. For facilities, practices and activities with a design management zone specified in s. NR 140.22 (3) Table 4, the department may determine that no response is necessary and that an exemption under s. NR 140.28 is not required when either of the following conditions is met:

(a) The concentration of a substance within a design management zone is detected above the preventive action limit, the enforcement standard has not been attained or exceeded within the design management zone, and the department determines that there is no indication that the preventive action limit will be attained or exceeded at any point outside the design management zone, or

(b) The background concentration of a substance is greater than the preventive action limit, the anticipated or detected incremental increase in the concentration of a substance which results from a specific facility, practice or activity is not greater than the preventive action limit, and the anticipated or detected concentration is not greater than the enforcement standard either within or outside of the design management zone.

(6) PROHIBITION AND CLOSURE CRITERIA. The department may not impose a prohibition on a practice or activity or require closure of a facility which produces the substance unless the department:

(a) Bases its decision upon reliable test data;

(b) Determines, to a reasonable certainty, by the greater weight of the credible evidence, that no other remedial action would prevent the violation of the enforcement standard at the point of standards application;

(c) Establishes the basis for the boundary and duration of the prohibition; and

(d) Ensures that any prohibition imposed shall be reasonably related in time and scope to maintaining compliance with the enforcement standard at the point of standards application.

History: Cr. Register, September, 1985, No. 357, eff. 10–1–85; am. (5) (intro.) and (6) (intro.), Register, October, 1988, No. 394, eff. 11–1–88; am. (1) (intro.), (a), (b), (c) (intro.), 5. and 10., (2) (intro.), and (5) (intro.), renum. (7) to be NR 104.02 (4), Register, January, 1992, No. 433, eff. 2–1–92; am. (1) (intro.), (c) (intro.), (3) (intro.) and Table 5, Register, March, 1994, No. 459, eff. 4–1–94; am. (1) (a), (5) (intro.), Register, August, 1995, No. 476, eff. 9–1–95; am. (2) (intro.), (4) and Table 5, Register, October, 1996, No. 490, eff. 11–1–96; am. (1) (a), Register, December, 1998, No. 516, eff. 1–1–99.

NR 140.26 Responses when an enforcement standard is attained or exceeded. (1) NOTIFICATION AND ASSESSMENT. If the concentration of a substance in groundwater attains or exceeds an enforcement standard at a point of standards application as described in s. NR 140.22 (2):

(a) The owner or operator of the facility, practice or activity shall notify the department in writing when monitoring data is submitted that an enforcement standard has been attained or exceeded in accordance with any deadlines in applicable statutes, rules, permits or plan approvals. Where no deadlines are imposed, the owner or operator shall notify the department as soon as practical after the results are received. When the results of any private well sampling attain or exceed an enforcement standard or preventive action limit, the owner or operator of the facility, practice or activity shall notify the department within 10 days after the results are received. The notification shall provide a preliminary analysis of the cause and significance of the concentration.

Note: Section 292.11 (2) (a), Stats., requires that the department be notified immediately of hazardous substance discharges.

Note: See s. NR 140.27.

(b) Upon receipt of the notice under par. (a), the department shall evaluate the information and, if further information is required to make the assessment under par. (c), direct the owner or operator to prepare and submit a report by a specified deadline. The report shall assess the cause and significance of the increased concentration based on a consideration of the factors identified in s. NR 140.24 (1) (c) and shall propose a response to achieve compliance with the enforcement standard at the point of standards application and to comply with sub. (4).

(c) The department shall assess the cause and significance of the concentration of the substance in determining the appropriate response measures to achieve compliance with the enforcement standard at the point of standards application and to comply with sub. (4). In addition to all other relevant information, the department shall consider the information submitted under sub. (1) and the factors listed in s. NR 140.24 (1) (c), where applicable.

(2) REGULATORY RESPONSES. (a) If a facility, activity or practice is regulated under subch. IV of ch. 283, Stats., ch. 289, 291, or 292, Stats., the department shall require responses as necessary, based on the evaluation of the increased concentration as outlined in sub. (1), to prevent any new releases of the substance from traveling beyond the design management zone or other applicable point of standards application described in s. NR 140.22 and restore contaminated groundwater within a reasonable period of time, considering the criteria specified in s. NR 722.07. Both the source control and the groundwater restoration components of the response shall be designed to achieve compliance with the enforcement standard at the point of standards application and to achieve compliance with the preventive action limit at the point of standards application unless compliance with the preventive action limit is not technically and economically feasible. The range of responses which the department may take or may require the owner or operator of a facility, practice or activity to take if an enforcement standard for a substance of public health or welfare concern has been attained or exceeded at a point of standards application is listed in Table 6. More than one response listed in Table 6 may be required by the department. In addition, the department may take or may require the owner or operator of a facility, practice or activity to take one or more responses from Table 5, except response number one.

Table 6

Range of Responses for Exceedance of Enforcement Standards for Substances of Health or Welfare Concern

1. Require a revision of the operational procedures at a facility, practice or activity.
2. Require a change in the design or construction of the facility, practice or activity.
3. Require an alternate method of waste treatment or disposal.
4. Require prohibition or closure and abandonment of a facility, practice or activity.
5. Require remedial action to renovate or restore groundwater quality.
6. Require remedial action to prevent or minimize the further release of the substance to groundwater.
7. Revise rules or criteria on facility design, location or management practices.
8. Require the collection and evaluation of data to determine whether natural attenuation can be effective to restore groundwater quality within a reasonable period of time, considering applicable criteria specified in ss. NR 140.24, 722.07 and 722.09 or 722.11, and require monitoring to determine whether or not natural attenuation is occurring in compliance with the requirements of s. NR 140.26 (2) (a).

(b) If an activity or practice is not subject to regulation under subch. IV of ch. 283, Stats., ch. 289, 291, or 292, Stats., and if the concentration of a substance in groundwater attains or exceeds an enforcement standard at a point of standards application, the department shall take the following responses unless it can be shown to the department that, to a reasonable certainty, by the greater weight of the credible evidence, an alternative response will achieve compliance with the enforcement standard at the point of standards application:

1. Prohibit the activity or practice which uses or produces the substance; and

2. Require remedial actions with respect to the specific site in accordance with this chapter.

(3) RESPONSES FOR NITRATE AND SUBSTANCES OF PUBLIC WELFARE CONCERN. If nitrates or any substance of welfare concern only attains or exceeds an enforcement standard, the department is not required to impose a prohibition or close a facility if it determines that:

(a) The enforcement standard was attained or exceeded, in whole or in part, because of high background concentrations of the substance; and

(b) The additional concentration does not represent a public welfare concern.

(4) COMPLIANCE WITH PREVENTIVE ACTION LIMITS. When compliance with the enforcement standard is achieved at the point of standards application, s. NR 140.24 applies.

History: Cr. Register, September, 1985, No. 357, eff. 10–1–85; am. (1) (intro.), (a), (b), (2), r. (6), Register, January, 1992, No. 433, eff. 2–1–92; am. (1) (intro.) and Table 6, renum. (2) to (5) to be (2) (a), (b), (3) and (4), Register, March, 1994, No. 459, eff. 4–1–94; am. (1) (a), Register, August, 1995, No. 476, eff. 9–1–95; correction in (1) (b) and (c) made under s. 13.93 (2m) (b) 7., Stats., Register, August, 1995, No. 476; am. (2) (a) and Table 6, Register, October, 1996, No. 490, eff. 11–1–96; am. (1) (a), Register, December, 1998, No. 516, eff. 1–1–99; **correction in (2) (a), (b) (intro.) made under s. 13.92 (4) (b) 7., Stats., Register February 2017 No. 734.**

NR 140.27 Responses when an enforcement standard is attained or exceeded at a location other than a point of standards application. If the concentration of a substance in groundwater attains or exceeds an enforcement standard at a location other than a point of standards application for an enforcement standard, s. NR 140.24 shall apply.

History: Cr. Register, October, 1988, No. 394, eff. 11–1–88.

NR 140.28 Exemptions. (1) APPLICABILITY. (a) The department may not approve a proposed facility, practice or activity at a location where a preventive action limit or enforcement standard adopted under s. NR 140.10 or 140.12 has been attained or exceeded unless an exemption has been granted under this section.

(b) For an existing facility, practice or activity, a response is required under s. NR 140.24 (2) or 140.26 (2) when a preventive action limit or an enforcement standard has been attained or exceeded at a point of standards application unless an exemption has been granted under this section or the criteria of s. NR 140.24 (5) (a) or (b) are met.

(c) For an existing facility, practice or activity that has taken or is taking a response under s. NR 140.24 (2) or 140.26 (2), a continued response is required unless a substance no longer attains or exceeds a preventive action limit or an exemption has been granted under this section.

(d) If a substance or remedial material is to be infiltrated or injected into groundwater at a concentration which attains or exceeds a preventive action limit, or at any concentration for a substance or remedial material for which a groundwater quality standard has not been established under this chapter, a temporary exemption is required under sub. (5).

(2) CRITERIA FOR GRANTING EXEMPTIONS WHERE THE BACKGROUND CONCENTRATION IS BELOW THE PREVENTIVE ACTION LIMIT. (a) The department may grant an exemption under this section to a facility, practice or activity which is regulated by the department in an area where the background concentration of nitrate or a substance of public welfare concern is below the preventive action limit if the facility, practice or activity is designed and implemented to achieve the lowest possible concentration for that substance which is technically and economically feasible and the existing or anticipated increase in the concentration of that substance does not present a threat to public health or welfare.

(b) The department may grant an exemption under this section to a facility, practice or activity which is regulated by the department in an area where the background concentration of a substance of public health concern, other than nitrate, is below the preventive action limit for that substance if all of the following occur:

1. The measured or anticipated increase in the concentration of the substance will be minimized to the extent technically and economically feasible.

2. Compliance with the preventive action limit is either not technically or economically feasible.

3. The enforcement standard for that substance will not be attained or exceeded at the point of standards application.

4. Any existing or projected increase in the concentration of the substance above the background concentration does not present a threat to public health or welfare.

Note: An exemption may be considered under this subsection even if monitoring data indicates no detectable background concentration of the substance.

(3) CRITERIA FOR GRANTING EXEMPTIONS WHERE THE BACKGROUND CONCENTRATION IS ABOVE A PREVENTIVE ACTION LIMIT. (a) The department may grant an exemption under this section to a facility, practice or activity which is regulated by the department in an area where the background concentration of nitrate or a substance of public welfare concern attains or exceeds the preventive action limit if the facility, practice or activity is designed to achieve the lowest possible concentration for that substance which is technically and economically feasible and the existing or anticipated increase in the concentration of the substance does not present a threat to public health or welfare.

(b) The department may grant an exemption under this section to a facility, practice or activity which is regulated by the department in an area where the background concentration of a substance of public health concern, other than nitrate, attains or exceeds a preventive action limit for that substance:

1. If the facility, practice or activity has not caused and will not cause the further release of that substance into the environment; or

2. If the background concentration of the substance does not exceed the enforcement standard for that substance, the facility, practice or activity has not caused and will not cause the concentration of the substance to exceed the enforcement standard for that substance at a point of standards application and the facility, practice or activity is designed to achieve the lowest possible concentration of that substance which is technically and economically feasible.

(4) CRITERIA FOR GRANTING EXEMPTIONS WHERE THE BACKGROUND CONCENTRATION IS ABOVE AN ENFORCEMENT STANDARD. (a) The department may grant an exemption under this section to a facility, practice or activity which is regulated by the department in an area where the background concentration of nitrate or a substance of public welfare concern attains or exceeds an enforcement standard if the facility, practice or activity is designed to achieve the lowest possible concentration for that substance which is technically and economically feasible and the existing or anticipated increase in the concentration of the substance does not present a threat to public health or welfare.

(b) The department may grant an exemption under this section to a facility, practice or activity which is regulated by the department in an area where the background concentration of a substance of public health concern, other than nitrate, attains or exceeds the enforcement standard for that substance if:

1. The facility has not caused and will not cause the further release of that substance into the environment; or

2. a. The facility is designed to achieve the lowest possible concentration of that substance which is technically and economically feasible; and

b. The existing or anticipated increase in the concentration of the substance has not caused or will not cause an increased threat to public health or welfare; and

c. The existing or anticipated incremental increase in the concentration of the substance by itself, has not exceeded or will not exceed the preventive action limit.

(c) The department shall take action under s. NR 140.26 if it determines that the increase in the concentration of the substance causes an increased threat to public health or welfare or it determines that the incremental increase in the concentration of the substance, by itself, exceeds the preventive action limit.

(5) CRITERIA FOR GRANTING A TEMPORARY EXEMPTION WHERE INFILTRATION OR INJECTION IS UTILIZED FOR A REMEDIAL ACTION. (a) *General.* In lieu of an exemption granted in compliance with the criteria in subs. (2) to (4), the department may grant a temporary exemption if the criteria in this subsection are complied with. This exemption applies to the owner or operator of a facility, practice or activity that is undertaking a remedial action that: includes the infiltration or injection of contaminated groundwater or remedial material, has been approved by the department, and will comply with the applicable response objectives under s. NR 140.24 or 140.26 within a reasonable period of time. The owner or operator of the facility, practice or activity may submit a temporary exemption request to the department at the same time or after the department has approved the remedial action.

(b) *Exemption request.* The owner or operator of the facility, practice or activity shall submit a request for a temporary exemption to the department. As part of the request, the applicant shall indicate how the exemption prerequisites under par. (c) and applicable remedial design, operational and monitoring criteria under par. (d) will be met.

Note: For most remedial actions, a microcosm or treatability study, or other bench scale or pilot scale study will be required by the department prior to consideration of an exemption for the full−scale remedial action under this section. If a pilot scale study is deemed necessary before an exemption for a full−scale remedial action can be granted, a separate temporary exemption issued under this section is required before the pilot scale study can begin.

(c) *Exemption prerequisites.* As part of the temporary exemption request, the owner or operator shall demonstrate to the satisfaction of the department that all of the following requirements will be met:

1. The remedial action for restoring contaminated soil or groundwater, and any infiltrated or injected contaminated water and remedial material, shall achieve the applicable response objectives required by s. NR 140.24 (2) or 140.26 (2) within a reasonable period of time.

2. The type, concentration and volume of substances or remedial material to be infiltrated or injected shall be minimized to the extent that is necessary for restoration of the contaminated soil or groundwater and be approved by the department prior to use.

3. Any infiltration or injection of contaminated water or remedial material into soil or groundwater will not significantly increase the threat to public health or welfare.

4. No uncontaminated or contaminated water, substance or remedial material will be infiltrated or injected into an area where a floating non−aqueous phase liquid is present in the contaminated soil or groundwater.

5. There will be no expansion of soil or groundwater contamination, or migration of any infiltrated or injected contaminated water or remedial material, beyond the edges of previously contaminated areas, except that infiltration or injection into previously uncontaminated areas may be allowed if the department determines that expansion into adjacent, previously uncontaminated areas is necessary for the restoration of the contaminated soil or groundwater, and the requirements of subd. 1. will be met.

6. All necessary federal, state and local licenses, permits and other approvals are obtained and all applicable environmental protection requirements will be complied with.

Note: The issuance of a wastewater discharge permit by the department is required prior to the infiltration or injection of substances or remedial material into unsaturated soil or groundwater for discharges, as defined by s. 283.01 (4), Stats. A wastewater discharge permit establishes the effluent or injection limits for substances or remedial material which may be infiltrated or injected into unsaturated soil or groundwater. A temporary exemption granted under this subsection applies to substances or remedial material which may enter groundwater or may be detected at a point of standards applications; it does not apply to substances or remedial material infiltrated or injected into unsaturated soil.

(d) *Remedial action design, operation and monitoring criteria.* In addition to providing information on how the requirements under par. (c) will be met, the application shall specify the following information where applicable.

1. The remedial action design, operation and soil and groundwater monitoring procedures to insure compliance with the requirements under par. (c) and applicable criteria under this paragraph.

2. The level of pre−treatment for contaminated groundwater prior to reinfiltration or reinjection.

3. The types and concentrations of substances or remedial material being proposed for infiltration or injection.

4. The volume and rate of infiltration or injection of contaminated groundwater or remedial material.

5. The location where the contaminated groundwater or remedial material will be infiltrated or injected.

(e) *Granting an exemption.* The department may only grant a temporary exemption under this subsection at the same time or after the department has approved the remedial action. When the department grants an exemption under this subsection, it shall follow the exemption procedures included in sub. (6) and shall require the owner or operator of the facility, practice or activity to comply with the requirements and criteria in pars. (c) and (d). The temporary exemption shall also include:

1. The expiration date of the temporary exemption. The expiration date shall be selected to achieve the applicable response objectives required by s. NR 140.24 (2) or 140.26 (2) within a reasonable period of time, not to exceed 5 years from the effective date of the exemption. The temporary exemption may be reissued following a department review of information documenting the performance of the remedial action and a successful demonstration that reissuance of the exemption is necessary to achieve the response objectives required by s. NR 140.24 (2) or 140.26 (2).necessary relating to the temporary exemption.

(f) *Responses to exemption violations.* If the department determines that the conditions or requirements specified in the temporary exemption are not being met, the department may:

1. Require that the owner or operator of the facility, practice or activity revise the remedial action design, operation or monitoring procedures in accordance with par. (d). All revisions shall comply with the requirements established under pars. (c) and (e) and may require approval from the department prior to implementation.

2. Revoke the exemption and require implementation of an alternate remedial action to restore soil or groundwater quality.

(6) EXEMPTION PROCEDURES. If the department grants an exemption under this section for a substance or a remedial material, it shall specify:

(a) The substance or remedial material to which the exemption applies;

(b) The terms and conditions of the exemption, which may include an alternative concentration limit, under which the department may seek a response under s. NR 140.24 or 140.26 relating to the substance or remedial material; and

(c) Any other conditions relating to the exemption.

History: Cr. Register, September, 1985, No. 357, eff. 10−1−85; am. (1) (a) and (b), (3) (a), (b) (intro.) and 2., (4) (a) and (b) 1. and (5) (b), Register, October, 1988, No. 394, eff. 11−1−88; am. (1) (b), Register, January, 1992, No. 433, eff. 2−1−92; correction in (4) (b) made under s. 13.93 (2m) (b) 1., Stats., Register, January, 1992, No. 433; am. (1) (b) and (5) (b), Register, March, 1994, No. 459, eff. 4−1−94; renum. (5) to be (6), cr. (5), Register, August, 1995, No. 476, eff. 9−1−95; cr. (1) (c), (d), am. (2) (intro.), (5) (a), (6) (intro.), (a) and (b), Register, December, 1998, No. 516, eff. 1−1−99; r. and recr. (2), Register, March, 2000, No. 531, eff. 4−1−00.

CHAPTER NR 140
APPENDIX I TO TABLE 1
PUBLIC HEALTH GROUNDWATER QUALITY STANDARDS

Substance	**CAS RN[1]**	**Common synonyms/*Tradename*[2]**
Acetochlor	34256−82−1	*Cadence, Degree, Harness, Keystone, Overtime, Volley*
Acetochlor ethane sulfonic acid + oxanilic acid	187022−11−3 (ESA) 184992−44−4 (OXA)	Acetochlor − ESA + OXA
Acetone	67−64−1	*Propanone*
Alachlor	15972−60−8	*Lasso*
Alachlor ethane sulfonic acid	142363−53−9	Alachlor−ESA, Alachlor Ethane Sulfonate, MON 5775
Aldicarb	116−06−3	*Temik*
Aluminum	7429−90−5	
Ammonia	7664−41−7	
Anthracene	120−12−7	Para−naphthalene
Asbestos	1332−21−4	
Bentazon	25057−89−0	*Basagran*
Benzene	71−43−2	
Benzo(b)fluoranthene	205−99−2	B(b)F,3,4−Benzofluoranthene
Benzo(a)pyrene	50−32−8	BaP, B(a)P
Boron	7440−42−8	
Bromodichloromethane	75−27−4	Dichlorobromomethane, BDCM
Bromoform	75−25−2	Tribromomethane
Bromomethane	74−83−9	Methyl bromide
Butylate	2008−41−5	S−ethyl di−isobutylthiocarbamate, *Sutan+*
Carbaryl	63−25−2	*Sevin*
Carbofuran	1563−66−2	*Furadan*
Carbon disulfide	75−15−0	Carbon bisulfide
Carbon tetrachloride	56−23−5	Tetrachloromethane, Perchloroethane
Chloramben	133−90−4	
Chlordane	57−74−9	
Chlorodifluoromethane	75−45−6	HCFC−22, Freon 22
Chloroethane	75−00−3	Ethyl chloride, Monochloroethane
Chloroform	67−66−3	Trichloromethane
Chlorpyrifos	2921−88−2	*Dursban, Lorsban, Warhawk, Hatchet, Yuma, Whirlwind, Eraser*
Chloromethane	74−87−3	Methyl chloride
Chromium (total)	7440−47−3	
Chrysene	218−01−9	1,2−Benzphenanthrene
Cobalt	7440−48−4	
Cyanazine	21725−46−2	*Bladex* , 2−chloro−4−ethylamino−6−nitriloisopropylamino−s−triazine
Cyanide, free	57−12−5	
Dacthal	1861−32−1	DPCA, Chlorothal, *Dacthalor*, 1,4−benzenedicarboxylic acid
Dibromochloromethane	124−48−1	Chlorodibromomethane, DBCM
1,2−Dibromo−3−chloropropane	96−12−8	DBCP, Dibromochloropropane
1,2−Dibromoethane	106−93−4	EDB, Ethylene dibromide, Dibromoethane
Dibutyl phthalate	84−74−2	DP, Di−*n*−butyl phthalate, *n*−Butyl phthalate
Dicamba	1918−00−9	*Banvel*
1,2−Dichlorobenzene	95−50−1	o−Dichlorobenzene, o−DCB
1,3−Dichlorobenzene	541−73−1	m−Dichlorobenzene, m−DCB
1,4−Dichlorobenzene	106−46−7	p−Dichlorobenzene, p−DCB
Dichlorodifluoromethane	75−71−8	*Freon 12*
1,1,−Dichloroethane	75−34−3	Ethylidine chloride
1,2−Dichloroethane	107−06−2	1,2−DCA, Ethylene dichloride

Substance	**CAS RN**[1]	**Common synonyms/*Tradename***[2]
1,1−Dichloroethylene	75−35−4	1,1−DCE, 1,1−Dichloroethene, Vinylidene chloride
1,2−Dichloroethylene (cis)	156−59−2	cis−Dichloroethylene, 1,2−Dichloroethene (cis)
1,2−Dichloroethylene (trans)	156−60−5	trans−1,2−Dichloroethylene
2,4−Dichlorophenoxyacetic acid	94−75−7	2,4−D
1,2−Dichloropropane	78−87−5	Propylene dichloride
1,3−Dichloropropene (cis/trans)[3]	542−75−6	*Telone,* DCP, Dichloropropylene
Di(2−ethylhexyl) phthalate	117−81−7	DEHP, Bis(2−ethylhexyl) phthalate, 1,2−Benzenedicarboxylic acid, Bis (2−ethylhexyl)ester
Dimethenamid/Dimethinamid−P	87674−68−8 163515−14−8 (−P)	*Frontier, Outlook, Propel, Establish, Sortie, Tower*
Dimethoate	60−51−5	
2,4−Dinitrotoluene	121−14−2	2,4−DNT, 1−methyl−2,4−dinitrobenzene
2,6−Dinitrotoluene	606−20−2	2,6−DNT, 2−methyl−1,3−dinitrobenzene
Dinitrotoluene, Total Residues	25321−14−6	Dinitrotoluene, DNT
Dinoseb	88−85−7	2−(1−methylpropyl)−4,6−dinitrophenol
1,4−Dioxane	123−91−1	*p*−Dioxane
Dioxin	1746−01−6	2,3,7,8−TCDD,2,3,7,8−Tetrachlorodibenzo−p−dioxin
Endrin	72−20−8	
EPTC	759−94−4	*Eptam, Eradicane*
Ethylbenzene	100−41−4	Phenylethane, EB
Ethyl ether	60−29−7	Diethyl Ether
Ethylene glycol	107−21−1	
Fluoranthene	206−44−0	Benzo(jk)fluorene
Fluorene	86−73−7	2,3−Benzidine, Diphenylenemethane
Fluoride	7681−49−4	
Fluorotrichloromethane	75−69−4	*Freon11*, Trichlorofluoromethane
Formaldehyde	50−00−0	
Heptachlor	76−44−8	*Velsicol*
Heptachlor epoxide	1024−57−3	
Hexachlorobenzene	118−74−1	Perchlorobenzene, *Granox*
N−Hexane	110−54−3	Hexane, Skellysolve B
Hydrogen sulfide	7783−06−4	Dihydrogen sulfide
Lindane	58−89−9	
Manganese	7439−96−5	
Mercury	7439−97−6	
Methanol	67−56−1	Methyl alcohol, Wood alcohol
Methoxychlor	72−43−5	
Methylene chloride	75−09−2	Dichloromethane, Methylene dichloride
Methyl ethyl ketone	78−93−3	MEK, 2−Butanone
Methyl isobutyl ketone	108−10−1	MIBK, 4−Methyl−2−pentanone, Isopropylacetone, *Hexone*
Methyl tert−butyl ether	1634−04−4	MTBE, 2−Methoxy−2−methyl−propane, tert−Butyl methyl ether
Metolachlor/s−Metolachlor	51218−45−2 87392−12−9 (s−)	*Dual, Bicep, Milocep, Stalwart, Parallel, Prefix, Charger, Brawl, Cinch, Dual Magnum, Boundary*
Metolachlor ethane sulfonic acid + oxanilic acid	171118−09−5 (ESA) 152019−73−3 (OXA)	Metolachlor − ESA + OXA
Metribuzin	21087−64−9	Sencor, Lexone
Molybdenum	7439−98−7	
Monochlorobenzene	108−90−7	Chlorobenzene
Naphthalene	91−20−3	

Substance	**CAS RN[1]**	**Common synonyms/*Tradename*[2]**
N−Nitrosodiphenylamine	86−30−6	NDPA
Pentachlorophenol	87−86−5	PCP, Pentachlorohydroxybenzene
Perchlorate	14797−73−0	Perchlorate and perchlorate salts, Perchlorate ion
Phenol	108−95−2	
Picloram	1918−02−1	*Tordon*, 4−amino−3,5,6−trichloropicolinic acid
Polychlorinated biphenyls[4]		PCBs
Prometon	1610−18−0	*Pramitol, Prometone*
Pyrene	129−00−0	Benzo(def)phenanthrene
Pyridine	110−86−1	Azabenzene
Simazine	122−34−9	*Princep,* 2−chloro−4,6−diethylamino− s−triazine
Styrene	100−42−5	Ethenylbenzene, Vinylbenzene
Tertiary Butyl Alcohol	75−65−0	TBA
1,1,1,2−Tetrachlorethane	630−20−6	1,1,1,2−TCA, 1,1,1,2−PCA
1,1,2,2,−Tetrachloroethane	79−34−5	1,1,2,2−TCA, 1,1,2,2−PCA
Tetrachloroethylene	127−18−4	Perchloroethylene, PERC, Tetrachloroethene
Tetrahydrofuran	109−99−9	THF
Toluene	108−88−3	Methylbenzene
Toxaphene	8001−35−2	
1,2,4−Trichlorobenzene	120−82−1	
1,1,1−Trichloroethane	71−55−6	Methyl chloroform, 1,1,1−TCA
1,1,2−Trichloroethane	79−00−5	1,1,2−TCA, Vinyl trichloride
Trichloroethylene	79−01−6	TCE, Chloroethene
2,4,5−Trichlorophenoxy−propionic acid	93−72−1	2,4,5−TP,*Silvex*
1,2,3−Trichloropropane	96−18−4	1,2,3−TCP, Glycerol trichlorohyrin
Trifluralin	1582−09−8	*Treflan*
1,2,4−Trimethylbenzene	95−63−6	
1,3,5−Trimethylbenzene	108−67−8	
Vanadium	7440−62−2	
Vinyl chloride	75−01−4	VC, Chloroethene
Xylene[5]		

---

[1] Chemical Abstracts Service (CAS) registry numbers are unique numbers assigned to a chemical substance. The CAS registry numbers were published by the U.S. Environmental Protection Agency in 40 CFR Part 264, Appendix IV

[2] Common synonyms include those widely used in government regulations, scientific publications, commerce and the general public. A trade name, also known as the proprietary name, is the specific, registered name given by a manufacturer to a product. Trade names are listed in *italics*. Common synonyms and trade names should be cross−referenced with CAS registry number to ensure the correct substance is identified.

[3] This is a combined chemical substance which includes cis 1,3−Dichloropropene (CAS RN 10061−01−5) and trans 1,3−Dichloropropene (CAS RN 10061−02−6).

[4] Polychlorinated biphenyls (CAS RN 1336−36−3); this category contains congener chemicals (same molecular composition, different molecular structure and formula), including constituents of Aroclor−1016 (CAS RN12674−11−2), Aroclor−1221 (CAS RN 11104−28−2), Aroclor−1232 (CAS RN 11141−16−5), Aroclor−1242 (CAS RN 53469−21−9), Aroclor−1248 (CAS RN 12672−29−6), Aroclor−1254 (CAS RN 11097−69−1), and Aroclor−1260 (CAS RN 11096−82−5).

[5] Xylene (CAS RN 1330−20−7) refers to a mixture of three isomers, meta−xylene (CAS RN 108−38−3), ortho−xylene (CAS RN 95−47−6), and para−xylene (CAS RN 106−42−3)

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	muta-gen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				1.2E-03	O					-0.85	1	1	Yes	Acephate	30560-19-1					2.4E+00	3.4E+03		2.4E+00	
		2.2E-06	I			9.0E-03	I	V		-0.34	1	1	Yes	Acetaldehyde	75-07-0			2.6E+00	2.6E+00			1.9E+00	1.9E+00	
				2.0E-02	I					3.03	1	0.9	Yes	Acetochlor	34256-82-1					4.0E+01	2.9E+02		3.5E+01	
				9.0E-01	I	3.1E+01	A	V		-0.24	1	1	Yes	Acetone	67-64-1					1.8E+03	4.4E+05	6.4E+03	1.4E+03	
						2.0E-03	X			-0.03	1	1	Yes	Acetone Cyanohydrin	75-86-5									
						6.0E-02	I	V		-0.34	1	1	Yes	Acetonitrile	75-05-8							1.3E+01	1.3E+01	
				1.0E-01	I			V		1.58	1	1	Yes	Acetophenone	98-86-2					2.0E+02	4.6E+03		1.9E+02	
3.8E+00	C	1.3E-03	C							3.12	1	1	Yes	Acetylaminofluorene, 2-	53-96-3	2.1E-02	6.7E-02		1.6E-02					
				5.0E-04	I	2.0E-05	I	V		-0.01	1	1	Yes	Acrolein	107-02-8					1.0E+00	1.7E+02	4.2E-03	4.2E-03	
5.0E-01	I	1.0E-04	I	2.0E-03	I	6.0E-03	I		M	-0.67	1	1	Yes	Acrylamide	79-06-1	5.0E-02	2.3E+01		5.0E-02	4.0E+00	2.1E+03		4.0E+00	
				5.0E-01	I	1.0E-03	I	V		0.35	1	1	Yes	Acrylic Acid	79-10-7					1.0E+03	1.1E+05	2.1E-01	2.1E-01	
5.4E-01	I	6.8E-05	I	4.0E-02	A	2.0E-03	I	V		0.25	1	1	Yes	Acrylonitrile	107-13-1	1.4E-01	1.4E+01	8.3E-02	5.2E-02	8.0E+01	8.9E+03	4.2E-01	4.1E-01	
						6.0E-03	P			-0.32	1	1	Yes	Adiponitrile	111-69-3									
5.6E-02	C			1.0E-02	I					3.52	1	0.9	Yes	Alachlor	15972-60-8	1.4E+00	4.4E+00		1.1E+00	2.0E+01	6.9E+01		1.6E+01	2.0E+00
				1.0E-03	I					1.13	1	1	Yes	Aldicarb	116-06-3					2.0E+00	1.4E+02		2.0E+00	3.0E+00
				1.0E-03	I					-0.57	1	1	Yes	Aldicarb Sulfone	1646-88-4					2.0E+00	2.4E+03		2.0E+00	2.0E+00
										-0.78	1	1	Yes	Aldicarb sulfoxide	1646-87-3									4.0E+00
1.7E+01	I	4.9E-03	I	3.0E-05	I			V		6.5	1	1	No	Aldrin	309-00-2	4.6E-03		1.1E-03	9.2E-04	6.0E-02			6.0E-02	
				5.0E-03	I	1.0E-04	X	V		0.17	1	1	Yes	Allyl Alcohol	107-18-6					1.0E+01	1.3E+03	2.1E-02	2.1E-02	
2.1E-02	C	6.0E-06	C			1.0E-03	I	V		1.93	1	1	Yes	Allyl Chloride	107-05-1	3.7E+00	3.5E+01	9.4E-01	7.3E-01			2.1E-01	2.1E-01	
				1.0E+00	P	5.0E-03	P				1	1	Yes	Aluminum	7429-90-5					2.0E+03	4.6E+05		2.0E+03	
				4.0E-04	I						1	1	Yes	Aluminum Phosphide	20859-73-8					8.0E-01	1.8E+02		8.0E-01	
				9.0E-03	I					2.98	1	1	Yes	Ametryn	834-12-8					1.8E+01	9.8E+01		1.5E+01	
2.1E+01	C	6.0E-03	C							2.86	1	1	Yes	Aminobiphenyl, 4-	92-67-1	3.7E-03	1.5E-02		3.0E-03					
				8.0E-02	P					0.21	1	1	Yes	Aminophenol, m-	591-27-5					1.6E+02	2.8E+04		1.6E+02	
				4.0E-03	X					0.62	1	1	Yes	Aminophenol, o-	95-55-6					8.0E+00	7.5E+02		7.9E+00	
				2.0E-02	P					0.04	1	1	Yes	Aminophenol, p-	123-30-8					4.0E+01	9.1E+03		4.0E+01	
				2.5E-03	I					5.5	1	0.9	Yes	Amitraz	33089-61-1					5.0E+00	9.8E-01		8.2E-01	
						5.0E-01	I	V		0.23	1	1		Ammonia	7664-41-7									
				2.0E-01	I						1	1	Yes	Ammonium Sulfamate	7773-06-0					4.0E+02	9.1E+04		4.0E+02	
						3.0E-03	X	V		0.89	1	1	Yes	Amyl Alcohol, tert-	75-85-4							6.3E-01	6.3E-01	
5.7E-03	I	1.6E-06	C	7.0E-03	P	1.0E-03	I			0.9	1	1	Yes	Aniline	62-53-3	1.4E+01	6.9E+02		1.3E+01	1.4E+01	7.7E+02		1.4E+01	
4.0E-02	P			2.0E-03	X					3.39	1	0.9	Yes	Anthraquinone, 9,10-	84-65-1	1.9E+00	5.1E+00		1.4E+00	4.0E+00	1.1E+01		3.0E+00	
				4.0E-04	I						0.15	1	Yes	Antimony (metallic)	7440-36-0					8.0E-01	2.7E+01		7.8E-01	6.0E+00
				5.0E-04	H						0.15	1	Yes	Antimony Pentoxide	1314-60-9					1.0E+00	3.4E+01		9.7E-01	
				4.0E-04	H						0.15	1	Yes	Antimony Tetroxide	1332-81-6					8.0E-01	2.7E+01		7.8E-01	
						2.0E-04	I				0.15	1	Yes	Antimony Trioxide	1309-64-4									
1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C				1	1	Yes	Arsenic, Inorganic	7440-38-2	5.2E-02	9.7E+00		5.2E-02	6.0E-01	1.4E+02		6.0E-01	1.0E+01
				3.5E-06	C	5.0E-05	I				1	1	Yes	Arsine	7784-42-1					7.0E-03	1.6E+00		7.0E-03	
				3.6E-02	O					-0.27	1	1	Yes	Asulam	3337-71-1					7.2E+01	5.8E+04		7.2E+01	
2.3E-01	C			3.5E-02	I					2.61	1	1	Yes	Atrazine	1912-24-9	3.4E-01	2.8E+00		3.0E-01	7.0E+01	6.2E+02		6.3E+01	3.0E+00
8.8E-01	C	2.5E-04	C							2.98	1	0.9	Yes	Auramine	492-80-8	8.9E-02	2.7E-01		6.7E-02					
				4.0E-04	I					4.48	1	1	No	Avermectin B1	65195-55-3					8.0E-01			8.0E-01	
				3.0E-03	A	1.0E-02	A			2.75	1	1	Yes	Azinphos-methyl	86-50-0					6.0E+00	8.3E+01		5.6E+00	
1.1E-01	I	3.1E-05	I					V		3.82	1	1	Yes	Azobenzene	103-33-3	7.1E-01	7.3E-01	1.8E-01	1.2E-01					
				1.0E+00	P	7.0E-06	P			-1.7	1	1	Yes	Azodicarbonamide	123-77-3					2.0E+03	6.8E+06		2.0E+03	
				2.0E-01	I	5.0E-04	H				0.07	1	Yes	Barium	7440-39-3					4.0E+02	6.4E+03		3.8E+02	2.0E+03
				5.0E-03	O			V		5.29	1	0.8	Yes	Benfluralin	1861-40-1					1.0E+01	4.0E+00		2.8E+00	
				5.0E-02	I					2.12	1	1	Yes	Benomyl	17804-35-2					1.0E+02	3.0E+03		9.7E+01	
				2.0E-01	I					2.18	1	1	Yes	Bensulfuron-methyl	83055-99-6					4.0E+02	2.4E+04		3.9E+02	
				3.0E-02	I					2.34	1	1	Yes	Bentazon	25057-89-0					6.0E+01	9.4E+02		5.7E+01	
4.0E-03	P			1.0E-01	I			V		1.48	1	1	Yes	Benzaldehyde	100-52-7	1.9E+01	4.4E+02		1.9E+01	2.0E+02	4.9E+03		1.9E+02	
5.5E-02	I	7.8E-06	I	4.0E-03	I	3.0E-02	I	V		2.13	1	1	Yes	Benzene	71-43-2	1.4E+00	9.8E+00	7.2E-01	4.6E-01	8.0E+00	6.1E+01	6.3E+00	3.3E+00	5.0E+00
1.0E-01	X			3.0E-04	X					-3.7267	1	1	No	Benzenediamine-2-methyl sulfate, 1,4-	6369-59-1	7.8E-01			7.8E-01	6.0E-01			6.0E-01	
				1.0E-03	P			V		2.52	1	1	Yes	Benzenethiol	108-98-5					2.0E+00	1.0E+01		1.7E+00	
2.3E+02	I	6.7E-02	I	3.0E-03	I				M	1.34	1	1	Yes	Benzidine	92-87-5	1.1E-04	5.0E-03		1.1E-04	6.0E+00	3.0E+02		5.9E+00	
				4.0E+00	I					1.87	1	1	Yes	Benzoic Acid	65-85-0					8.0E+03	1.2E+05		7.5E+03	
1.3E+01	I							V		3.9	1	1	Yes	Benzotrichloride	98-07-7	6.0E-03	6.0E-03		3.0E-03					
				1.0E-01	P					1.1	1	1	Yes	Benzyl Alcohol	100-51-6					2.0E+02	8.9E+03		2.0E+02	
1.7E-01	I	4.9E-05	C	2.0E-03	P	1.0E-03	P	V		2.3	1	1	Yes	Benzyl Chloride	100-44-7	4.6E-01	3.4E+00	1.1E-01	8.9E-02	4.0E+00	3.2E+01	2.1E-01	2.0E-01	
		2.4E-03	I	2.0E-03	I	2.0E-05	I				0.007	1	Yes	Beryllium and compounds	7440-41-7					4.0E+00	6.4E+00		2.5E+00	4.0E+00
				9.0E-03	P					4.48	1	0.9	Yes	Bifenox	42576-02-3					1.8E+01	2.3E+01		1.0E+01	
				1.5E-02	I					6	1	0	Yes	Biphenthrin	82657-04-3					3.0E+01			3.0E+01	
8.0E-03	I			5.0E-01	I	4.0E-04	X	V		4.01	1	1	Yes	Biphenyl, 1,1'-	92-52-4	9.7E+00	6.5E+00		3.9E+00	1.0E+03	7.3E+02	8.3E-02	8.3E-02	
				4.0E-02	I			V		2.48	1	1	Yes	Bis(2-chloro-1-methylethyl) ether	108-60-1					8.0E+01	6.5E+02		7.1E+01	
				3.0E-03	P					1.3	1	1	Yes	Bis(2-chloroethoxy)methane	111-91-1					6.0E+00	3.0E+02		5.9E+00	
1.1E+00	I	3.3E-04	I					V		1.29	1	1	Yes	Bis(2-chloroethyl)ether	111-44-4	7.1E-02	2.7E+00	1.7E-02	1.4E-02					

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
2.2E+02	I	6.2E-02	I					V		0.57	1	1	Yes	Bis(chloromethyl)ether	542-88-1	3.5E-04	3.4E-02	9.1E-05	7.2E-05					
				5.0E-02	I					3.32	1	1	Yes	Bisphenol A	80-05-7					1.0E+02	3.2E+02		7.7E+01	
				2.0E-01	I	2.0E-02	H				1	1	Yes	Boron And Borates Only	7440-42-8					4.0E+02	9.1E+04		4.0E+02	
				2.0E+00	P	2.0E-02	P	V		1.16	1	1	Yes	Boron Trichloride	10294-34-5					4.0E+03	9.1E+05	4.2E+00	4.2E+00	
				4.0E-02	C	1.3E-02	C	V		0.22	1	1	Yes	Boron Trifluoride	7637-07-2					8.0E+01	1.8E+04	2.7E+00	2.6E+00	
7.0E-01	I			4.0E-03	I						1	1	Yes	Bromate	15541-45-4	1.1E-01	2.1E+01		1.1E-01	8.0E+00	1.8E+03		8.0E+00	1.0E+01
2.0E+00	X	6.0E-04	X					V		1.92	1	1	Yes	Bromo-2-chloroethane, 1-	107-04-0	3.9E-02	5.7E-01	9.4E-03	7.4E-03					
				3.0E-04	X			V		2.92	1	1	Yes	Bromo-3-fluorobenzene, 1-	1073-06-9					6.0E-01	2.6E+00		4.9E-01	
				3.0E-04	X			V		3.08	1	1	Yes	Bromo-4-fluorobenzene, 1-	460-00-4					6.0E-01	2.0E+00		4.6E-01	
				8.0E-03	I	6.0E-02	I	V		2.99	1	1	Yes	Bromobenzene	108-86-1					1.6E+01	5.4E+01	1.3E+01	6.2E+00	
						4.0E-02	X	V		1.41	1	1	Yes	Bromochloromethane	74-97-5							8.3E+00	8.3E+00	
6.2E-02	I	3.7E-05	C	2.0E-02	I			V		2	1	1	Yes	Bromodichloromethane	75-27-4	1.3E+00	1.9E+01	1.5E-01	1.3E-01	4.0E+01	6.5E+02		3.8E+01	8.0E+01(F)
7.9E-03	I	1.1E-06	I	2.0E-02	I			V		2.4	1	1	Yes	Bromoform	75-25-2	9.9E+00	1.4E+02	5.1E+00	3.3E+00	4.0E+01	6.2E+02		3.8E+01	8.0E+01(F)
				1.4E-03	I	5.0E-03	I	V		1.19	1	1	Yes	Bromomethane	74-83-9					2.8E+00	1.0E+02	1.0E+00	7.5E-01	
				5.0E-03	H			V		5.21	1	0.8	Yes	Bromophos	2104-96-3					1.0E+01	5.5E+00		3.5E+00	
						1.0E-01	A	V		2.1	1	1	Yes	Bromopropane, 1-	106-94-5							2.1E+01	2.1E+01	
1.0E-01	O			1.5E-02	O					2.8	1	0.9	Yes	Bromoxynil	1689-84-5	7.6E-01	3.1E+00		6.1E-01	3.0E+01	1.3E+02		2.5E+01	
				1.5E-02	O			V		5.4	1	0.8	Yes	Bromoxynil Octanoate	1689-99-2					3.0E+01	1.6E+01		1.0E+01	
3.4E+00	C	3.0E-05	I			2.0E-03	I	V		1.99	1	1	Yes	Butadiene, 1,3-	106-99-0	2.3E-02	1.6E-01	1.9E-01	1.8E-02			4.2E-01	4.2E-01	
				3.0E-02	O					3.53	1	0.9	Yes	Butanoic acid, 4-(2,4-dichlorophenoxy)-	94-82-6					6.0E+01	1.8E+02		4.5E+01	
				1.0E-01	I			V		0.88	1	1	Yes	Butanol, N-	71-36-3					2.0E+02	1.0E+04		2.0E+02	
				2.0E+00	P	3.0E+01	P	V		0.61	1	1	Yes	Butyl alcohol, sec-	78-92-2					4.0E+03	3.0E+05	6.3E+03	2.4E+03	
				5.0E-02	I			V		4.15	1	1	Yes	Butylate	2008-41-5					1.0E+02	8.5E+01		4.6E+01	
2.0E-04	C	5.7E-08	C							3.5	1	0.8	Yes	Butylated hydroxyanisole	25013-16-5	3.9E+02	2.5E+02		1.5E+02					
3.6E-03	P			3.0E-01	P					5.1	1	1	Yes	Butylated hydroxytoluene	128-37-0	2.2E+01	4.0E+00		3.4E+00	6.0E+02	1.2E+02		1.0E+02	
				5.0E-02	P			V		4.38	1	1	No	Butylbenzene, n-	104-51-8					1.0E+02			1.0E+02	
				1.0E-01	X			V		4.57	1	1	No	Butylbenzene, sec-	135-98-8					2.0E+02			2.0E+02	
				1.0E-01	X			V		4.11	1	1	Yes	Butylbenzene, tert-	98-06-6					2.0E+02	1.1E+02		6.9E+01	
				2.0E-02	A					0.36	1	1	Yes	Cacodylic Acid	75-60-5					4.0E+01	6.7E+03		4.0E+01	
		1.8E-03	I	1.0E-03	I	1.0E-05	A				0.025	1		Cadmium (Diet)	7440-43-9									
		1.8E-03	I	5.0E-04	I	1.0E-05	A				0.05	1	Yes	Cadmium (Water)	7440-43-9					1.0E+00	1.1E+01		9.2E-01	5.0E+00
				5.0E-01	I	2.2E-03	C			-0.19	1	1	Yes	Caprolactam	105-60-2					1.0E+03	9.0E+04		9.9E+02	
1.5E-01	C	4.3E-05	C	2.0E-03	I					3.8	1	0.9	Yes	Captafol	2425-06-1	5.2E-01	1.8E+00		4.0E-01	4.0E+00	1.5E+01		3.2E+00	
2.3E-03	C	6.6E-07	C	1.3E-01	I					2.8	1	1	Yes	Captan	133-06-2	3.4E+01	3.6E+02		3.1E+01	2.6E+02	3.0E+03		2.4E+02	
				1.0E-01	I					2.36	1	1	Yes	Carbaryl	63-25-2					2.0E+02	2.4E+03		1.8E+02	
				5.0E-03	I					2.32	1	1	Yes	Carbofuran	1563-66-2					1.0E+01	1.4E+02		9.4E+00	4.0E+01
				1.0E-01	I	7.0E-01	I	V		1.94	1	1	Yes	Carbon Disulfide	75-15-0					2.0E+02	2.0E+03	1.5E+02	8.1E+01	
7.0E-02	I	6.0E-06	I	4.0E-03	I	1.0E-01	I	V		2.83	1	1	Yes	Carbon Tetrachloride	56-23-5	1.1E+00	4.3E+00	9.4E-01	4.6E-01	8.0E+00	3.4E+01	2.1E+01	4.9E+00	5.0E+00
						1.0E-01	P	V		-1.33	1	1	Yes	Carbonyl Sulfide	463-58-1							2.1E+01	2.1E+01	
				1.0E-02	I					5.57	1	0.8	Yes	Carbosulfan	55285-14-8					2.0E+01	6.9E+00		5.1E+00	
				1.0E-01	I					2.14	1	1	Yes	Carboxin	5234-68-4					2.0E+02	4.1E+03		1.9E+02	
						9.0E-04	I				1	1	Yes	Ceric oxide	1306-38-3									
				1.0E-01	I			V		0.99	1	1	Yes	Chloral Hydrate	302-17-0					2.0E+02	1.5E+04		2.0E+02	
				1.5E-02	I					1.9	1	1	Yes	Chloramben	133-90-4					3.0E+01	7.4E+02		2.9E+01	
4.0E-01	H									2.22	1	1	Yes	Chloranil	118-75-2	1.9E-01	3.5E+00		1.8E-01					
3.5E-01	I	1.0E-04	I	5.0E-04	I	7.0E-04	I	V		6.16	1	0.7	Yes	Chlordane	12789-03-6	2.2E-01	3.6E-02	5.6E-02	2.0E-02	1.0E+00	1.8E-01	1.5E-01	7.4E-02	2.0E+00
1.0E+01	I	4.6E-03	C	3.0E-04	I					5.41	1	0.8	Yes	Chlordecone (Kepone)	143-50-0	7.8E-03	6.5E-03		3.5E-03	6.0E-01	5.4E-01		2.9E-01	
				7.0E-04	A					3.81	1	0.9	Yes	Chlorfenvinphos	470-90-6					1.4E+00	5.6E+00		1.1E+00	
				9.0E-02	O					2.5	1	1	Yes	Chlorimuron, Ethyl-	90982-32-4					1.8E+02	6.8E+03		1.8E+02	
				1.0E-01	I	1.5E-04	A	V		0.85	1	1	Yes	Chlorine	7782-50-5					2.0E+02	4.6E+04	3.0E-02	3.0E-02	
				3.0E-02	I	2.0E-04	I	V			1	1	Yes	Chlorine Dioxide	10049-04-4					6.0E+01	1.4E+04	4.2E-02	4.2E-02	
				3.0E-02	I						1	1	Yes	Chlorite (Sodium Salt)	7758-19-2					6.0E+01	1.4E+04		6.0E+01	1.0E+03
						5.0E+01	I	V		2.05	1	1	Yes	Chloro-1,1-difluoroethane, 1-	75-68-3							1.0E+04	1.0E+04	
		3.0E-04	I	2.0E-02	H	2.0E-02	I	V		2.53	1	1	Yes	Chloro-1,3-butadiene, 2-	126-99-8			1.9E-02	1.9E-02	4.0E+01	1.8E+02	4.2E+00	3.7E+00	
4.6E-01	H									2.27	1	1	Yes	Chloro-2-methylaniline HCl, 4-	3165-93-3	1.7E-01	5.1E+02		1.7E-01					
1.0E-01	P	7.7E-05	C	3.0E-03	X					2.27	1	1	Yes	Chloro-2-methylaniline, 4-	95-69-2	7.8E-01	6.6E+00		7.0E-01	6.0E+00	5.6E+01		5.4E+00	
2.7E-01	X							V		0.09	1	1	Yes	Chloroacetaldehyde, 2-	107-20-0	2.9E-01	4.6E+01		2.9E-01					
										0.22	1	1	Yes	Chloroacetic Acid	79-11-8									6.0E+01
						3.0E-05	I			1.93	1	1	Yes	Chloroacetophenone, 2-	532-27-4									
2.0E-01	P			4.0E-03	I					1.83	1	1	Yes	Chloroaniline, p-	106-47-8	3.9E-01	5.9E+00		3.7E-01	8.0E+00	1.3E+02		7.6E+00	
				2.0E-02	I	5.0E-02	P	V		2.84	1	1	Yes	Chlorobenzene	108-90-7					4.0E+01	1.3E+02	1.0E+01	7.8E+00	1.0E+02
				1.0E-01	X					-0.52	1	1	Yes	Chlorobenzene sulfonic acid, p-	98-66-8					2.0E+02	1.8E+05		2.0E+02	
1.1E-01	C	3.1E-05	C	2.0E-02	I					4.74	1	0.8	Yes	Chlorobenzilate	510-15-6	7.1E-01	5.6E-01		3.1E-01	4.0E+01	3.5E+01		1.9E+01	
				3.0E-02	X					2.65	1	1	Yes	Chlorobenzoic Acid, p-	74-11-3					6.0E+01	3.4E+02		5.1E+01	
				3.0E-03	P	3.0E-01	P	V		3.6	1	1	Yes	Chlorobenzotrifluoride, 4-	98-56-6					6.0E+00	9.3E+00	6.3E+01	3.5E+00	
				4.0E-02	P			V		2.64	1	1	Yes	Chlorobutane, 1-	109-69-3					8.0E+01	3.1E+02		6.4E+01	
						5.0E+01	I	V		1.08	1	1	Yes	Chlorodifluoromethane	75-45-6							1.0E+04	1.0E+04	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				2.0E-02	P			V		0.03	1	1	Yes	Chloroethanol, 2-	107-07-3					4.0E+01	7.7E+03		4.0E+01	
3.1E-02	C	2.3E-05	I	1.0E-02	I	9.8E-02	A	V		1.97	1	1	Yes	Chloroform	67-66-3	2.5E+00	2.9E+01	2.4E-01	2.2E-01	2.0E+01	2.5E+02	2.0E+01	9.7E+00	8.0E+01(F)
						9.0E-02	I	V		0.91	1	1	Yes	Chloromethane	74-87-3							1.9E+01	1.9E+01	
2.4E+00	C	6.9E-04	C					V		0.32	1	1	Yes	Chloromethyl Methyl Ether	107-30-2	3.2E-02	3.7E+00	8.1E-03	6.5E-03					
3.0E-01	P			3.0E-03	P	1.0E-05	X			2.24	1	1	Yes	Chloronitrobenzene, o-	88-73-3	2.6E-01	2.6E+00		2.4E-01	6.0E+00	6.4E+01		5.5E+00	
6.0E-02	P			7.0E-04	P	2.0E-03	P			2.39	1	1	Yes	Chloronitrobenzene, p-	100-00-5	1.3E+00	1.0E+01		1.2E+00	1.4E+00	1.2E+01		1.3E+00	
				5.0E-03	I			V		2.15	1	1	Yes	Chlorophenol, 2-	95-57-8					1.0E+01	1.0E+02		9.1E+00	
						4.0E-04	C	V		2.09	1	1	Yes	Chloropicrin	76-06-2							8.3E-02	8.3E-02	
3.1E-03	C	8.9E-07	C	1.5E-02	I					3.05	1	0.9	Yes	Chlorothalonil	1897-45-6	2.5E+01	1.6E+02		2.2E+01	3.0E+01	2.1E+02		2.6E+01	
				2.0E-02	I			V		3.42	1	1	Yes	Chlorotoluene, o-	95-49-8					4.0E+01	5.8E+01		2.4E+01	
				2.0E-02	X			V		3.33	1	1	Yes	Chlorotoluene, p-	106-43-4					4.0E+01	6.6E+01		2.5E+01	
2.4E+02	C	6.9E-02	C							-1.02	1	1	Yes	Chlorozotocin	54749-90-5	3.2E-04	1.0E+00		3.2E-04					
				5.0E-02	O					3.51	1	0.9	Yes	Chlorpropham	101-21-3					1.0E+02	2.5E+02		7.1E+01	
				1.0E-03	A					4.96	1	0.8	Yes	Chlorpyrifos	2921-88-2					2.0E+00	1.5E+00		8.4E-01	
				1.0E-02	H					4.31	1	0.9	Yes	Chlorpyrifos Methyl	5598-13-0					2.0E+01	2.9E+01		1.2E+01	
				2.0E-02	O					2	1	1	Yes	Chlorsulfuron	64902-72-3					4.0E+01	2.3E+03		3.9E+01	
				1.0E-02	I					4.28	1	0.9	Yes	Chlorthal-dimethyl	1861-32-1					2.0E+01	3.3E+01		1.2E+01	
				8.0E-04	H					5.8	1	0.8	Yes	Chlorthiophos	60238-56-4					1.6E+00	3.4E-01		2.8E-01	
				1.5E+00	I						0.013	1	Yes	Chromium(III), Insoluble Salts	16065-83-1					3.0E+03	8.9E+03		2.2E+03	
5.0E-01	C	8.4E-02	S	3.0E-03	I	1.0E-04	I		M		0.025	1	Yes	Chromium(VI)	18540-29-9	5.0E-02	1.2E-01		3.5E-02	6.0E+00	1.7E+01		4.4E+00	
											0.013	1	Yes	Chromium, Total	7440-47-3									1.0E+02
				1.3E-02	I					3.1	1	0.9	Yes	Clofentezine	74115-24-5					2.6E+01	2.1E+02		2.3E+01	
		9.0E-03	P	3.0E-04	P	6.0E-06	P				1	1	Yes	Cobalt	7440-48-4					6.0E-01	3.4E+02		6.0E-01	
		6.2E-04	I					V	M		1	0		Coke Oven Emissions	8007-45-2									
				4.0E-02	H						1	1	Yes	Copper	7440-50-8					8.0E+01	1.8E+04		8.0E+01	1.3E+03
				5.0E-02	I	6.0E-01	C			1.96	1	1	Yes	Cresol, m-	108-39-4					1.0E+02	1.2E+03		9.3E+01	
				5.0E-02	I	6.0E-01	C			1.95	1	1	Yes	Cresol, o-	95-48-7					1.0E+02	1.2E+03		9.3E+01	
				1.0E-01	A	6.0E-01	C			1.94	1	1	Yes	Cresol, p-	106-44-5					2.0E+02	2.5E+03		1.9E+02	
				1.0E-01	A					3.1	1	1	Yes	Cresol, p-chloro-m-	59-50-7					2.0E+02	5.2E+02		1.4E+02	
				1.0E-01	A	6.0E-01	C			1.95	1	0.9	Yes	Cresols	1319-77-3					2.0E+02	6.7E+02		1.5E+02	
1.9E+00	H			1.0E-03	P			V		0.6	1	1	Yes	Crotonaldehyde, trans-	123-73-9	4.1E-02	2.7E+00		4.0E-02	2.0E+00	1.5E+02		2.0E+00	
				1.0E-01	I	4.0E-01	I	V		3.66	1	1	Yes	Cumene	98-82-8					2.0E+02	1.9E+02	8.3E+01	4.5E+01	
2.2E-01	C	6.3E-05	C							-1.73	1	1	Yes	Cupferron	135-20-6	3.5E-01	1.3E+04		3.5E-01					
8.4E-01	H			2.0E-03	H					2.22	1	1	Yes	Cyanazine	21725-46-2	9.3E-02	1.6E+00		8.8E-02	4.0E+00	7.6E+01		3.8E+00	
														Cyanides										
				1.0E-03	I						1	1	Yes	~Calcium Cyanide	592-01-8					2.0E+00	4.6E+02		2.0E+00	
				5.0E-03	I						1	1	Yes	~Copper Cyanide	544-92-3					1.0E+01	2.3E+03		1.0E+01	
				6.0E-04	I	8.0E-04	S	V			1	1	Yes	~Cyanide (CN-)	57-12-5					1.2E+00	2.7E+02	1.7E-01	1.5E-01	2.0E+02
				1.0E-03	I			V		0.07	1	1	Yes	~Cyanogen	460-19-5					2.0E+00	5.1E+02		2.0E+00	
				9.0E-02	I			V			1	1	Yes	~Cyanogen Bromide	506-68-3					1.8E+02	1.6E+05		1.8E+02	
				5.0E-02	I			V			1	1	Yes	~Cyanogen Chloride	506-77-4					1.0E+02	5.8E+04		1.0E+02	
				6.0E-04	I	8.0E-04	I	V		-0.25	1	1	Yes	~Hydrogen Cyanide	74-90-8					1.2E+00	2.7E+02	1.7E-01	1.5E-01	
				2.0E-03	I						1	1	Yes	~Potassium Cyanide	151-50-8					4.0E+00	4.6E+02		4.0E+00	
				5.0E-03	I						0.04	1	Yes	~Potassium Silver Cyanide	506-61-6					1.0E+01	4.6E+01		8.2E+00	
				1.0E-01	I						0.04	1	Yes	~Silver Cyanide	506-64-9					2.0E+02	1.8E+03		1.8E+02	
				1.0E-03	I						1	1	Yes	~Sodium Cyanide	143-33-9					2.0E+00	4.6E+02		2.0E+00	2.0E+02
				2.0E-04	P						1	0	Yes	~Thiocyanates	E1790664					4.0E-01	9.1E+01		4.0E-01	
				2.0E-04	X			V		0.58	1	1	Yes	~Thiocyanic Acid	463-56-9					4.0E-01	9.1E+01		4.0E-01	
				5.0E-02	I						1	1	Yes	~Zinc Cyanide	557-21-1					1.0E+02	3.8E+04		1.0E+02	
						6.0E+00	I	V		3.44	1	1	Yes	Cyclohexane	110-82-7							1.3E+03	1.3E+03	
2.0E-02	X			2.0E-02	X					4.72	1	0.9	Yes	Cyclohexane, 1,2,3,4,5-pentabromo-6-chloro-	87-84-3	3.9E+00	9.6E+00		2.8E+00	4.0E+01	1.1E+02		2.9E+01	
				5.0E+00	I	7.0E-01	P	V		0.81	1	1	Yes	Cyclohexanone	108-94-1					1.0E+04	6.5E+05	1.5E+02	1.4E+02	
				5.0E-03	P	1.0E+00	X	V		2.86	1	1	Yes	Cyclohexene	110-83-8					1.0E+01	2.5E+01	2.1E+02	7.0E+00	
				2.0E-01	I			V		1.49	1	1	Yes	Cyclohexylamine	108-91-8					4.0E+02	9.3E+03		3.8E+02	
				2.5E-02	I					5.95	1	0.7	Yes	Cyfluthrin	68359-37-5					5.0E+01	1.6E+01		1.2E+01	
				1.0E-03	O					6.9	1	0.5	No	Cyhalothrin	68085-85-8					2.0E+00			2.0E+00	
				6.0E-02	O					6.6	1	0.7	No	Cypermethrin	52315-07-8					1.2E+02			1.2E+02	
				1.5E-02	O					-0.061	1	1	Yes	Cyromazine	66215-27-8					3.0E+01	2.4E+03		3.0E+01	
2.4E-01	I	6.9E-05	C	3.0E-05	X					6.02	1	0.8	Yes	DDD, p,p`- (DDD)	72-54-8	3.2E-01	3.5E-02		3.2E-02	6.0E-02	7.1E-03		6.3E-03	
3.4E-01	I	9.7E-05	C	3.0E-04	X			V		6.51	1	0.8	No	DDE, p,p'-	72-55-9	2.3E-01		5.8E-02	4.6E-02	6.0E-01			6.0E-01	
3.4E-01	I	9.7E-05	I	5.0E-04	I					6.91	1	0.7	No	DDT	50-29-3	2.3E-01			2.3E-01	1.0E+00			1.0E+00	
				3.0E-02	I					0.78	1	1	Yes	Dalapon	75-99-0					6.0E+01	5.5E+03		6.0E+01	2.0E+02
1.8E-02	C	5.1E-06	C	1.5E-01	I					-1.5	1	1	Yes	Daminozide	1596-84-5	4.3E+00	1.3E+04		4.3E+00	3.0E+02	1.0E+06		3.0E+02	
7.0E-04	I			7.0E-03	I					12.11	1	0	No	Decabromodiphenyl ether, 2,2',3,3',4,4',5,5',6,6'- (BDE-209)	1163-19-5	1.1E+02			1.1E+02	1.4E+01			1.4E+01	
				4.0E-05	I					3.21	1	0.8	Yes	Demeton	8065-48-3					8.0E-02	8.8E-02		4.2E-02	
1.2E-03	I			6.0E-01	I					6.11	1	0	Yes	Di(2-ethylhexyl)adipate	103-23-1	6.5E+01			6.5E+01	1.2E+03			1.2E+03	4.0E+02
6.1E-02	H									4.49	1	0.9	Yes	Diallate	2303-16-4	1.3E+00	9.2E-01		5.4E-01					

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				7.0E-04	A					3.81	1	0.9	Yes	Diazinon	333-41-5					1.4E+00	3.9E+00		1.0E+00	
				1.0E-02	X			V		4.38	1	1	Yes	Dibenzothiophene	132-65-0					2.0E+01	9.6E+00		6.5E+00	
8.0E-01	P	6.0E-03	P	2.0E-04	P	2.0E-04	I	V	M	2.96	1	1	Yes	Dibromo-3-chloropropane, 1,2-	96-12-8	3.1E-02	1.7E-01	3.4E-04	3.3E-04	4.0E-01	2.4E+00	4.2E-02	3.7E-02	2.0E-01
				4.0E-04	X			V		3.75	1	0.9	Yes	Dibromobenzene, 1,3-	108-36-1					8.0E-01	1.6E+00		5.3E-01	
				1.0E-02	I			V		3.79	1	0.9	Yes	Dibromobenzene, 1,4-	106-37-6					2.0E+01	3.7E+01		1.3E+01	
8.4E-02	I			2.0E-02	I			V		2.16	1	1	Yes	Dibromochloromethane	124-48-1	9.3E-01	1.4E+01		8.7E-01	4.0E+01	6.7E+02		3.8E+01	8.0E+01(F)
2.0E+00	I	6.0E-04	I	9.0E-03	I	9.0E-03	I	V		1.96	1	1	Yes	Dibromoethane, 1,2-	106-93-4	3.9E-02	7.1E-01	9.4E-03	7.5E-03	1.8E+01	3.6E+02	1.9E+00	1.7E+00	5.0E-02
						4.0E-03	X	V		1.7	1	1	Yes	Dibromomethane (Methylene Bromide)	74-95-3							8.3E-01	8.3E-01	
				3.0E-04	P						1	0	No	Dibutyltin Compounds	E1790660					6.0E-01			6.0E-01	
				3.0E-02	I					2.21	1	1	Yes	Dicamba	1918-00-9					6.0E+01	1.0E+03		5.7E+01	
		4.2E-03	P					V		2.6	1	1	Yes	Dichloro-2-butene, 1,4-	764-41-0			1.3E-03	1.3E-03					
		4.2E-03	P					V		2.6	1	1	Yes	Dichloro-2-butene, cis-1,4-	1476-11-5			1.3E-03	1.3E-03					
		4.2E-03	P					V		2.6	1	1	Yes	Dichloro-2-butene, trans-1,4-	110-57-6			1.3E-03	1.3E-03					
5.0E-02	I			4.0E-03	I					0.92	1	1	Yes	Dichloroacetic Acid	79-43-6	1.6E+00	9.6E+01		1.5E+00	8.0E+00	5.4E+02		7.9E+00	6.0E+01
				9.0E-02	I	2.0E-01	H	V		3.43	1	1	Yes	Dichlorobenzene, 1,2-	95-50-1					1.8E+02	2.9E+02	4.2E+01	3.0E+01	6.0E+02
5.4E-03	C	1.1E-05	C	7.0E-02	A	8.0E-01	I	V		3.44	1	1	Yes	Dichlorobenzene, 1,4-	106-46-7	1.4E+01	2.1E+01	5.1E-01	4.8E-01	1.4E+02	2.2E+02	1.7E+02	5.7E+01	7.5E+01
4.5E-01	I	3.4E-04	C							3.51	1	1	Yes	Dichlorobenzidine, 3,3'-	91-94-1	1.7E-01	4.5E-01		1.3E-01					
				9.0E-03	X					4.44	1	0.9	Yes	Dichlorobenzophenone, 4,4'-	90-98-2					1.8E+01	1.4E+01		7.8E+00	
				2.0E-01	I	1.0E-01	X	V		2.16	1	1	Yes	Dichlorodifluoromethane	75-71-8					4.0E+02	3.8E+03	2.1E+01	2.0E+01	
5.7E-03	C	1.6E-06	C	2.0E-01	P			V		1.79	1	1	Yes	Dichloroethane, 1,1-	75-34-3	1.4E+01	1.8E+02	3.5E+00	2.8E+00	4.0E+02	5.8E+03		3.8E+02	
9.1E-02	I	2.6E-05	I	6.0E-03	X	7.0E-03	P	V		1.48	1	1	Yes	Dichloroethane, 1,2-	107-06-2	8.6E-01	1.8E+01	2.2E-01	1.7E-01	1.2E+01	2.8E+02	1.5E+00	1.3E+00	5.0E+00
				5.0E-02	I	2.0E-01	I	V		2.13	1	1	Yes	Dichloroethylene, 1,1-	75-35-4					1.0E+02	8.5E+02	4.2E+01	2.8E+01	7.0E+00
				2.0E-03	I			V		1.86	1	1	Yes	Dichloroethylene, 1,2-cis-	156-59-2					4.0E+00	3.6E+01		3.6E+00	7.0E+01
				2.0E-02	I			V		2.09	1	1	Yes	Dichloroethylene, 1,2-trans-	156-60-5					4.0E+01	3.6E+02		3.6E+01	1.0E+02
				3.0E-03	I					3.06	1	1	Yes	Dichlorophenol, 2,4-	120-83-2					6.0E+00	1.9E+01		4.6E+00	
				1.0E-02	I					2.81	1	1	Yes	Dichlorophenoxy Acetic Acid, 2,4-	94-75-7					2.0E+01	1.4E+02		1.7E+01	7.0E+01
3.7E-02	P	3.7E-06	P	4.0E-02	P	4.0E-03	I	V		1.98	1	1	Yes	Dichloropropane, 1,2-	78-87-5	2.1E+00	2.3E+01	1.5E+00	8.5E-01	8.0E+01	9.6E+02	8.3E-01	8.2E-01	5.0E+00
				2.0E-02	P			V		2	1	1	Yes	Dichloropropane, 1,3-	142-28-9					4.0E+01	4.6E+02		3.7E+01	
				3.0E-03	I					0.78	1	1	Yes	Dichloropropanol, 2,3-	616-23-9					6.0E+00	5.0E+02		5.9E+00	
1.0E-01	I	4.0E-06	I	3.0E-02	I	2.0E-02	I	V		2.04	1	1	Yes	Dichloropropene, 1,3-	542-75-6	7.8E-01	7.8E+00	1.4E+00	4.7E-01	6.0E+01	6.6E+02	4.2E+00	3.9E+00	
2.9E-01	I	8.3E-05	C	5.0E-04	I	5.0E-04	I			1.43	1	1	Yes	Dichlorvos	62-73-7	2.7E-01	1.4E+01		2.6E-01	1.0E+00	5.6E+01		9.9E-01	
				7.0E-05	O					0	1	1	Yes	Dicrotophos	141-66-2					1.4E-01	7.7E+01		1.4E-01	
				8.0E-02	P	3.0E-04	X	V		3.16	1	1	Yes	Dicyclopentadiene	77-73-6					1.6E+02	3.5E+02	6.3E-02	6.3E-02	
1.6E+01	I	4.6E-03	I	5.0E-05	I					5.4	1	0.8	Yes	Dieldrin	60-57-1	4.9E-03	2.7E-03		1.8E-03	1.0E-01	6.1E-02		3.8E-02	
		3.0E-04	C			5.0E-03	I				1	0		Diesel Engine Exhaust	E17136615									
				2.0E-03	P	2.0E-04	P			-1.43	1	1	Yes	Diethanolamine	111-42-2					4.0E+00	8.4E+03		4.0E+00	
				3.0E-02	P	1.0E-04	P			0.56	1	1	Yes	Diethylene Glycol Monobutyl Ether	112-34-5					6.0E+01	8.7E+03		6.0E+01	
				6.0E-02	P	3.0E-04	P			-0.54	1	1	Yes	Diethylene Glycol Monoethyl Ether	111-90-0					1.2E+02	7.8E+04		1.2E+02	
				1.0E-03	P			V		0.05	1	1	Yes	Diethylformamide	617-84-5					2.0E+00	4.3E+02		2.0E+00	
3.5E+02	C	1.0E-01	C							5.07	1	0.9	Yes	Diethylstilbestrol	56-53-1	2.2E-04	6.6E-05		5.1E-05					
				8.3E-02	O					0.65	1	1	Yes	Difenzoquat	43222-48-6					1.7E+02	7.5E+04		1.7E+02	
				2.0E-02	I					3.88	1	0.9	Yes	Diflubenzuron	35367-38-5					4.0E+01	1.0E+02		2.9E+01	
						4.0E+01	I	V		0.75	1	1	Yes	Difluoroethane, 1,1-	75-37-6							8.3E+03	8.3E+03	
						3.0E+01	X	V		2.29	1	1	Yes	Difluoropropane, 2,2-	420-45-1							6.3E+03	6.3E+03	
4.4E-02	C	1.3E-05	C					V		3.58	1	1	Yes	Dihydrosafrole	94-58-6	1.8E+00	2.3E+00	4.3E-01	3.0E-01					
						7.0E-01	P	V		1.52	1	1	Yes	Diisopropyl Ether	108-20-3							1.5E+02	1.5E+02	
				8.0E-02	I			V		1.03	1	1	Yes	Diisopropyl Methylphosphonate	1445-75-6					1.6E+02	1.3E+04		1.6E+02	
				2.2E-02	O					-0.17	1	1	Yes	Dimethipin	55290-64-7					4.4E+01	2.6E+04		4.4E+01	
				2.2E-03	O					0.78	1	1	Yes	Dimethoate	60-51-5					4.4E+00	7.0E+02		4.4E+00	
1.6E+00	P									1.81	1	1	Yes	Dimethoxybenzidine, 3,3'-	119-90-4	4.9E-02	1.6E+00		4.7E-02					
1.7E-03	P			6.0E-02	P					-0.61	1	1	Yes	Dimethyl methylphosphonate	756-79-6	4.6E+01	2.8E+04		4.6E+01	1.2E+02	8.1E+04		1.2E+02	
4.6E+00	C	1.3E-03	C							4.58	1	1	Yes	Dimethylamino azobenzene [p-]	60-11-7	1.7E-02	7.2E-03		5.0E-03					
5.8E-01	H									2.17	1	1	Yes	Dimethylaniline HCl, 2,4-	21436-96-4	1.3E-01	5.2E+02		1.3E-01					
2.0E-01	P			2.0E-03	X					1.68	1	1	Yes	Dimethylaniline, 2,4-	95-68-1	3.9E-01	7.1E+00		3.7E-01	4.0E+00	8.0E+01		3.8E+00	
2.7E-02	P			2.0E-03	I			V		2.31	1	1	Yes	Dimethylaniline, N,N-	121-69-7	2.9E+00	2.0E+01		2.5E+00	4.0E+00	3.1E+01		3.5E+00	
1.1E+01	P									2.34	1	1	Yes	Dimethylbenzidine, 3,3'-	119-93-7	7.1E-03	8.5E-02		6.5E-03					
				1.0E-01	P	3.0E-02	I	V		-1.01	1	1	Yes	Dimethylformamide	68-12-2					2.0E+02	1.8E+05	6.3E+00	6.1E+00	
				1.0E-04	X	2.0E-06	X	V		-1.19	1	1	Yes	Dimethylhydrazine, 1,1-	57-14-7					2.0E-01	3.5E+02	4.2E-04	4.2E-04	
5.5E+02	C	1.6E-01	C					V		-0.54	1	1	Yes	Dimethylhydrazine, 1,2-	540-73-8	1.4E-04	5.0E-02	3.5E-05	2.8E-05					
				2.0E-02	I					2.3	1	1	Yes	Dimethylphenol, 2,4-	105-67-9					4.0E+01	3.1E+02		3.6E+01	
				6.0E-04	I					2.36	1	1	Yes	Dimethylphenol, 2,6-	576-26-1					1.2E+00	8.5E+00		1.1E+00	
				1.0E-03	I					2.23	1	1	Yes	Dimethylphenol, 3,4-	95-65-8					2.0E+00	1.7E+01		1.8E+00	
4.5E-02	C	1.3E-05	C					V		2.58	1	1	Yes	Dimethylvinylchloride	513-37-1	1.7E+00	6.5E+00	4.3E-01	3.3E-01					
				8.0E-05	X					2.13	1	1	Yes	Dinitro-o-cresol, 4,6-	534-52-1					1.6E-01	2.6E+00		1.5E-01	
				2.0E-03	I					4.12	1	0.9	Yes	Dinitro-o-cyclohexyl Phenol, 4,6-	131-89-5					4.0E+00	5.4E+00		2.3E+00	
				1.0E-04	P					1.69	1	1	Yes	Dinitrobenzene, 1,2-	528-29-0					2.0E-01	5.3E+00		1.9E-01	
				1.0E-04	I					1.49	1	1	Yes	Dinitrobenzene, 1,3-	99-65-0					2.0E-01	7.3E+00		2.0E-01	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	muta-gen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				1.0E-04	P					1.46	1	1	Yes	Dinitrobenzene, 1,4-	100-25-4					2.0E-01	7.6E+00		2.0E-01	
				2.0E-03	I					1.67	1	1	Yes	Dinitrophenol, 2,4-	51-28-5					4.0E+00	1.2E+02		3.9E+00	
6.8E-01	I									2.18	1	1	Yes	Dinitrotoluene Mixture, 2,4/2,6-	E1615210	1.1E-01	1.5E+00		1.1E-01					
3.1E-01	C	8.9E-05	C	2.0E-03	I					1.98	1	1	Yes	Dinitrotoluene, 2,4-	121-14-2	2.5E-01	4.3E+00		2.4E-01	4.0E+00	7.5E+01		3.8E+00	
1.5E+00	P			3.0E-04	X					2.1	1	1	Yes	Dinitrotoluene, 2,6-	606-20-2	5.2E-02	7.4E-01		4.9E-02	6.0E-01	9.3E+00		5.7E-01	
				2.0E-03	S					1.84	1	1	Yes	Dinitrotoluene, 2-Amino-4,6-	35572-78-2					4.0E+00	1.0E+02		3.9E+00	
				2.0E-03	S					1.84	1	1	Yes	Dinitrotoluene, 4-Amino-2,6-	19406-51-0					4.0E+00	1.0E+02		3.9E+00	
4.5E-01	X			9.0E-04	X					2.18	1	0.8	Yes	Dinitrotoluene, Technical grade	25321-14-6	1.7E-01	2.6E-01		1.0E-01	1.8E+00	3.0E+00		1.1E+00	
				1.0E-03	I					3.56	1	0.9	Yes	Dinoseb	88-85-7					2.0E+00	5.4E+00		1.5E+00	7.0E+00
1.0E-01	I	5.0E-06	I	3.0E-02	I	3.0E-02	I	V		-0.27	1	1	Yes	Dioxane, 1,4-	123-91-1	7.8E-01	2.3E+02	1.1E+00	4.6E-01	6.0E+01	1.9E+04	6.3E+00	5.7E+00	
														Dioxins										
6.2E+03	I	1.3E+00	I							8.21	1	0	No	~Hexachlorodibenzo-p-dioxin, Mixture		1.3E-05			1.3E-05					
1.3E+05	C	3.8E+01	C	7.0E-10	I	4.0E-08	C	V		6.8	1	0.5	No	~TCDD, 2,3,7,8-	1746-01-6	6.0E-07		1.5E-07	1.2E-07	1.4E-06		8.3E-06	1.2E-06	3.0E-05
				3.0E-02	I					2.17	1	1	Yes	Diphenamid	957-51-7					6.0E+01	4.2E+02		5.3E+01	
						4.0E-04	X	V		4.21	1	1	Yes	Diphenyl Ether	101-84-8							8.3E-02	8.3E-02	
				8.0E-04	X					2.4	1	1	Yes	Diphenyl Sulfone	127-63-9					1.6E+00	2.0E+01		1.5E+00	
				1.0E-01	O					3.5	1	1	Yes	Diphenylamine	122-39-4					2.0E+02	3.4E+02		1.3E+02	
8.0E-01	I	2.2E-04	I							2.94	1	1	Yes	Diphenylhydrazine, 1,2-	122-66-7	9.7E-02	3.9E-01		7.8E-02					
				2.2E-03	I					-4.6	1	1	No	Diquat	85-00-7					4.4E+00			4.4E+00	2.0E+01
7.1E+00	C	1.4E-01	C							4.9	1	1	No	Direct Black 38	1937-37-7	1.1E-02			1.1E-02					
7.4E+00	C	1.4E-01	C							2.6	1	1	No	Direct Blue 6	2602-46-2	1.1E-02			1.1E-02					
6.7E+00	C	1.4E-01	C							-6.53	1	1	No	Direct Brown 95	16071-86-6	1.2E-02			1.2E-02					
				4.0E-05	I					4.02	1	0.9	Yes	Disulfoton	298-04-4					8.0E-02	1.3E-01		5.0E-02	
				1.0E-02	I			V		0.77	1	1	Yes	Dithiane, 1,4-	505-29-3					2.0E+01	1.6E+03		2.0E+01	
				2.0E-03	I					2.68	1	1	Yes	Diuron	330-54-1					4.0E+00	3.6E+01		3.6E+00	
				2.0E-02	O					1.15	1	1	Yes	Dodine	2439-10-3					4.0E+01	5.3E+03		4.0E+01	
				5.0E-02	O			V		3.21	1	1	Yes	EPTC	759-94-4					1.0E+02	3.0E+02		7.5E+01	
				6.0E-03	I			V		3.83	1	0.9	Yes	Endosulfan	115-29-7					1.2E+01	6.3E+01		1.0E+01	
				2.0E-02	I					1.91	1	1	Yes	Endothall	145-73-3					4.0E+01	8.5E+02		3.8E+01	1.0E+02
				3.0E-04	I					5.2	1	0.8	Yes	Endrin	72-20-8					6.0E-01	3.7E-01		2.3E-01	2.0E+00
9.9E-03	I	1.2E-06	I	6.0E-03	P	1.0E-03	I	V		0.45	1	1	Yes	Epichlorohydrin	106-89-8	7.9E+00	7.9E+02	4.7E+00	2.9E+00	1.2E+01	1.3E+03	2.1E-01	2.0E-01	
						2.0E-02	I	V		0.86	1	1	Yes	Epoxybutane, 1,2-	106-88-7							4.2E+00	4.2E+00	
				4.0E-02	P					-1.18	1	1	Yes	Ethanol, 2-(2-methoxyethoxy)-	111-77-3					8.0E+01	3.9E+04		8.0E+01	
				5.0E-03	I					-0.22	1	1	Yes	Ethephon	16672-87-0					1.0E+01	4.2E+03		1.0E+01	
				5.0E-04	I					5.07	1	0.8	Yes	Ethion	563-12-2					1.0E+00	7.7E-01		4.3E-01	
				1.0E-01	P	6.0E-02	P	V		0.59	1	1	Yes	Ethoxyethanol Acetate, 2-	111-15-9					2.0E+02	2.3E+04	1.3E+01	1.2E+01	
				9.0E-02	P	2.0E-01	I	V		-0.32	1	1	Yes	Ethoxyethanol, 2-	110-80-5					1.8E+02	6.3E+04	4.2E+01	3.4E+01	
				9.0E-01	I	7.0E-02	P	V		0.73	1	1	Yes	Ethyl Acetate	141-78-6					1.8E+03	1.2E+05	1.5E+01	1.4E+01	
				5.0E-03	P	8.0E-03	P	V		1.32	1	1	Yes	Ethyl Acrylate	140-88-5					1.0E+01	3.0E+02	1.7E+00	1.4E+00	
						1.0E+01	I	V		1.43	1	1	Yes	Ethyl Chloride (Chloroethane)	75-00-3							2.1E+03	2.1E+03	
				2.0E-01	I			V		0.89	1	1	Yes	Ethyl Ether	60-29-7					4.0E+02	2.0E+04		3.9E+02	
						3.0E-01	P	V		1.94	1	1	Yes	Ethyl Methacrylate	97-63-2							6.3E+01	6.3E+01	
				1.0E-05	I					4.78	1	0.8	Yes	Ethyl-p-nitrophenyl Phosphonate	2104-64-5					2.0E-02	1.6E-02		8.9E-03	
1.1E-02	C	2.5E-06	C	1.0E-01	I	1.0E+00	I	V		3.15	1	1	Yes	Ethylbenzene	100-41-4	7.1E+00	1.2E+01	2.2E+00	1.5E+00	2.0E+02	3.8E+02	2.1E+02	8.1E+01	7.0E+02
				7.0E-02	P					-0.94	1	1	Yes	Ethylene Cyanohydrin	109-78-4					1.4E+02	1.1E+05		1.4E+02	
				9.0E-02	P			V		-2.04	1	1	No	Ethylene Diamine	107-15-3					1.8E+02			1.8E+02	
				2.0E+00	I	4.0E-01	C			-1.36	1	1	Yes	Ethylene Glycol	107-21-1					4.0E+03	5.7E+06		4.0E+03	
				1.0E-01	I	1.6E+00	I			0.83	1	1	Yes	Ethylene Glycol Monobutyl Ether	111-76-2					2.0E+02	1.4E+04		2.0E+02	
3.1E-01	C	3.0E-03	I			3.0E-02	C	V	M	-0.3	1	1	Yes	Ethylene Oxide	75-21-8	8.1E-02	1.7E+01	6.8E-04	6.7E-04			6.3E+00	6.3E+00	
4.5E-02	C	1.3E-05	C	8.0E-05	I					-0.66	1	1	Yes	Ethylene Thiourea	96-45-7	1.7E+00	1.0E+03		1.7E+00	1.6E-01	1.0E+02		1.6E-01	
6.5E+01	C	1.9E-02	C					V		-0.28	1	1	Yes	Ethyleneimine	151-56-4	1.2E-03	2.5E-01	3.0E-04	2.4E-04					
				3.0E+00	I					2.19	1	1	Yes	Ethylphthalyl Ethyl Glycolate	84-72-0					6.0E+03	1.5E+05		5.8E+03	
				2.5E-04	I					3.23	1	0.9	Yes	Fenamiphos	22224-92-6					5.0E-01	3.4E+00		4.4E-01	
				2.5E-02	I					5.7	1	0.8	Yes	Fenpropathrin	39515-41-8					5.0E+01	7.3E+00		6.4E+00	
				2.5E-02	I					6.2	1	0.7	No	Fenvalerate	51630-58-1					5.0E+01			5.0E+01	
				1.3E-02	I					2.42	1	1	Yes	Fluometuron	2164-17-2					2.6E+01	3.4E+02		2.4E+01	
				4.0E-02	C	1.3E-02	C				1	1	Yes	Fluoride	16984-48-8					8.0E+01	1.8E+04		8.0E+01	
				6.0E-02	I	1.3E-02	C				1	1	Yes	Fluorine (Soluble Fluoride)	7782-41-4					1.2E+02	2.7E+04		1.2E+02	4.0E+03
				8.0E-02	I					3.16	1	0.9	Yes	Fluridone	59756-60-4					1.6E+02	1.4E+03		1.4E+02	
				1.5E-02	O					3.34	1	0.9	Yes	Flurprimidol	56425-91-3					3.0E+01	1.8E+02		2.6E+01	
				2.0E-03	O					3.7	1	0.9	Yes	Flusilazole	85509-19-9					4.0E+00	1.4E+01		3.1E+00	
				5.0E-01	O					3.7	1	0.9	Yes	Flutolanil	66332-96-5					1.0E+03	3.7E+03		7.9E+02	
				1.0E-02	I					6.81	1	0.6	No	Fluvalinate	69409-94-5					2.0E+01			2.0E+01	
				9.0E-02	O					2.85	1	1	Yes	Folpet	133-07-3					1.8E+02	1.9E+03		1.6E+02	
				2.5E-03	O					2.9	1	1	Yes	Fomesafen	72178-02-0					5.0E+00	1.2E+02		4.8E+00	
				2.0E-03	I					3.94	1	0.9	Yes	Fonofos	944-22-9					4.0E+00	6.3E+00		2.4E+00	
		1.3E-05	I	2.0E-01	I	9.8E-03	A	V		0.35	1	1	Yes	Formaldehyde	50-00-0			4.3E-01	4.3E-01	4.0E+02	3.2E+04	2.0E+00	2.0E+00	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				9.0E-01	P	3.0E-04	X	V		-0.54	1	1	Yes	Formic Acid	64-18-6					1.8E+03	6.4E+05	6.3E-02	6.3E-02	
				2.5E+00	O					-2.4	1	1	No	Fosetyl-AL	39148-24-8					5.0E+03			5.0E+03	
														Furans										
				1.0E-03	X			V		4.12	1	1	Yes	~Dibenzofuran	132-64-9					2.0E+00	1.3E+00		7.9E-01	
				1.0E-03	I			V		1.34	1	1	Yes	~Furan	110-00-9					2.0E+00	4.8E+01		1.9E+00	
				9.0E-01	I	2.0E+00	I	V		0.46	1	1	Yes	~Tetrahydrofuran	109-99-9					1.8E+03	1.7E+05	4.2E+02	3.4E+02	
3.8E+00	H									-0.04	1	1	Yes	Furazolidone	67-45-8	2.1E-02	1.0E+01		2.0E-02					
				3.0E-03	I	5.0E-02	H	V		0.41	1	1	Yes	Furfural	98-01-1					6.0E+00	7.1E+02	1.0E+01	3.8E+00	
1.5E+00	C	4.3E-04	C							1.8	1	1	Yes	Furium	531-82-8	5.2E-02	1.9E+00		5.1E-02					
3.0E-02	I	8.6E-06	C							4.38	1	0.9	Yes	Furmecyclox	60568-05-0	2.6E+00	2.0E+00		1.1E+00					
				6.0E-03	O					-4.81	1	1	No	Glufosinate, Ammonium	77182-82-2					1.2E+01			1.2E+01	
				1.0E-01	A	8.0E-05	C			-0.33	1	1	Yes	Glutaraldehyde	111-30-8					2.0E+02	6.0E+04		2.0E+02	
				4.0E-04	I	1.0E-03	H	V		-0.12	1	1	Yes	Glycidyl	765-34-4					8.0E-01	1.8E+02	2.1E-01	1.7E-01	
				1.0E-01	I					-3.4	1	1	No	Glyphosate	1071-83-6					2.0E+02			2.0E+02	7.0E+02
				1.0E-02	X			V		-1.63	1	1	Yes	Guanidine	113-00-8					2.0E+01	4.2E+04		2.0E+01	
				2.0E-02	P					-3.56	1	1	No	Guanidine Chloride	50-01-1					4.0E+01			4.0E+01	
				3.0E-02	X					-8.35	1	1	No	Guanidine Nitrate	506-93-4					6.0E+01			6.0E+01	
				5.0E-05	I					4.07	1	0.9	Yes	Haloxyfop, Methyl	69806-40-2					1.0E-01	3.1E-01		7.6E-02	
4.5E+00	I	1.3E-03	I	5.0E-04	I			V		6.1	1	0.8	Yes	Heptachlor	76-44-8	1.7E-02	2.3E-03	4.3E-03	1.4E-03	1.0E+00	1.5E-01		1.3E-01	4.0E-01
9.1E+00	I	2.6E-03	I	1.3E-05	I			V		4.98	1	0.8	Yes	Heptachlor Epoxide	1024-57-3	8.6E-03	7.1E-03	2.2E-03	1.4E-03	2.6E-02	2.4E-02		1.2E-02	2.0E-01
						3.0E-03	X	V		2.29	1	1	Yes	Heptanal, n-	111-71-7							6.3E-01	6.3E-01	
				3.0E-04	X	4.0E-01	P	V		4.66	1	1	No	Heptane, N-	142-82-5					6.0E-01		8.3E+01	6.0E-01	
				2.0E-03	I			V		6.07	1	0.7	No	Hexabromobenzene	87-82-1					4.0E+00			4.0E+00	
				2.0E-04	I						1	0	No	Hexabromodiphenyl ether, 2,2',4,4',5,5'- (BDE-153)	68631-49-2					4.0E-01			4.0E-01	
1.6E+00	I	4.6E-04	I	8.0E-04	I			V		5.73	1	0.9	No	Hexachlorobenzene	118-74-1	4.9E-02		1.2E-02	9.8E-03	1.6E+00			1.6E+00	1.0E+00
7.8E-02	I	2.2E-05	I	1.0E-03	P			V		4.78	1	0.9	Yes	Hexachlorobutadiene	87-68-3	1.0E+00	4.4E-01	2.6E-01	1.4E-01	2.0E+00	9.5E-01		6.5E-01	
6.3E+00	I	1.8E-03	I	8.0E-03	A					3.8	1	0.9	Yes	Hexachlorocyclohexane, Alpha-	319-84-6	1.2E-02	1.8E-02		7.2E-03	1.6E+01	2.5E+01		9.7E+00	
1.8E+00	I	5.3E-04	I							3.78	1	0.9	Yes	Hexachlorocyclohexane, Beta-	319-85-7	4.3E-02	6.1E-02		2.5E-02					
1.1E+00	C	3.1E-04	C	3.0E-04	I					3.72	1	0.9	Yes	Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	7.1E-02	1.0E-01		4.2E-02	6.0E-01	9.3E-01		3.6E-01	2.0E-01
1.8E+00	I	5.1E-04	I							4.14	1	0.9	Yes	Hexachlorocyclohexane, Technical	608-73-1	4.3E-02	6.1E-02		2.5E-02					
				6.0E-03	I	2.0E-04	I	V		5.04	1	0.9	Yes	Hexachlorocyclopentadiene	77-47-4					1.2E+01	4.2E+00	4.2E-02	4.1E-02	5.0E+01
4.0E-02	I	1.1E-05	C	7.0E-04	I	3.0E-02	I	V		4.14	1	1	Yes	Hexachloroethane	67-72-1	1.9E+00	1.7E+00	5.1E-01	3.3E-01	1.4E+00	1.4E+00	6.3E+00	6.2E-01	
				3.0E-04	I					7.54	1	0	No	Hexachlorophene	70-30-4					6.0E-01			6.0E-01	
1.1E-01	I			3.0E-03	I					0.87	1	1	Yes	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	7.1E-01	8.6E+01		7.0E-01	6.0E+00	8.0E+02		6.0E+00	
						1.0E-05	I	V		3.2	1	1	Yes	Hexamethylene Diisocyanate, 1,6-	822-06-0							2.1E-03	2.1E-03	
				4.0E-04	P					0.28	1	1	Yes	Hexamethylphosphoramide	680-31-9					8.0E-01	2.0E+02		8.0E-01	
						7.0E-01	I	V		3.9	1	1	Yes	Hexane, N-	110-54-3							1.5E+02	1.5E+02	
				2.0E+00	P					0.08	1	1	Yes	Hexanedioic Acid	124-04-9					4.0E+03	1.1E+06		4.0E+03	
				5.0E-03	I	3.0E-02	I	V		1.38	1	1	Yes	Hexanone, 2-	591-78-6					1.0E+01	2.8E+02	6.3E+00	3.8E+00	
				3.3E-02	I					1.85	1	1	Yes	Hexazinone	51235-04-2					6.6E+01	2.4E+03		6.4E+01	
				2.5E-02	I					5.57	1	0.8	Yes	Hexythiazox	78587-05-0					5.0E+01	1.4E+01		1.1E+01	
				1.7E-02	O					2.31	1	1	Yes	Hydramethylnon	67485-29-4					3.4E+01	2.9E+03		3.4E+01	
3.0E+00	I	4.9E-03	I			3.0E-05	P	V		-2.07	1	1	Yes	Hydrazine	302-01-2	2.6E-02	1.1E+02	1.1E-03	1.1E-03			6.3E-03	6.3E-03	
3.0E+00	I	4.9E-03	I								1	1	Yes	Hydrazine Sulfate	10034-93-2	2.6E-02	4.9E+00		2.6E-02					
						2.0E-02	I	V			1	1	Yes	Hydrogen Chloride	7647-01-0							4.2E+00	4.2E+00	
				4.0E-02	C	1.4E-02	C	V		0.23	1	1	Yes	Hydrogen Fluoride	7664-39-3					8.0E+01	1.8E+04	2.9E+00	2.8E+00	
						2.0E-03	I	V		0.23	1	1	Yes	Hydrogen Sulfide	7783-06-4							4.2E-01	4.2E-01	
6.0E-02	P			4.0E-02	P					0.59	1	1	Yes	Hydroquinone	123-31-9	1.3E+00	1.2E+02		1.3E+00	8.0E+01	7.9E+03		7.9E+01	
6.1E-02	O			2.5E-03	O					3.82	1	0.9	Yes	Imazalil	35554-44-0	1.3E+00	3.1E+00		9.0E-01	5.0E+00	1.3E+01		3.6E+00	
				2.5E-01	I					1.86	1	1	Yes	Imazaquin	81335-37-7					5.0E+02	2.6E+04		4.9E+02	
				2.5E+00	O					1.49	1	1	Yes	Imazethapyr	81335-77-5					5.0E+03	7.2E+04		4.7E+03	
				1.0E-02	A					2.49	1	1	Yes	Iodine	7553-56-2					2.0E+01	4.6E+03		2.0E+01	
				4.0E-02	I					3	1	0.9	Yes	Iprodione	36734-19-7					8.0E+01	9.1E+02		7.4E+01	
				7.0E-01	P						1	1	Yes	Iron	7439-89-6					1.4E+03	3.2E+05		1.4E+03	
				3.0E-01	I			V		0.76	1	1	Yes	Isobutyl Alcohol	78-83-1					6.0E+02	3.6E+04		5.9E+02	
9.5E-04	I			2.0E-01	I	2.0E+00	C			1.7	1	1	Yes	Isophorone	78-59-1	8.2E+01	1.6E+03		7.8E+01	4.0E+02	8.6E+03		3.8E+02	
				1.5E-02	I			V		5.8	1	0.8	Yes	Isopropalin	33820-53-0					3.0E+01	4.6E+00		4.0E+00	
				2.0E+00	P	2.0E-01	P	V		0.05	1	1	Yes	Isopropanol	67-63-0					4.0E+03	6.5E+05	4.2E+01	4.1E+01	
				1.0E-01	I					0.27	1	1	Yes	Isopropyl Methyl Phosphonic Acid	1832-54-8					2.0E+02	3.9E+04		2.0E+02	
				5.0E-02	I					3.94	1	0.9	Yes	Isoxaben	82558-50-7					1.0E+02	2.7E+02		7.3E+01	
						3.0E-01	A	V		8	1	0	No	JP-7	E1737665							6.3E+01	6.3E+01	
				8.0E-03	O					4.81	1	0.9	Yes	Lactofen	77501-63-4					1.6E+01	2.7E+01		1.0E+01	
				2.0E-04	X					-0.94	1	1	Yes	Lactonitrile	78-97-7					4.0E-01	3.2E+02		4.0E-01	
														Lead Compounds										
8.5E-03	C	1.2E-05	C								1	0.8	Yes	~Lead Phosphate	7446-27-7	9.2E+00	1.7E+03		9.1E+00					
8.5E-03	C	1.2E-05	C							-0.08	1	1	Yes	~Lead acetate	301-04-2	9.2E+00	9.1E+03		9.2E+00					
											1	1	Yes	~Lead and Compounds	7439-92-1								1.5E+01	1.5E+01

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	muta-gen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
8.5E-03	C	1.2E-05	C							-4	1	1	No	~Lead subacetate	1335-32-6	9.2E+00			9.2E+00					
				1.0E-07	I			V		4.15	1	0.9	Yes	~Tetraethyl Lead	78-00-2					2.0E-04	3.8E-04		1.3E-04	
				5.0E-06	P			V		2.56	1	1	Yes	Lewisite	541-25-3					1.0E-02	9.1E-02		9.0E-03	
				7.7E-03	O					3.2	1	0.9	Yes	Linuron	330-55-2					1.5E+01	7.6E+01		1.3E+01	
				2.0E-03	P						1	1	Yes	Lithium	7439-93-2					4.0E+00	9.1E+02		4.0E+00	
				5.0E-04	I					3.25	1	1	Yes	MCPA	94-74-6					1.0E+00	3.0E+00		7.5E-01	
				4.4E-03	O					2.79	1	0.9	Yes	MCPB	94-81-5					8.8E+00	2.4E+01		6.5E+00	
				1.0E-03	I					3.13	1	1	Yes	MCPP	93-65-2					2.0E+00	7.1E+00		1.6E+00	
				2.0E-02	I					2.36	1	1	Yes	Malathion	121-75-5					4.0E+01	1.1E+03		3.9E+01	
				1.0E-01	I	7.0E-04	C			1.62	1	1	Yes	Maleic Anhydride	108-31-6					2.0E+02	3.8E+03		1.9E+02	
				5.0E-01	I					-0.84	1	1	Yes	Maleic Hydrazide	123-33-1					1.0E+03	8.9E+05		1.0E+03	
				1.0E-04	P					-0.6	1	1	Yes	Malononitrile	109-77-3					2.0E-01	9.2E+01		2.0E-01	
				3.0E-02	H					1.33	1	0.9	Yes	Mancozeb	8018-01-7					6.0E+01	4.9E+02		5.4E+01	
				5.0E-03	I					0.62	1	1	Yes	Maneb	12427-38-2					1.0E+01	3.6E+02		9.8E+00	
				1.4E-01	I	5.0E-05	I				1	1		Manganese (Diet)	7439-96-5									
				2.4E-02	S	5.0E-05	I				0.04	1	Yes	Manganese (Non-diet)	7439-96-5					4.8E+01	4.4E+02		4.3E+01	
				9.0E-05	H					1.04	1	1	Yes	Mephosfolan	950-10-7					1.8E-01	2.5E+01		1.8E-01	
				3.0E-02	I					-2.82	1	1	No	Mepiquat Chloride	24307-26-4					6.0E+01			6.0E+01	
1.1E-02	P			4.0E-03	P					2.42	1	1	Yes	Mercaptobenzothiazole, 2-	149-30-4	7.1E+00	5.6E+01		6.3E+00	8.0E+00	6.9E+01		7.2E+00	
														Mercury Compounds										
				3.0E-04	I	3.0E-04	S			-0.22	0.07	1	Yes	~Mercuric Chloride (and other Mercury salts)	7487-94-7					6.0E-01	9.6E+00		5.7E-01	2.0E+00
						3.0E-04	I	V		0.62	1	1	Yes	~Mercury (elemental)	7439-97-6							6.3E-02	6.3E-02	2.0E+00
				1.0E-04	I						1	1	Yes	~Methyl Mercury	22967-92-6					2.0E-01	4.6E+01		2.0E-01	
				8.0E-05	I					0.71	1	1	Yes	~Phenylmercuric Acetate	62-38-4					1.6E-01	5.7E+01		1.6E-01	
				3.0E-05	I			V		7.67	1	0.3	No	Merphos	150-50-5					6.0E-02			6.0E-02	
				1.0E-04	O					5.7	1	0.9	Yes	Merphos Oxide	78-48-8					2.0E-01	3.3E-02		2.8E-02	
				6.0E-02	I					1.65	1	1	Yes	Metalaxyl	57837-19-1					1.2E+02	6.4E+03		1.2E+02	
				1.0E-04	I	3.0E-02	P	V		0.68	1	1	Yes	Methacrylonitrile	126-98-7					2.0E-01	1.3E+01	6.3E+00	1.9E-01	
				5.0E-05	I					-0.8	1	1	Yes	Methamidophos	10265-92-6					1.0E-01	1.0E+02		1.0E-01	
				2.0E+00	I	2.0E+01	I	V		-0.77	1	1	Yes	Methanol	67-56-1					4.0E+03	1.8E+06	4.2E+03	2.0E+03	
				1.5E-03	O					2.2	1	1	Yes	Methidathion	950-37-8					3.0E+00	8.7E+01		2.9E+00	
				2.5E-02	I					0.6	1	1	Yes	Methomyl	16752-77-5					5.0E+01	6.8E+03		5.0E+01	
4.9E-02	C	1.4E-05	C							1.47	1	1	Yes	Methoxy-5-nitroaniline, 2-	99-59-2	1.6E+00	5.4E+01		1.5E+00					
				5.0E-03	I					5.08	1	0.8	Yes	Methoxychlor	72-43-5					1.0E+01	5.9E+00		3.7E+00	4.0E+01
				8.0E-03	P	1.0E-03	P	V		0.1	1	1	Yes	Methoxyethanol Acetate, 2-	110-49-6					1.6E+01	3.5E+03	2.1E-01	2.1E-01	
				5.0E-03	P	2.0E-02	I	V		-0.77	1	1	Yes	Methoxyethanol, 2-	109-86-4					1.0E+01	6.3E+03	4.2E+00	2.9E+00	
				1.0E+00	X			V		0.18	1	1	Yes	Methyl Acetate	79-20-9					2.0E+03	2.9E+05		2.0E+03	
						2.0E-02	P	V		0.8	1	1	Yes	Methyl Acrylate	96-33-3							4.2E+00	4.2E+00	
				6.0E-01	I	5.0E+00	I	V		0.29	1	1	Yes	Methyl Ethyl Ketone (2-Butanone)	78-93-3					1.2E+03	1.5E+05	1.0E+03	5.6E+02	
		1.0E-03	X	1.0E-03	P	2.0E-05	X	V		-1.05	1	1	Yes	Methyl Hydrazine	60-34-4			5.6E-03	5.6E-03	2.0E+00	1.5E+03	4.2E-03	4.2E-03	
						3.0E+00	I	V		1.31	1	1	Yes	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	108-10-1							6.3E+02	6.3E+02	
						1.0E-03	C	V		0.79	1	1	Yes	Methyl Isocyanate	624-83-9							2.1E-01	2.1E-01	
				1.4E+00	I	7.0E-01	I	V		1.38	1	1	Yes	Methyl Methacrylate	80-62-6					2.8E+03	7.7E+04	1.5E+02	1.4E+02	
				2.5E-04	I					2.86	1	1	Yes	Methyl Parathion	298-00-0					5.0E-01	4.1E+00		4.5E-01	
				6.0E-02	X					-0.7	1	1	Yes	Methyl Phosphonic Acid	993-13-5					1.2E+02	1.2E+05		1.2E+02	
				6.0E-03	H	4.0E-02	H	V		3.44	1	0.8	Yes	Methyl Styrene (Mixed Isomers)	25013-15-4					1.2E+01	4.3E+00	8.3E+00	2.3E+00	
9.9E-02	C	2.8E-05	C							-0.66	1	1	Yes	Methyl methanesulfonate	66-27-3	7.9E-01	4.8E+02		7.9E-01					
1.8E-03	C	2.6E-07	C			3.0E+00	I	V		0.94	1	1	Yes	Methyl tert-Butyl Ether (MTBE)	1634-04-4	4.3E+01	2.0E+03	2.2E+01	1.4E+01			6.3E+02	6.3E+02	
				3.0E-04	X					-2.06	1	1	Yes	Methyl-1,4-benzenediamine dihydrochloride, 2-	615-45-2					6.0E-01	5.9E+03		6.0E-01	
						3.0E+00	X	V		1.43	1	1	Yes	Methyl-2-Pentanol, 4-	108-11-2							6.3E+02	6.3E+02	
9.0E-03	P			2.0E-02	X					1.87	1	1	Yes	Methyl-5-Nitroaniline, 2-	99-55-8	8.7E+00	1.4E+02		8.2E+00	4.0E+01	7.3E+02		3.8E+01	
8.3E+00	C	2.4E-03	C							-0.92	1	1	Yes	Methyl-N-nitro-N-nitrosoguanidine, N-	70-25-7	9.4E-03	1.1E+01		9.4E-03					
1.3E-01	C	3.7E-05	C							1.62	1	1	Yes	Methylaniline Hydrochloride, 2-	636-21-5	6.0E-01	3.9E+03		6.0E-01					
				1.0E-02	A					-1.18	1	1	Yes	Methylarsonic acid	124-58-3					2.0E+01	3.6E+04		2.0E+01	
				2.0E-04	X						1	0	No	Methylbenzene,1-4-diamine monohydrochloride, 2-	74612-12-7					4.0E-01			4.0E-01	
1.0E-01	X			3.0E-04	X						1	0	No	Methylbenzene-1,4-diamine sulfate, 2-	615-50-9	7.8E-01			7.8E-01	6.0E-01			6.0E-01	
2.2E+01	C	6.3E-03	C						M	6.42	1	0.8	No	Methylcholanthrene, 3-	56-49-5	1.1E-03			1.1E-03					
2.0E-03	I	1.0E-08	I	6.0E-03	I	6.0E-01	I	V	M	1.25	1	1	Yes	Methylene Chloride	75-09-2	1.3E+01	3.5E+02	2.0E+02	1.1E+01	1.2E+01	3.7E+02	1.3E+02	1.1E+01	5.0E+00
1.0E-01	P	4.3E-04	C	2.0E-03	P				M	3.91	1	0.9	Yes	Methylene-bis(2-chloroaniline), 4,4'-	101-14-4	2.5E-01	4.3E-01		1.6E-01	4.0E+00	7.5E+00		2.6E+00	
4.6E-02	I	1.3E-05	C							4.37	1	1	Yes	Methylene-bis(N,N-dimethyl) Aniline, 4,4'-	101-61-1	1.7E+00	6.7E-01		4.8E-01					
1.6E+00	C	4.6E-04	C			2.0E-02	C			1.59	1	1	Yes	Methylenebisbenzenamine, 4,4'-	101-77-9	4.9E-02	1.7E+00		4.7E-02					
						6.0E-04	I			5.22	1	0.9	Yes	Methylenediphenyl Diisocyanate	101-68-8									
				7.0E-02	H			V		3.48	1	1	Yes	Methylstyrene, Alpha-	98-83-9					1.4E+02	1.7E+02		7.8E+01	
				1.5E-01	I					3.13	1	1	Yes	Metolachlor	51218-45-2					3.0E+02	2.6E+03		2.7E+02	
				2.5E-02	I					1.7	1	1	Yes	Metribuzin	21087-64-9					5.0E+01	1.8E+03		4.9E+01	
				2.5E-01	I					2.2	1	1	Yes	Metsulfuron-methyl	74223-64-6					5.0E+02	2.4E+04		4.9E+02	
				3.0E+00	P			V		6.1	1	1	No	Mineral oils	8012-95-1					6.0E+03			6.0E+03	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
1.8E+01	C	5.1E-03	C	2.0E-04	I			V		6.89	1	0.5	No	Mirex	2385-85-5	4.3E-03		1.1E-03	8.8E-04	4.0E-01			4.0E-01	
				2.0E-03	I					3.21	1	1	Yes	Molinate	2212-67-1					4.0E+00	1.2E+01		3.0E+00	
				5.0E-03	I						1	1	Yes	Molybdenum	7439-98-7					1.0E+01	2.3E+03		1.0E+01	
				1.0E-01	I						1	1	Yes	Monochloramine	10599-90-3					2.0E+02	4.6E+04		2.0E+02	4.0E+03
				2.0E-03	P					1.66	1	1	Yes	Monomethylaniline	100-61-8					4.0E+00	7.5E+01		3.8E+00	
				2.5E-02	I					2.94	1	1	Yes	Myclobutanil	88671-89-0					5.0E+01	4.7E+02		4.5E+01	
				3.0E-04	X					4.04	1	0.9	Yes	N,N'-Diphenyl-1,4-benzenediamine	74-31-7					6.0E-01	8.9E-01		3.6E-01	
				2.0E-03	I			V		1.38	1	1	Yes	Naled	300-76-5					4.0E+00	6.8E+02		4.0E+00	
				3.0E-02	X	1.0E-01	P	V			1	0	No	Naphtha, High Flash Aromatic (HFAN)	64742-95-6					6.0E+01		2.1E+01	1.5E+01	
1.8E+00	C	0.0E+00	C							2.28	1	1	Yes	Naphthylamine, 2-	91-59-8	4.3E-02	3.6E-01		3.9E-02					
				1.2E-01	O					3.36	1	0.9	Yes	Napropamide	15299-99-7					2.4E+02	1.1E+03		2.0E+02	
		2.6E-04	C	1.1E-02	C	1.4E-05	C			-1.38	1	1	Yes	Nickel Acetate	373-02-4					2.2E+01	6.8E+04		2.2E+01	
		2.6E-04	C	1.1E-02	C	1.4E-05	C			-2.12	1	1	Yes	Nickel Carbonate	3333-67-3					2.2E+01	1.4E+05		2.2E+01	
		2.6E-04	C	1.1E-02	C	1.4E-05	C	V			1	0	Yes	Nickel Carbonyl	13463-39-3			2.2E-02	2.2E-02	2.2E+01		2.9E-03	2.9E-03	
		2.6E-04	C	1.1E-02	C	1.4E-05	C				0.04	1	Yes	Nickel Hydroxide	12054-48-7					2.2E+01	2.0E+02		2.0E+01	
		2.6E-04	C	1.1E-02	C	2.0E-05	C				0.04	1	Yes	Nickel Oxide	1313-99-1					2.2E+01	2.0E+02		2.0E+01	
		2.4E-04	I	1.1E-02	C	1.4E-05	C				0.04	0	Yes	Nickel Refinery Dust	E715532					2.2E+01	1.0E+03		2.2E+01	
		2.6E-04	C	2.0E-02	I	9.0E-05	A				0.04	1	Yes	Nickel Soluble Salts	7440-02-0					4.0E+01	1.8E+03		3.9E+01	
1.7E+00	C	4.8E-04	I	1.1E-02	C	1.4E-05	C				0.04	1	Yes	Nickel Subsulfide	12035-72-2	4.6E-02	1.7E+00		4.5E-02	2.2E+01	1.0E+03		2.2E+01	
		2.6E-04	C	1.1E-02	C	1.4E-05	C				1	0	Yes	Nickelocene	1271-28-9					2.2E+01			2.2E+01	
				1.6E+00	I						1	1	Yes	Nitrate	14797-55-8					3.2E+03	7.3E+05		3.2E+03	1.0E+04
											1	0	Yes	Nitrate + Nitrite (as N)	E701177									1.0E+04
				1.0E-01	I						1	1	Yes	Nitrite	14797-65-0					2.0E+02	4.6E+04		2.0E+02	1.0E+03
				1.0E-02	X	5.0E-05	X			1.85	1	1	Yes	Nitroaniline, 2-	88-74-4					2.0E+01	3.4E+02		1.9E+01	
2.0E-02	P			4.0E-03	P	6.0E-03	P			1.39	1	1	Yes	Nitroaniline, 4-	100-01-6	3.9E+00	1.2E+02		3.8E+00	8.0E+00	2.8E+02		7.8E+00	
		4.0E-05	I	2.0E-03	I	9.0E-03	I	V		1.85	1	1	Yes	Nitrobenzene	98-95-3			1.4E-01	1.4E-01	4.0E+00	6.2E+01	1.9E+00	1.3E+00	
				3.0E+03	P					-4.56	1	1	No	Nitrocellulose	9004-70-0					6.0E+06			6.0E+06	
				7.0E-02	H					-0.47	1	1	Yes	Nitrofurantoin	67-20-9					1.4E+02	1.6E+05		1.4E+02	
1.3E+00	C	3.7E-04	C							0.23	1	1	Yes	Nitrofurazone	59-87-0	6.0E-02	1.7E+01		6.0E-02					
1.7E-02	P			1.0E-04	P					1.62	1	1	Yes	Nitroglycerin	55-63-0	4.6E+00	1.8E+02		4.5E+00	2.0E-01	8.7E+00		2.0E-01	
				1.0E-01	I					-0.89	1	1	Yes	Nitroguanidine	556-88-7					2.0E+02	1.8E+05		2.0E+02	
		8.8E-06	P			5.0E-03	P	V		-0.35	1	1	Yes	Nitromethane	75-52-5			6.4E-01	6.4E-01			1.0E+00	1.0E+00	
		2.7E-03	H			2.0E-02	I	V		0.93	1	1	Yes	Nitropropane, 2-	79-46-9			2.1E-03	2.1E-03			4.2E+00	4.2E+00	
2.7E+01	C	7.7E-03	C						M	0.23	1	1	Yes	Nitroso-N-ethylurea, N-	759-73-9	9.3E-04	1.5E-01		9.2E-04					
1.2E+02	C	3.4E-02	C						M	-0.03	1	1	Yes	Nitroso-N-methylurea, N-	684-93-5	2.1E-04	4.6E-02		2.1E-04					
5.4E+00	I	1.6E-03	I					V		2.63	1	1	Yes	Nitroso-di-N-butylamine, N-	924-16-3	1.4E-02	7.9E-02	3.5E-03	2.7E-03					
7.0E+00	I	2.0E-03	C							1.36	1	1	Yes	Nitroso-di-N-propylamine, N-	621-64-7	1.1E-02	3.5E-01		1.1E-02					
2.8E+00	I	8.0E-04	C							-1.28	1	1	Yes	Nitrosodiethanolamine, N-	1116-54-7	2.8E-02	8.1E+01		2.8E-02					
1.5E+02	I	4.3E-02	I						M	0.48	1	1	Yes	Nitrosodiethylamine, N-	55-18-5	1.7E-04	1.7E-02		1.7E-04					
5.1E+01	I	1.4E-02	I	8.0E-06	P	4.0E-05	X	V	M	-0.57	1	1	Yes	Nitrosodimethylamine, N-	62-75-9	4.9E-04	2.0E-01	1.4E-04	1.1E-04	1.6E-02	7.4E+00	8.3E-03	5.5E-03	
4.9E-03	I	2.6E-06	C							3.13	1	1	Yes	Nitrosodiphenylamine, N-	86-30-6	1.6E+01	5.2E+01		1.2E+01					
2.2E+01	I	6.3E-03	C					V		0.04	1	1	Yes	Nitrosomethylethylamine, N-	10595-95-6	3.5E-03	6.4E-01	8.9E-04	7.1E-04					
6.7E+00	C	1.9E-03	C							-0.44	1	1	Yes	Nitrosomorpholine [N-]	59-89-2	1.2E-02	5.3E+00		1.2E-02					
9.4E+00	C	2.7E-03	C							0.36	1	1	Yes	Nitrosopiperidine [N-]	100-75-4	8.3E-03	1.1E+00		8.2E-03					
2.1E+00	I	6.1E-04	I							-0.19	1	1	Yes	Nitrosopyrrolidine, N-	930-55-2	3.7E-02	1.0E+01		3.7E-02					
				1.0E-04	X					2.45	1	1	Yes	Nitrotoluene, m-	99-08-1					2.0E-01	1.4E+00		1.7E-01	
2.2E-01	P			9.0E-04	P			V		2.3	1	1	Yes	Nitrotoluene, o-	88-72-2	3.5E-01	2.8E+00		3.1E-01	1.8E+00	1.5E+01		1.6E+00	
1.6E-02	P			4.0E-03	P					2.37	1	1	Yes	Nitrotoluene, p-	99-99-0	4.9E+00	3.4E+01		4.3E+00	8.0E+00	6.2E+01		7.1E+00	
				3.0E-04	X	2.0E-02	P	V		5.65	1	1	No	Nonane, n-	111-84-2					6.0E-01		4.2E+00	5.3E-01	
				1.5E-02	O					2.3	1	1	Yes	Norflurazon	27314-13-2					3.0E+01	7.5E+02		2.9E+01	
				3.0E-03	I					8.71	1	0.3	No	Octabromodiphenyl Ether	32536-52-0					6.0E+00			6.0E+00	
				5.0E-02	I					0.16	1	1	Yes	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0					1.0E+02	6.3E+04		1.0E+02	
				2.0E-03	H					-1.01	1	1	Yes	Octamethylpyrophosphoramide	152-16-9					4.0E+00	1.4E+04		4.0E+00	
7.8E-03	O			1.4E-01	O					3.73	1	0.9	Yes	Oryzalin	19044-88-3	1.0E+01	3.8E+01		7.9E+00	2.8E+02	1.2E+03		2.3E+02	
				5.0E-03	I					4.8	1	0.8	Yes	Oxadiazon	19666-30-9					1.0E+01	9.0E+00		4.7E+00	
				2.5E-02	I					-0.47	1	1	Yes	Oxamyl	23135-22-0					5.0E+01	5.1E+04		5.0E+01	2.0E+02
7.3E-02	O			3.0E-02	O					4.73	1	0.8	Yes	Oxyfluorfen	42874-03-3	1.1E+00	1.1E+00		5.4E-01	6.0E+01	6.7E+01		3.2E+01	
				1.3E-02	I					3.2	1	0.9	Yes	Paclobutrazol	76738-62-0					2.6E+01	1.7E+02		2.3E+01	
				4.5E-03	I					-4.5	1	1	No	Paraquat Dichloride	1910-42-5					9.0E+00			9.0E+00	
				6.0E-03	H					3.83	1	0.9	Yes	Parathion	56-38-2					1.2E+01	3.0E+01		8.6E+00	
				5.0E-02	H			V		3.83	1	1	Yes	Pebulate	1114-71-2					1.0E+02	1.3E+02		5.6E+01	
				3.0E-02	O					5.2	1	0.9	Yes	Pendimethalin	40487-42-1					6.0E+01	1.8E+01		1.4E+01	
				2.0E-03	I			V		6.84	1	0.6	No	Pentabromodiphenyl Ether	32534-81-9					4.0E+00			4.0E+00	
				1.0E-04	I					7.66	1	0.6	No	Pentabromodiphenyl ether, 2,2',4,4',5- (BDE-99)	60348-60-9					2.0E-01			2.0E-01	
				8.0E-04	I			V		5.17	1	0.9	Yes	Pentachlorobenzene	608-93-5					1.6E+00	3.9E-01		3.2E-01	
9.0E-02	P							V		3.22	1	1	Yes	Pentachloroethane	76-01-7	8.7E-01	2.5E+00		6.5E-01					
2.6E-01	H			3.0E-03	I			V		4.64	1	0.9	Yes	Pentachloronitrobenzene	82-68-8	3.0E-01	2.0E-01		1.2E-01	6.0E+00	4.4E+00		2.6E+00	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
4.0E-01	I	5.1E-06	C	5.0E-03	I					5.12	1	0.9	Yes	Pentachlorophenol	87-86-5	1.9E-01	5.2E-02		4.1E-02	1.0E+01	2.9E+00		2.3E+00	1.0E+00
4.0E-03	X			2.0E-03	P					2.38	1	1	Yes	Pentaerythritol tetranitrate (PETN)	78-11-5	1.9E+01	4.3E+02		1.9E+01	4.0E+00	9.6E+01		3.9E+00	
						1.0E+00	P	V		3.39	1	1	Yes	Pentane, n-	109-66-0							2.1E+02	2.1E+02	
														Perchlorates										
				7.0E-04	I						1	1	Yes	~Ammonium Perchlorate	7790-98-9					1.4E+00	3.2E+02		1.4E+00	
				7.0E-04	I						1	1	Yes	~Lithium Perchlorate	7791-03-9					1.4E+00	3.2E+02		1.4E+00	
				7.0E-04	I						1	1	Yes	~Perchlorate and Perchlorate Salts	14797-73-0					1.4E+00	3.2E+02		1.4E+00	1.5E+01(F)
				7.0E-04	I						1	1	Yes	~Potassium Perchlorate	7778-74-7					1.4E+00	1.6E+02		1.4E+00	
				7.0E-04	I						1	1	Yes	~Sodium Perchlorate	7601-89-0					1.4E+00	3.2E+02		1.4E+00	
				2.0E-02	P						1	0	Yes	Perfluorobutane sulfonic acid (PFBS)	375-73-5					4.0E+01			4.0E+01	
				2.0E-02	P						1	0	Yes	Perfluorobutanesulfonate	45187-15-3					4.0E+01			4.0E+01	
				5.0E-02	I					6.5	1	0.6	No	Permethrin	52645-53-1					1.0E+02			1.0E+02	
2.2E-03	C	6.3E-07	C							1.58	1	1	Yes	Phenacetin	62-44-2	3.5E+01	1.1E+03		3.4E+01					
				2.4E-01	O					3.59	1	0.9	Yes	Phenmedipham	13684-63-4					4.8E+02	1.8E+03		3.8E+02	
				3.0E-01	I	2.0E-01	C			1.46	1	1	Yes	Phenol	108-95-2					6.0E+02	1.4E+04		5.8E+02	
				4.0E-03	I					1.52	1	1	Yes	Phenol, 2-(1-methylethoxy)-, methylcarbamate	114-26-1					8.0E+00	3.6E+02		7.8E+00	
				5.0E-04	X					4.15	1	1	Yes	Phenothiazine	92-84-2					1.0E+00	7.6E-01		4.3E-01	
				2.0E-04	X			V		3.28	1	1	Yes	Phenyl Isothiocyanate	103-72-0					4.0E-01	7.6E-01		2.6E-01	
				6.0E-03	I					-0.33	1	1	Yes	Phenylenediamine, m-	108-45-2					1.2E+01	4.8E+03		1.2E+01	
1.2E-01	P			4.0E-03	P					0.15	1	1	Yes	Phenylenediamine, o-	95-54-5	6.5E-01	1.1E+02		6.5E-01	8.0E+00	1.5E+03		8.0E+00	
				1.0E-03	X					-0.3	1	1	Yes	Phenylenediamine, p-	106-50-3					2.0E+00	7.6E+02		2.0E+00	
1.9E-03	H									3.09	1	1	Yes	Phenylphenol, 2-	90-43-7	4.0E+01	1.2E+02		3.0E+01					
				2.0E-04	H					3.56	1	0.9	Yes	Phorate	298-02-2					4.0E-01	1.2E+00		3.0E-01	
						3.0E-04	I	V		-0.71	1	1		Phosgene	75-44-5									
				2.0E-02	I					2.78	1	1	Yes	Phosmet	732-11-6					4.0E+01	5.3E+02		3.7E+01	
														Phosphates, Inorganic										
				4.9E+01	P						1	1	Yes	~Aluminum metaphosphate	13776-88-0					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	0	Yes	~Ammonium polyphosphate	68333-79-9					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Calcium pyrophosphate	7790-76-3					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Diammonium phosphate	7783-28-0					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Dicalcium phosphate	7757-93-9					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Dimagnesium phosphate	7782-75-4					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Dipotassium phosphate	7758-11-4					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Disodium phosphate	7558-79-4					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Monoaluminum phosphate	13530-50-2					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Monoammonium phosphate	7722-76-1					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Monocalcium phosphate	7758-23-8					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Monomagnesium phosphate	7757-86-0					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Monopotassium phosphate	7778-77-0					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Monosodium phosphate	7558-80-7					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Polyphosphoric acid	8017-16-1					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	0.9	Yes	~Potassium tripolyphosphate	13845-36-8					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Sodium acid pyrophosphate	7758-16-9					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Sodium aluminum phosphate (acidic)	7785-88-8					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	0	Yes	~Sodium aluminum phosphate (anhydrous)	10279-59-1					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	0.8	Yes	~Sodium aluminum phosphate (tetrahydrate)	10305-76-7					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	0.9	Yes	~Sodium hexametaphosphate	10124-56-8					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Sodium polyphosphate	68915-31-1					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Sodium trimetaphosphate	7785-84-4					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Sodium tripolyphosphate	7758-29-4					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Tetrapotassium phosphate	7320-34-5					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Tetrasodium pyrophosphate	7722-88-5					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	0.8	Yes	~Trialuminum sodium tetra decahydrogenoctaorthophosphate (dihydrate)	15136-87-5					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Tricalcium phosphate	7758-87-4					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Trimagnesium phosphate	7757-87-1					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Tripotassium phosphate	7778-53-2					9.7E+04	2.2E+07		9.7E+04	
				4.9E+01	P						1	1	Yes	~Trisodium phosphate	7601-54-9					9.7E+04	2.2E+07		9.7E+04	
				3.0E-04	I	3.0E-04	I	V		-0.27	1	1	Yes	Phosphine	7803-51-2					6.0E-01	1.4E+02	6.3E-02	5.7E-02	
				4.9E+01	P	1.0E-02	I				1	1	Yes	Phosphoric Acid	7664-38-2					9.7E+04	2.2E+07		9.7E+04	
				2.0E-05	I			V		3.08	1	1	Yes	Phosphorus, White	7723-14-0					4.0E-02	9.1E+00		4.0E-02	
														Phthalates										
1.4E-02	I	2.4E-06	C	2.0E-02	I					7.6	1	0.8	No	~Bis(2-ethylhexyl)phthalate	117-81-7	5.6E+00			5.6E+00	4.0E+01			4.0E+01	6.0E+00
1.9E-03	P			2.0E-01	I					4.73	1	0.9	Yes	~Butyl Benzyl Phthalate	85-68-7	4.1E+01	2.7E+01		1.6E+01	4.0E+02	2.9E+02		1.7E+02	
				1.0E+00	I					4.15	1	0.9	Yes	~Butylphthalyl Butylglycolate	85-70-1					2.0E+03	4.1E+03		1.3E+03	
				1.0E-01	I					4.5	1	0.9	Yes	~Dibutyl Phthalate	84-74-2					2.0E+02	1.6E+02		9.0E+01	
				8.0E-01	I					2.42	1	1	Yes	~Diethyl Phthalate	84-66-2					1.6E+03	2.0E+04		1.5E+03	
				1.0E-01	I			V		2.25	1	1	Yes	~Dimethylterephthalate	120-61-6					2.0E+02	2.7E+03		1.9E+02	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				1.0E-02	P					8.1	1	0	No	~Octyl Phthalate, di-N-	117-84-0					2.0E+01			2.0E+01	
				1.0E+00	H					2	1	1	Yes	~Phthalic Acid, P-	100-21-0					2.0E+03	3.3E+04		1.9E+03	
				2.0E+00	I	2.0E-02	C			1.6	1	1	Yes	~Phthalic Anhydride	85-44-9					4.0E+03	1.1E+05		3.9E+03	
				7.0E-02	I					1.9	1	1	Yes	Picloram	1918-02-1					1.4E+02	4.3E+03		1.4E+02	5.0E+02
				1.0E-04	X					0.93	1	1	Yes	Picramic Acid (2-Amino-4,6-dinitrophenol)	96-91-3					2.0E-01	2.1E+01		2.0E-01	
				9.0E-04	X					1.44	1	1	Yes	Picric Acid (2,4,6-Trinitrophenol)	88-89-1					1.8E+00	1.2E+02		1.8E+00	
				6.7E-05	O					4.2	1	0.9	Yes	Pirimiphos, Methyl	29232-93-7					1.3E-01	2.1E-01		8.1E-02	
3.0E+01	C	8.6E-03	C	7.0E-06	H						1	0	No	Polybrominated Biphenyls	59536-65-1	2.6E-03			2.6E-03	1.4E-02			1.4E-02	
														Polychlorinated Biphenyls (PCBs)										
7.0E-02	S	2.0E-05	S	7.0E-05	I			V		5.69	1	0	No	~Aroclor 1016	12674-11-2	1.1E+00		2.8E-01	2.2E-01	1.4E-01			1.4E-01	
2.0E+00	S	5.7E-04	S					V		4.65	1	1	Yes	~Aroclor 1221	11104-28-2	3.9E-02	1.2E-02	9.8E-03	4.7E-03					
2.0E+00	S	5.7E-04	S					V		4.4	1	1	Yes	~Aroclor 1232	11141-16-5	3.9E-02	1.2E-02	9.8E-03	4.7E-03					
2.0E+00	S	5.7E-04	S					V		6.34	1	0.7	No	~Aroclor 1242	53469-21-9	3.9E-02		9.8E-03	7.8E-03					
2.0E+00	S	5.7E-04	S					V		6.2	1	0	No	~Aroclor 1248	12672-29-6	3.9E-02		9.8E-03	7.8E-03					
2.0E+00	S	5.7E-04	S	2.0E-05	I			V		6.5	1	0.5	No	~Aroclor 1254	11097-69-1	3.9E-02		9.8E-03	7.8E-03	4.0E-02			4.0E-02	
2.0E+00	S	5.7E-04	S					V		7.55	1	0	No	~Aroclor 1260	11096-82-5	3.9E-02		9.8E-03	7.8E-03					
				6.0E-04	X			V		6.34	1	0.7	No	~Aroclor 5460	11126-42-4					1.2E+00			1.2E+00	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		8.27	1	0	No	~Heptachlorobiphenyl, 2,3,3',4,4',5,5'- (PCB 189)	39635-31-9	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		7.5	1	0	No	~Hexachlorobiphenyl, 2,3',4,4',5,5'- (PCB 167)	52663-72-6	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		7.6	1	0	No	~Hexachlorobiphenyl, 2,3,3',4,4',5'- (PCB 157)	69782-90-7	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		7.6	1	0	No	~Hexachlorobiphenyl, 2,3,3',4,4',5- (PCB 156)	38380-08-4	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+03	E	1.1E+00	E	2.3E-08	E	1.3E-06	E	V		7.41	1	0.1	No	~Hexachlorobiphenyl, 3,3',4,4',5,5'- (PCB 169)	32774-16-6	2.0E-05		4.9E-06	4.0E-06	4.7E-05		2.8E-04	4.0E-05	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		6.98	1	0.4	No	~Pentachlorobiphenyl, 2',3,4,4',5- (PCB 123)	65510-44-3	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		7.12	1	0.3	No	~Pentachlorobiphenyl, 2,3',4,4',5- (PCB 118)	31508-00-6	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		6.79	1	0.5	No	~Pentachlorobiphenyl, 2,3,3',4,4'- (PCB 105)	32598-14-4	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
3.9E+00	E	1.1E-03	E	2.3E-05	E	1.3E-03	E	V		6.98	1	0.4	No	~Pentachlorobiphenyl, 2,3,4,4',5- (PCB 114)	74472-37-0	2.0E-02		4.9E-03	4.0E-03	4.7E-02		2.8E-01	4.0E-02	
1.3E+04	E	3.8E+00	E	7.0E-09	E	4.0E-07	E	V		6.98	1	0.4	No	~Pentachlorobiphenyl, 3,3',4,4',5- (PCB 126)	57465-28-8	6.0E-06		1.5E-06	1.2E-06	1.4E-05		8.3E-05	1.2E-05	
2.0E+00	I	5.7E-04	I					V		7.1	1	0.7	No	~Polychlorinated Biphenyls (high risk)	1336-36-3	1.9E-01		5.6E-02	4.4E-02					5.0E-01
4.0E-01	I	1.0E-04	I					V		7.1	1	0.7		~Polychlorinated Biphenyls (low risk)	1336-36-3									5.0E-01
7.0E-02	I	2.0E-05	I					V		7.1	1	0.7		~Polychlorinated Biphenyls (lowest risk)	1336-36-3									5.0E-01
1.3E+01	E	3.8E-03	E	7.0E-06	E	4.0E-04	E			6.63	1	0.6	No	~Tetrachlorobiphenyl, 3,3',4,4'- (PCB 77)	32598-13-3	6.0E-03			6.0E-03	1.4E-02			1.4E-02	
3.9E+01	E	1.1E-02	E	2.3E-06	E	1.3E-04	E	V		6.34	1	0.7	No	~Tetrachlorobiphenyl, 3,4,4',5- (PCB 81)	70362-50-4	2.0E-03		4.9E-04	4.0E-04	4.7E-03		2.8E-02	4.0E-03	
						6.0E-04	I			10.46	1	0	No	Polymeric Methylene Diphenyl Diisocyanate (PMDI)	9016-87-9									
														Polynuclear Aromatic Hydrocarbons (PAHs)										
				6.0E-02	I			V		3.92	1	1	Yes	~Acenaphthene	83-32-9					1.2E+02	9.6E+01		5.3E+01	
				3.0E-01	I			V		4.45	1	1	Yes	~Anthracene	120-12-7					6.0E+02	2.5E+02		1.8E+02	
1.0E-01	E	6.0E-05	E					V	M	5.76	1	1	No	~Benz[a]anthracene	56-55-3	2.5E-01		3.4E-02	3.0E-02					
1.2E+00	C	1.1E-04	C							6.11	1	0.9	No	~Benzo(j)fluoranthene	205-82-3	6.5E-02			6.5E-02					
1.0E+00	I	6.0E-04	I	3.0E-04	I	2.0E-06	I		M	6.13	1	1	No	~Benzo[a]pyrene	50-32-8	2.5E-02			2.5E-02	6.0E-01			6.0E-01	2.0E-01
1.0E-01	E	6.0E-05	E						M	5.78	1	1	No	~Benzo[b]fluoranthene	205-99-2	2.5E-01			2.5E-01					
1.0E-02	E	6.0E-06	E						M	6.11	1	0.9	No	~Benzo[k]fluoranthene	207-08-9	2.5E+00			2.5E+00					
				8.0E-02	I			V		3.9	1	1	Yes	~Chloronaphthalene, Beta-	91-58-7					1.6E+02	1.4E+02		7.5E+01	
1.0E-03	E	6.0E-07	E						M	5.81	1	1	No	~Chrysene	218-01-9	2.5E+01			2.5E+01					
1.0E+00	E	6.0E-04	E						M	6.75	1	0.6	No	~Dibenz[a,h]anthracene	53-70-3	2.5E-02			2.5E-02					
1.2E+01	C	1.1E-03	C							7.71	1	0.3	No	~Dibenzo(a,e)pyrene	192-65-4	6.5E-03			6.5E-03					
2.5E+02	C	7.1E-02	C						M	5.8	1	0.9	No	~Dimethylbenz(a)anthracene, 7,12-	57-97-6	1.0E-04			1.0E-04					
				4.0E-02	I					5.16	1	1	No	~Fluoranthene	206-44-0					8.0E+01			8.0E+01	
				4.0E-02	I			V		4.18	1	1	Yes	~Fluorene	86-73-7					8.0E+01	4.6E+01		2.9E+01	
1.0E-01	E	6.0E-05	E						M	6.7	1	0.6	No	~Indeno[1,2,3-cd]pyrene	193-39-5	2.5E-01			2.5E-01					
2.9E-02	P			7.0E-02	A			V		3.87	1	1	Yes	~Methylnaphthalene, 1-	90-12-0	2.7E+00	2.0E+00		1.1E+00	1.4E+02	1.1E+02		6.2E+01	
				4.0E-03	I			V		3.86	1	1	Yes	~Methylnaphthalene, 2-	91-57-6					8.0E+00	6.5E+00		3.6E+00	
		3.4E-05	C	2.0E-02	I	3.0E-03	I	V		3.3	1	1	Yes	~Naphthalene	91-20-3			1.7E-01	1.7E-01	4.0E+01	7.0E+01	6.3E-01	6.1E-01	
1.2E+00	C	1.1E-04	C							4.75	1	0.9	Yes	~Nitropyrene, 4-	57835-92-4	6.5E-02	2.7E-02		1.9E-02					
				3.0E-02	I			V		4.88	1	1	Yes	~Pyrene	129-00-0					6.0E+01	1.5E+01		1.2E+01	
				2.0E-02	P						1	0	Yes	Potassium Perfluorobutane Sulfonate	29420-49-3					4.0E+01			4.0E+01	
1.5E-01	I			9.0E-03	I					4.1	1	0.9	Yes	Prochloraz	67747-09-5	5.2E-01	1.4E+00		3.8E-01	1.8E+01	5.1E+01		1.3E+01	
				6.0E-03	H			V		5.58	1	0.8	Yes	Profluralin	26399-36-0					1.2E+01	3.3E+00		2.6E+00	
				1.5E-02	I					2.99	1	1	Yes	Prometon	1610-18-0					3.0E+01	1.6E+02		2.5E+01	
				4.0E-02	O					3.51	1	0.9	Yes	Prometryn	7287-19-6					8.0E+01	2.3E+02		6.0E+01	
				1.3E-02	I					2.18	1	1	Yes	Propachlor	1918-16-7					2.6E+01	4.3E+02		2.5E+01	
				5.0E-03	I					3.07	1	1	Yes	Propanil	709-98-8					1.0E+01	4.4E+01		8.2E+00	
3.3E-02	O			4.0E-02	O					5	1	0.8	Yes	Propargite	2312-35-8	2.4E+00	1.5E+00		9.2E-01	8.0E+01	5.5E+01		3.3E+01	
				2.0E-03	I			V		-0.38	1	1	Yes	Propargyl Alcohol	107-19-7					4.0E+00	1.2E+03		4.0E+00	
				2.0E-02	I					2.93	1	1	Yes	Propazine	139-40-2					4.0E+01	2.4E+02		3.4E+01	
				2.0E-02	I					2.6	1	1	Yes	Propham	122-42-9					4.0E+01	2.8E+02		3.5E+01	
				1.0E-01	O					3.72	1	0.9	Yes	Propiconazole	60207-90-1					2.0E+02	8.2E+02		1.6E+02	
						8.0E-03	I	V		0.59	1	1	Yes	Propionaldehyde	123-38-6							1.7E+00	1.7E+00	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				1.0E-01	X	1.0E+00	X	V		3.69	1	1	Yes	Propyl benzene	103-65-1					2.0E+02	1.8E+02	2.1E+02	6.6E+01	
						3.0E+00	C	V		1.77	1	1	Yes	Propylene	115-07-1							6.3E+02	6.3E+02	
				2.0E+01	P					-0.92	1	1	Yes	Propylene Glycol	57-55-6					4.0E+04	3.2E+07		4.0E+04	
						2.7E-04	A			1.83	1	1	Yes	Propylene Glycol Dinitrate	6423-43-4									
				7.0E-01	H	2.0E+00	I	V		-0.49	1	1	Yes	Propylene Glycol Monomethyl Ether	107-98-2					1.4E+03	3.9E+05	4.2E+02	3.2E+02	
2.4E-01	I	3.7E-06	I			3.0E-02	I	V		0.03	1	1	Yes	Propylene Oxide	75-56-9	3.2E-01	4.7E+01	1.5E+00	2.7E-01			6.3E+00	6.3E+00	
				7.5E-02	I					3.43	1	0.9	Yes	Propyzamide	23950-58-5					1.5E+02	5.5E+02		1.2E+02	
				1.0E-03	I			V		0.65	1	1	Yes	Pyridine	110-86-1					2.0E+00	1.5E+02		2.0E+00	
				5.0E-04	I					4.44	1	0.9	Yes	Quinalphos	13593-03-8					1.0E+00	1.0E+00		5.1E-01	
3.0E+00	I									2.03	1	1	Yes	Quinoline	91-22-5	2.6E-02	2.9E-01		2.4E-02					
				9.0E-03	I					4.28	1	0.9	Yes	Quizalofop-ethyl	76578-14-8					1.8E+01	3.8E+01		1.2E+01	
						3.0E-02	A				1	0	Yes	Refractory Ceramic Fibers	E715557									
				3.0E-02	I					6.14	1	0.7	Yes	Resmethrin	10453-86-8					6.0E+01	7.6E+00		6.7E+00	
				5.0E-02	H			V		4.88	1	0.8	Yes	Ronnel	299-84-3					1.0E+02	6.8E+01		4.1E+01	
				4.0E-03	I					4.1	1	0.9	Yes	Rotenone	83-79-4					8.0E+00	2.6E+01		6.1E+00	
2.2E-01	C	6.3E-05	C						M	3.45	1	1	Yes	Safrole	94-59-7	1.1E-01	6.0E-01		9.6E-02					
				5.0E-03	I						1	1	Yes	Selenious Acid	7783-00-8					1.0E+01	2.3E+03		1.0E+01	
				5.0E-03	I	2.0E-02	C				1	1	Yes	Selenium	7782-49-2					1.0E+01	2.3E+03		1.0E+01	5.0E+01
				5.0E-03	C	2.0E-02	C				1	1	Yes	Selenium Sulfide	7446-34-6					1.0E+01	2.3E+03		1.0E+01	
				1.4E-01	O					4.38	1	0.9	Yes	Sethoxydim	74051-80-2					2.8E+02	3.8E+02		1.6E+02	
						3.0E-03	C				1	1	Yes	Silica (crystalline, respirable)	7631-86-9									
				5.0E-03	I						0.04	1	Yes	Silver	7440-22-4					1.0E+01	1.5E+02		9.4E+00	
1.2E-01	H			5.0E-03	I					2.18	1	1	Yes	Simazine	122-34-9	6.5E-01	9.3E+00		6.1E-01	1.0E+01	1.6E+02		9.4E+00	4.0E+00
				1.3E-02	I					0.37	1	1	Yes	Sodium Acifluorfen	62476-59-9					2.6E+01	2.1E+04		2.6E+01	
				4.0E-03	I						1	1	Yes	Sodium Azide	26628-22-8					8.0E+00	1.8E+03		8.0E+00	
2.7E-01	H			3.0E-02	I					-1.43	1	1	Yes	Sodium Diethyldithiocarbamate	148-18-5	2.9E-01	8.5E+02		2.9E-01	6.0E+01	1.9E+05		6.0E+01	
				5.0E-02	A	1.3E-02	C				1	1	Yes	Sodium Fluoride	7681-49-4					1.0E+02	2.3E+04		1.0E+02	
				2.0E-05	I					-3.78	1	1	No	Sodium Fluoroacetate	62-74-8					4.0E-02			4.0E-02	
				1.0E-03	H						1	1	Yes	Sodium Metavanadate	13718-26-8					2.0E+00	4.6E+02		2.0E+00	
				8.0E-04	P						1	1	Yes	Sodium Tungstate	13472-45-2					1.6E+00	3.6E+02		1.6E+00	
				8.0E-04	P						1	1	Yes	Sodium Tungstate Dihydrate	10213-10-2					1.6E+00	3.6E+02		1.6E+00	
2.4E-02	H			3.0E-02	I					3.53	1	0.9	Yes	Stirofos (Tetrachlorovinphos)	961-11-5	3.2E+00	1.9E+01		2.8E+00	6.0E+01	3.8E+02		5.2E+01	
				6.0E-01	I						1	1	Yes	Strontium, Stable	7440-24-6					1.2E+03	2.7E+05		1.2E+03	
				3.0E-04	I					1.93	1	1	Yes	Strychnine	57-24-9					6.0E-01	3.2E+01		5.9E-01	
				2.0E-01	I	1.0E+00	I	V		2.95	1	1	Yes	Styrene	100-42-5					4.0E+02	1.0E+03	2.1E+02	1.2E+02	1.0E+02
				3.0E-03	P					3.1	1	1	Yes	Styrene-Acrylonitrile (SAN) Trimer						6.0E+00	2.4E+01		4.8E+00	
				1.0E-03	P	2.0E-03	X			-0.77	1	1	Yes	Sulfolane	126-33-0					2.0E+00	1.7E+03		2.0E+00	
				8.0E-04	P					3.9	1	0.9	Yes	Sulfonylbis(4-chlorobenzene), 1,1'-	80-07-9					1.6E+00	3.5E+00		1.1E+00	
						1.0E-03	C	V			1	1	Yes	Sulfur Trioxide	7446-11-9							2.1E-01	2.1E-01	
						1.0E-03	C				1	1	Yes	Sulfuric Acid	7664-93-9									
2.5E-02	I	7.1E-06	I	5.0E-02	H					4.82	1	0.8	Yes	Sulfurous acid, 2-chloroethyl 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester	140-57-8	3.1E+00	2.3E+00		1.3E+00	1.0E+02	8.2E+01		4.5E+01	
				3.0E-02	H					3.3	1	0.9	Yes	TCMTB	21564-17-0					6.0E+01	2.4E+02		4.8E+01	
				7.0E-02	I					1.79	1	1	Yes	Tebuthiuron	34014-18-1					1.4E+02	4.7E+03		1.4E+02	
				2.0E-02	H					5.96	1	0.7	No	Temephos	3383-96-8					4.0E+01			4.0E+01	
				1.3E-02	I					1.89	1	1	Yes	Terbacil	5902-51-2					2.6E+01	7.0E+02		2.5E+01	
				2.5E-05	H			V		4.48	1	0.9	Yes	Terbufos	13071-79-9					5.0E-02	4.5E-02		2.4E-02	
				1.0E-03	I					3.74	1	0.9	Yes	Terbutryn	886-50-0					2.0E+00	4.1E+00		1.3E+00	
				1.0E-04	I					6.77	1	0.6	No	Tetrabromodiphenyl ether, 2,2',4,4'- (BDE-47)	5436-43-1					2.0E-01			2.0E-01	
				3.0E-04	I			V		4.64	1	1	Yes	Tetrachlorobenzene, 1,2,4,5-	95-94-3					6.0E-01	2.4E-01		1.7E-01	
2.6E-02	I	7.4E-06	I	3.0E-02	I			V		2.93	1	1	Yes	Tetrachloroethane, 1,1,1,2-	630-20-6	3.0E+00	1.1E+01	7.6E-01	5.7E-01	6.0E+01	2.4E+02		4.8E+01	
2.0E-01	I	5.8E-05	C	2.0E-02	I			V		2.39	1	1	Yes	Tetrachloroethane, 1,1,2,2-	79-34-5	3.9E-01	3.3E+00	9.7E-02	7.6E-02	4.0E+01	3.6E+02		3.6E+01	
2.1E-03	I	2.6E-07	I	6.0E-03	I	4.0E-02	I	V		3.4	1	1	Yes	Tetrachloroethylene	127-18-4	3.7E+01	6.5E+01	2.2E+01	1.1E+01	1.2E+01	2.3E+01	8.3E+00	4.1E+00	5.0E+00
				3.0E-02	I					4.45	1	0.9	Yes	Tetrachlorophenol, 2,3,4,6-	58-90-2					6.0E+01	3.9E+01		2.4E+01	
2.0E+01	H							V		4.54	1	0.9	Yes	Tetrachlorotoluene, p- alpha, alpha, alpha-	5216-25-1	3.9E-03	2.0E-03		1.3E-03					
				5.0E-04	I					3.99	1	0.9	Yes	Tetraethyl Dithiopyrophosphate	3689-24-5					1.0E+00	2.4E+00		7.1E-01	
						8.0E+01	I	V		1.68	1	1	Yes	Tetrafluoroethane, 1,1,1,2-	811-97-2							1.7E+04	1.7E+04	
				2.0E-03	P					1.64	1	1	Yes	Tetryl (Trinitrophenylmethylnitramine)	479-45-8					4.0E+00	2.5E+02		3.9E+00	
				2.0E-05	S						1	0.9	Yes	Thallic Oxide	1314-32-5					4.0E-02	9.1E+00		4.0E-02	
				1.0E-05	X						1	1	Yes	Thallium (I) Nitrate	10102-45-1					2.0E-02	4.6E+00		2.0E-02	
				1.0E-05	X						1	1	Yes	Thallium (Soluble Salts)	7440-28-0					2.0E-02	4.6E+00		2.0E-02	2.0E+00
				1.0E-05	X			V		-0.17	1	1	Yes	Thallium Acetate	563-68-8					2.0E-02	1.7E+01		2.0E-02	
				2.0E-05	X			V		-0.86	1	1	Yes	Thallium Carbonate	6533-73-9					4.0E-02	9.3E+03		4.0E-02	
				1.0E-05	X						1	1	Yes	Thallium Chloride	7791-12-0					2.0E-02	4.6E+00		2.0E-02	
				1.0E-05	S						1	1	Yes	Thallium Selenite	12039-52-0					2.0E-02	4.6E+00		2.0E-02	
				2.0E-05	X						1	0.9	Yes	Thallium Sulfate	7446-18-6					4.0E-02	9.1E+00		4.0E-02	
				4.3E-02	O					1.56	1	1	Yes	Thifensulfuron-methyl	79277-27-3					8.6E+01	1.2E+04		8.6E+01	
				1.0E-02	I					3.4	1	0.9	Yes	Thiobencarb	28249-77-6					2.0E+01	7.7E+01		1.6E+01	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD$_o$ (mg/kg-day)	key	RfC$_i$ (mg/m^3)	key	vol	mutagen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
				7.0E-02	X					-0.63	1	1	Yes	Thiodiglycol	111-48-8					1.4E+02	9.7E+04		1.4E+02	
				3.0E-04	H					2.16	1	1	Yes	Thiofanox	39196-18-4					6.0E-01	4.4E+00		5.3E-01	
1.2E-02	O			2.7E-02	O					1.4	1	1	Yes	Thiophanate, Methyl	23564-05-8	6.7E+00	7.9E+02		6.7E+00	5.4E+01	6.8E+03		5.3E+01	
				1.5E-02	O					1.73	1	1	Yes	Thiram	137-26-8					3.0E+01	1.2E+03		2.9E+01	
				6.0E-01	H						1	1	Yes	Tin	7440-31-5					1.2E+03	2.7E+05		1.2E+03	
						1.0E-04	A	V			1	1	Yes	Titanium Tetrachloride	7550-45-0							2.1E-02	2.1E-02	
				8.0E-02	I	5.0E+00	I	V		2.73	1	1	Yes	Toluene	108-88-3					1.6E+02	5.3E+02	1.0E+03	1.1E+02	1.0E+03
		1.1E-05	C			8.0E-06	C	V		3.74	1	1	Yes	Toluene-2,4-diisocyanate	584-84-9			5.1E-01	5.1E-01			1.7E-03	1.7E-03	
1.8E-01	X			2.0E-04	X					0.16	1	1	Yes	Toluene-2,5-diamine	95-70-5	4.3E-01	8.2E+01		4.3E-01	4.0E-01	8.3E+01		4.0E-01	
		1.1E-05	C			8.0E-06	C	V		3.74	1	1	Yes	Toluene-2,6-diisocyanate	91-08-7			5.1E-01	5.1E-01			1.7E-03	1.7E-03	
				5.0E-03	P					2.27	1	1	Yes	Toluic Acid, p-	99-94-5					1.0E+01	8.9E+01		9.0E+00	
1.6E-02	P	5.1E-05	C							1.32	1	1	Yes	Toluidine, o- (Methylaniline, 2-)	95-53-4	4.9E+00	1.4E+02		4.7E+00					
3.0E-02	P			4.0E-03	X					1.39	1	1	Yes	Toluidine, p-	106-49-0	2.6E+00	6.8E+01		2.5E+00	8.0E+00	2.3E+02		7.7E+00	
				3.0E+00	P			V		6.1	1	1	No	Total Petroleum Hydrocarbons (Aliphatic High)	E1790670					6.0E+03			6.0E+03	
						6.0E-01	P	V		3.9	1	1	Yes	Total Petroleum Hydrocarbons (Aliphatic Low)	E1790666							1.3E+02	1.3E+02	
				1.0E-02	X	1.0E-01	P	V		5.65	1	1	No	Total Petroleum Hydrocarbons (Aliphatic Medium)	E1790668					2.0E+01		2.1E+01	1.0E+01	
				4.0E-02	P					5.16	1	1	No	Total Petroleum Hydrocarbons (Aromatic High)	E1790676					8.0E+01			8.0E+01	
				4.0E-03	P	3.0E-02	P	V		2.13	1	1	Yes	Total Petroleum Hydrocarbons (Aromatic Low)	E1790672					8.0E+00	6.1E+01	6.3E+00	3.3E+00	
				4.0E-03	P	3.0E-03	P	V		3.58	1	1	Yes	Total Petroleum Hydrocarbons (Aromatic Medium)	E1790674					8.0E+00	9.0E+00	6.3E-01	5.5E-01	
1.1E+00	I	3.2E-04	I							5.9	1	0.8	No	Toxaphene	8001-35-2	7.1E-02			7.1E-02					3.0E+00
				7.5E-03	I					7.56	1	0.5	No	Tralomethrin	66841-25-6					1.5E+01			1.5E+01	
				3.0E-04	A			V		4.1	1	0.9	Yes	Tri-n-butyltin	688-73-3					6.0E-01	9.9E-01		3.7E-01	
				8.0E+01	X					0.25	1	1	Yes	Triacetin	102-76-1					1.6E+05	5.3E+07		1.6E+05	
				3.4E-02	O					2.77	1	1	Yes	Triadimefon	43121-43-3					6.8E+01	7.8E+02		6.3E+01	
7.2E-02	O			2.5E-02	O			V		4.6	1	0.9	Yes	Triallate	2303-17-5	1.1E+00	8.3E-01		4.7E-01	5.0E+01	4.2E+01		2.3E+01	
				1.0E-02	I					1.1	1	1	Yes	Triasulfuron	82097-50-5					2.0E+01	6.0E+03		2.0E+01	
				8.0E-03	I					0.78	1	1	Yes	Tribenuron-methyl	101200-48-0					1.6E+01	5.0E+02		1.6E+01	
				5.0E-03	I			V		4.66	1	0.9	Yes	Tribromobenzene, 1,2,4-	615-54-3					1.0E+01	8.1E+00		4.5E+00	
				9.0E-03	X					4.13	1	0.9	Yes	Tribromophenol, 2,4,6-	118-79-6					1.8E+01	3.7E+01		1.2E+01	
9.0E-03	P			1.0E-02	P					4	1	0.9	Yes	Tributyl Phosphate	126-73-8	8.7E+00	1.3E+01		5.2E+00	2.0E+01	3.3E+01		1.2E+01	
				3.0E-04	P						1	0	No	Tributyltin Compounds	E1790678					6.0E-01			6.0E-01	
				3.0E-04	I					4.05	1	1	Yes	Tributyltin Oxide	56-35-9					6.0E-01	9.5E+00		5.7E-01	
				3.0E+01	I	5.0E+00	P	V		3.16	1	1	Yes	Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1					6.0E+04	1.9E+05	1.0E+03	1.0E+03	
7.0E-02	I			2.0E-02	I					1.33	1	1	Yes	Trichloroacetic Acid	76-03-9	1.1E+00	4.6E+01		1.1E+00	4.0E+01	1.8E+03		3.9E+01	6.0E+01
2.9E-02	H									-0.67	1	1	Yes	Trichloroaniline HCl, 2,4,6-	33663-50-2	2.7E+00	3.7E+03		2.7E+00					
7.0E-03	X			3.0E-05	X					3.52	1	1	Yes	Trichloroaniline, 2,4,6-	634-93-5	1.1E+01	2.0E+01		7.1E+00	6.0E-02	1.2E-01		4.0E-02	
				8.0E-04	X			V		4.05	1	1	Yes	Trichlorobenzene, 1,2,3-	87-61-6					1.6E+00	1.3E+00		7.0E-01	
2.9E-02	P			1.0E-02	I	2.0E-03	P	V		4.02	1	1	Yes	Trichlorobenzene, 1,2,4-	120-82-1	2.7E+00	2.0E+00		1.2E+00	2.0E+01	1.6E+01	4.2E-01	4.0E-01	7.0E+01
				2.0E+00	I	5.0E+00	I	V		2.49	1	1	Yes	Trichloroethane, 1,1,1-	71-55-6					4.0E+03	2.5E+04	1.0E+03	8.0E+02	2.0E+02
5.7E-02	I	1.6E-05	I	4.0E-03	I	2.0E-04	X	V		1.89	1	1	Yes	Trichloroethane, 1,1,2-	79-00-5	1.4E+00	2.0E+01	3.5E-01	2.8E-01	8.0E+00	1.3E+02	4.2E-02	4.1E-02	5.0E+00
4.6E-02	I	4.1E-06	I	5.0E-04	I	2.0E-03	I	V	M	2.42	1	1	Yes	Trichloroethylene	79-01-6	1.2E+00	7.4E+00	9.6E-01	4.9E-01	1.0E+00	6.9E+00	4.2E-01	2.8E-01	5.0E+00
				3.0E-01	I			V		2.53	1	1	Yes	Trichlorofluoromethane	75-69-4					6.0E+02	3.6E+03		5.2E+02	
				1.0E-01	I					3.72	1	1	Yes	Trichlorophenol, 2,4,5-	95-95-4					2.0E+02	2.9E+02		1.2E+02	
1.1E-02	I	3.1E-06	I	1.0E-03	P					3.69	1	1	Yes	Trichlorophenol, 2,4,6-	88-06-2	7.1E+00	9.8E+00		4.1E+00	2.0E+00	3.0E+00		1.2E+00	
				1.0E-02	I					3.31	1	0.9	Yes	Trichlorophenoxyacetic Acid, 2,4,5-	93-76-5					2.0E+01	8.7E+01		1.6E+01	
				8.0E-03	I					3.8	1	0.9	Yes	Trichlorophenoxypropionic acid, -2,4,5	93-72-1					1.6E+01	3.6E+01		1.1E+01	5.0E+01
				5.0E-03	I			V		2.43	1	1	Yes	Trichloropropane, 1,1,2-	598-77-6					1.0E+01	7.5E+01		8.8E+00	
3.0E+01	I			4.0E-03	I	3.0E-04	I	V	M	2.27	1	1	Yes	Trichloropropane, 1,2,3-	96-18-4	8.4E-04	7.3E-03		7.5E-04	8.0E+00	7.7E+01	6.3E-02	6.2E-02	
				3.0E-03	X	3.0E-04	P	V		2.78	1	1	Yes	Trichloropropene, 1,2,3-	96-19-5					6.0E+00	2.6E+01	6.3E-02	6.2E-02	
				2.0E-02	A					5.11	1	0.8	Yes	Tricresyl Phosphate (TCP)	1330-78-5					4.0E+01	2.6E+01		1.6E+01	
				3.0E-03	I					5.18	1	0.8	Yes	Tridiphane	58138-08-2					6.0E+00	2.6E+00		1.8E+00	
						7.0E-03	I	V		1.45	1	1	Yes	Triethylamine	121-44-8							1.5E+00	1.5E+00	
				2.0E+00	P					-1.75	1	1	Yes	Triethylene Glycol	112-27-6					4.0E+03	1.8E+07		4.0E+03	
						2.0E+01	P	V		1.74	1	1	Yes	Trifluoroethane, 1,1,1-	420-46-2							4.2E+03	4.2E+03	
7.7E-03	I			7.5E-03	I			V		5.34	1	0.8	Yes	Trifluralin	1582-09-8	1.0E+01	3.4E+00		2.6E+00	1.5E+01	5.5E+00		4.0E+00	
2.0E-02	P			1.0E-02	P					-0.65	1	1	Yes	Trimethyl Phosphate	512-56-1	3.9E+00	2.8E+03		3.9E+00	2.0E+01	1.6E+04		2.0E+01	
				1.0E-02	I	6.0E-02	I	V		3.66	1	1	Yes	Trimethylbenzene, 1,2,3-	526-73-8					2.0E+01	1.9E+01	1.3E+01	5.5E+00	
				1.0E-02	I	6.0E-02	I	V		3.63	1	1	Yes	Trimethylbenzene, 1,2,4-	95-63-6					2.0E+01	2.0E+01	1.3E+01	5.6E+00	
				1.0E-02	I	6.0E-02	I	V		3.42	1	1	Yes	Trimethylbenzene, 1,3,5-	108-67-8					2.0E+01	2.8E+01	1.3E+01	6.0E+00	
				1.0E-02	X			V		4.08	1	1	Yes	Trimethylpentene, 2,4,4-	25167-70-8					2.0E+01	9.6E+00		6.5E+00	
				3.0E-02	I					1.18	1	1	Yes	Trinitrobenzene, 1,3,5-	99-35-4					6.0E+01	4.7E+03		5.9E+01	
3.0E-02	I			5.0E-04	I					1.6	1	1	Yes	Trinitrotoluene, 2,4,6-	118-96-7	2.6E+00	1.1E+02		2.5E+00	1.0E+00	4.5E+01		9.8E-01	
				2.0E-02	P					2.83	1	1	Yes	Triphenylphosphine Oxide	791-28-6					4.0E+01	3.8E+02		3.6E+01	
				2.0E-02	A					3.65	1	0.9	Yes	Tris(1,3-Dichloro-2-propyl) Phosphate	13674-87-8					4.0E+01	3.2E+02		3.6E+01	
				1.0E-02	X					2.59	1	1	Yes	Tris(1-chloro-2-propyl)phosphate	13674-84-5					2.0E+01	3.8E+02		1.9E+01	
2.3E+00	C	6.6E-04	C					V		4.29	1	1	No	Tris(2,3-dibromopropyl)phosphate	126-72-7	3.4E-02		8.5E-03	6.8E-03					
2.0E-02	P			7.0E-03	P					1.44	1	1	Yes	Tris(2-chloroethyl)phosphate	115-96-8	3.9E+00	3.0E+02		3.8E+00	1.4E+01	1.2E+03		1.4E+01	

Key: I = IRIS; P = PPRTV; D = DWSHA; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #29); H = HEAST; F = See FAQ; E = see user guide Section 2.3.5; W = see user guide Section 2.3.6; L = see user guide on lead; M = mutagen; S = see user guide Section 5; V = volatile; R = RBA applied (See User Guide for Arsenic notice) ; c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide)

Toxicity and Chemical-specific Information														Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer CHILD Hazard Index (HI) = 0.1				
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD_o (mg/kg-day)	key	RfC_i (mg/m^3)	key	vol	muta-gen	LOGP	GIABS	FA	In EPD?	Analyte	CAS No.	Ingestion SL TR=1E-06 (ug/L)	Dermal SL TR=1E-06 (ug/L)	Inhalation SL TR=1E-06 (ug/L)	Carcinogenic SL TR=1E-06 (ug/L)	Ingestion SL Child THQ=0.1 (ug/L)	Dermal SL Child THQ=0.1 (ug/L)	Inhalation SL Child THQ=0.1 (ug/L)	Noncarcinogenic SL Child THI=0.1 (ug/L)	MCL (ug/L)
3.2E-03	P			1.0E-01	P					9.49	1	0	No	Tris(2-ethylhexyl)phosphate	78-42-2	2.4E+01			2.4E+01	2.0E+02			2.0E+02	
				8.0E-04	P						1	1	Yes	Tungsten	7440-33-7					1.6E+00	3.6E+02		1.6E+00	
				2.0E-04	A	4.0E-05	A				1	1	Yes	Uranium (Soluble Salts)	E715565					4.0E-01	9.1E+01		4.0E-01	3.0E+01
1.0E+00	C	2.9E-04	C						M	-0.15	1	1	Yes	Urethane	51-79-6	2.5E-02	6.1E+00		2.5E-02					
		8.3E-03	P	9.0E-03	I	7.0E-06	P				0.026	1	Yes	Vanadium Pentoxide	1314-62-1					1.8E+01	1.1E+02		1.5E+01	
				5.0E-03	S	1.0E-04	A				0.026	1	Yes	Vanadium and Compounds	7440-62-2					1.0E+01	6.0E+01		8.6E+00	
				1.0E-03	I			V		3.84	1	1	Yes	Vernolate	1929-77-7					2.0E+00	2.5E+00		1.1E+00	
				1.2E-03	O					3.1	1	0.9	Yes	Vinclozolin	50471-44-8					2.4E+00	1.8E+01		2.1E+00	
				1.0E+00	H	2.0E-01	I	V		0.73	1	1	Yes	Vinyl Acetate	108-05-4					2.0E+03	1.4E+05	4.2E+01	4.1E+01	
		3.2E-05	H			3.0E-03	I	V		1.57	1	1	Yes	Vinyl Bromide	593-60-2			1.8E-01	1.8E-01			6.3E-01	6.3E-01	
7.2E-01	I	4.4E-06	I	3.0E-03	I	1.0E-01	I	V	M	1.38	1	1	Yes	Vinyl Chloride	75-01-4	2.1E-02	2.8E-01	3.4E-01	1.9E-02	6.0E+00	8.9E+01	2.1E+01	4.4E+00	2.0E+00
				3.0E-04	I					2.7	1	1	Yes	Warfarin	81-81-2					6.0E-01	8.4E+00		5.6E-01	
				2.0E-01	S	1.0E-01	S	V		3.15	1	1	Yes	Xylene, P-	106-42-3					4.0E+02	7.6E+02	2.1E+01	1.9E+01	
				2.0E-01	S	1.0E-01	S	V		3.2	1	1	Yes	Xylene, m-	108-38-3					4.0E+02	7.1E+02	2.1E+01	1.9E+01	
				2.0E-01	S	1.0E-01	S	V		3.12	1	1	Yes	Xylene, o-	95-47-6					4.0E+02	8.0E+02	2.1E+01	1.9E+01	
				2.0E-01	I	1.0E-01	I	V		3.16	1	1	Yes	Xylenes	1330-20-7					4.0E+02	7.5E+02	2.1E+01	1.9E+01	1.0E+04
				3.0E-04	I						1	1	Yes	Zinc Phosphide	1314-84-7					6.0E-01	2.3E+02		6.0E-01	
				3.0E-01	I						1	1	Yes	Zinc and Compounds	7440-66-6					6.0E+02	2.3E+05		6.0E+02	
				5.0E-02	I					1.3	1	1	Yes	Zineb	12122-67-7					1.0E+02	9.7E+03		9.9E+01	
				8.0E-05	X						1	1	Yes	Zirconium	7440-67-7					1.6E-01	3.6E+01		1.6E-01	

Appendix D

Groundwater Sampling Schedules (2019-2020)

April 2019
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	Sulfate	VOC	DNT	Well Type	Sample Frequency
WE-ZE512	437	Central			1	1	Residential Well	Quarterly
Purcell-D	163	DBG			1	1	Residential Well	Quarterly
ELN-8203A	210	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-8203B	211	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-8203C	212	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8901	216	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8907	220	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8908	221	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8909	222	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-8902B	224	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-9107A	227	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-9107B	228	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-9402AR	231	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-9501	234	DBG			1	1	Monitoring Well	Semi-Annual
S1134R	236	DBG		1	1	1	Monitoring Well	Semi-Annual
DBM-8201	301	DBG		1	1	1	Monitoring Well	Semi-Annual
DBM-8202	302	DBG		1	1	1	Monitoring Well	Semi-Annual
DBM-8903	306	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501A	314	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501B	315	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501C	316	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501E	317	DBG			1	1	Monitoring Well	Semi-Annual
ELN-0801B	455	DBG			1	1	Monitoring Well	Semi-Annual
ELN-0801C	456	DBG			1	1	Monitoring Well	Semi-Annual
ELN-0801E	457	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1001B	460	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1001C	461	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1001E	462	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002A	463	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002B	464	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002C	465	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002E	466	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1003A	467	DBG			1	1	Monitoring Well	Quarterly
ELN-1003B	468	DBG			1	1	Monitoring Well	Quarterly
ELN-1003C	469	DBG			1	1	Monitoring Well	Quarterly
ELN-1003E	470	DBG			1	1	Monitoring Well	Quarterly
DBN-1001B	472	DBG			1	1	Monitoring Well	Semi-Annual
DBN-1001C	473	DBG			1	1	Monitoring Well	Semi-Annual
DBN-1001E	474	DBG			1	1	Monitoring Well	Semi-Annual
DBN-1002C	476	DBG		1	1	1	Monitoring Well	Semi-Annual
DBN-1002E	477	DBG		1	1	1	Monitoring Well	Semi-Annual
S1121	755	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1502A	533	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1502C	534	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1503A	535	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1503C	536	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1504B	537	DBG			1	1	Monitoring Well	Quarterly
RIM-0705	442	NC Area				1	Monitoring Well	Semi-Annual
RIM-1002	478	NC Area				1	Monitoring Well	Semi-Annual
RIN-1001A	480	NC Area				1	Monitoring Well	Semi-Annual
S1125	504	NC Area				1	Monitoring Well	Semi-Annual
PBM-0001	367	PBG	1		1	1	Monitoring Well	Semi-Annual
PBM-0002	368	PBG	1		1	1	Monitoring Well	Semi-Annual

Well Name	Well ID	Plume Area	Nitrates	Sulfate	VOC	DNT	Well Type	Sample Frequency
PBM-0006	372	PBG	1		1	1	Monitoring Well	Semi-Annual
PBM-0008	374	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9101C	561	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103B	571	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103C	572	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103D	573	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103E	574	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9104C	575	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9104D	576	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1001C	595	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8202A	613	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8202B	614	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8202C	615	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8205A	622	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8205B	623	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8205C	624	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8502A	632	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8503A	633	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8902C	645	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8903B	646	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8903C	647	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8912A	654	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8912B	655	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9112C	665	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9112D	666	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9301B	668	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9301C	669	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9303B	673	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9303C	674	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9303D	675	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9304D	687	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9902D	691	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903A	692	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903B	693	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903C	694	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903D	695	PBG			1	1	Monitoring Well	Semi-Annual
S1147	709	PBG			1	1	Monitoring Well	Semi-Annual
S1148	710	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8903B	718	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8903C	719	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8904B	720	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8904C	721	PBG			1	1	Monitoring Well	Semi-Annual
SPN-9103D	725	PBG			1	1	Monitoring Well	Semi-Annual
SPN-9104D	726	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302A	770	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302B	771	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302C	772	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302D	773	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303A	774	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303B	775	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303C	776	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303D	777	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1304A	778	PBG			1	1	Monitoring Well	Semi-Annual

Well Name	Well ID	Plume Area	Nitrates	Sulfate	VOC	DNT	Well Type	Sample Frequency
PBN-1304B	779	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1304C	780	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1304D	781	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1401A	782	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1401B	783	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1401C	784	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1404B	791	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1404C	792	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1404D	793	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8902BR	795	PBG			1	1	Monitoring Well	Semi-Annual
PBM-9001D	981	PBG			1	1	Monitoring Well	Semi-Annual
Totals			3	16	113	117		

June 2019
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
Purcell-D	163	DBG	1	1	Residential Well	Quarterly
ELN-1003A	467	DBG		1	Monitoring Well	Quarterly
ELN-1003B	468	DBG		1	Monitoring Well	Quarterly
ELN-1003C	469	DBG		1	Monitoring Well	Quarterly
ELN-1003E	470	DBG		1	Monitoring Well	Quarterly
ELN-1504B	537	DBG		1	Monitoring Well	Quarterly
WE-ZE512	437	Central	1	1	Residential Well	Quarterly
SEN-0501A	580	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501B	581	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501D	582	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502A	583	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502D	584	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503A	585	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503B	586	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503D	587	Central	1	1	Monitoring Well	Semi-Annual
NLN-1001A	331	Central		1	Monitoring Well	Annual
NLN-1001C	332	Central		1	Monitoring Well	Annual
NLN-8203A	258	Central		1	Monitoring Well	Annual
NLN-8203B	259	Central		1	Monitoring Well	Annual
NLN-8203C	260	Central		1	Monitoring Well	Annual
NPM-8901	506	Central		1	Monitoring Well	Annual
RIM-1003	491	Central		1	Monitoring Well	Annual
RIM-1004	494	Central		1	Monitoring Well	Annual
RIN-0701C	443	Central		1	Monitoring Well	Annual
RIN-0702C	444	Central		1	Monitoring Well	Annual
RIN-0703C	445	Central		1	Monitoring Well	Annual
RIN-1002A	492	Central		1	Monitoring Well	Annual
RIN-1002C	493	Central		1	Monitoring Well	Annual
RIN-1003A	495	Central		1	Monitoring Well	Annual
RIN-1004B	498	Central		1	Monitoring Well	Semi-Annual
RIN-1005A	496	Central		1	Monitoring Well	Annual
RIN-1005C	497	Central		1	Monitoring Well	Annual
RPM-8901	507	Central		1	Monitoring Well	Annual
S1111	751	Central		1	Monitoring Well	Annual
RIN-1501B	538	Central		1	Monitoring Well	Annual
RIN-1501C	539	Central		1	Monitoring Well	Annual
RIN-1501D	540	Central		1	Monitoring Well	Annual
RIN-1502B	541	Central		1	Monitoring Well	Annual
RIN-1502C	542	Central		1	Monitoring Well	Annual
RIN-1502D	543	Central		1	Monitoring Well	Annual
Totals			10	40		

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
Purcell-D	163	DBG	1	1	Residential Well	Quarterly
Anderson-R	411	DBG	1	1	Residential Well	Annual
Curto	412	DBG	1	1	Residential Well	Annual
Wenger	414	DBG	1	1	Residential Well	Annual
Grosse	415	DBG	1	1	Residential Well	Annual
Gruber-D	417	DBG	1	1	Residential Well	Annual
Hendershot	418	DBG	1	1	Residential Well	Annual
Howery	419	DBG	1	1	Residential Well	Annual
Osterland	422	DBG	1	1	Residential Well	Annual
Melum	423	DBG	1	1	Residential Well	Annual
Raschein	424	DBG	1	1	Residential Well	Annual
Revers	425	DBG	1	1	Residential Well	Annual
Roll	426	DBG	1	1	Residential Well	Annual
Reif	427	DBG	1	1	Residential Well	Annual
Schumann	428	DBG	1	1	Residential Well	Annual
Spear	803	DBG	1	1	Residential Well	Annual
Brey	817	DBG	1	1	Residential Well	Annual
Gibbs	839	DBG	1	1	Residential Well	Annual
Groth	842	DBG	1	1	Residential Well	Annual
Lukens	860	DBG	1	1	Residential Well	Annual
Kopras	874	DBG	1	1	Residential Well	Annual
Nowotarski	891	DBG	1	1	Residential Well	Annual
Olah	904	DBG	1	1	Residential Well	Annual
Purcell-G	916	DBG	1	1	Residential Well	Annual
Zurbachen-A	967	DBG	1	1	Residential Well	Annual
USDA 3	126	Central		1	Residential Well	Annual
USDA 6	128	Central		1	Residential Well	Annual
USDA 1	828	Central		1	Residential Well	Annual
USDA 2	829	Central		1	Residential Well	Annual
WE-TM599	129	Central		1	Residential Well	Annual
WE-RM383	153	Central		1	Residential Well	Annual
WE-RR542	156	Central		1	Residential Well	Annual
WE-QR441	157	Central	1	1	Residential Well	Annual
WE-QN039	158	Central	1	1	Residential Well	Annual
WE-RD430	159	Central		1	Residential Well	Annual
WE-SQ017	164	Central	1	1	Residential Well	Annual
WE-SQ001	165	Central	1	1	Residential Well	Annual
WE-RR598	169	Central		1	Residential Well	Annual
WE-SQ002	170	Central		1	Residential Well	Annual
WE-TF023	174	Central		1	Residential Well	Annual
WE-UK125	431	Central		1	Residential Well	Annual
WE-ZE512	437	Central	1	1	Residential Well	Quarterly
WE-UA297	433	Central		1	Residential Well	Annual
WE-XD828	434	Central		1	Residential Well	Annual
WE-XK342	435	Central		1	Residential Well	Annual
WE-YW972	436	Central	1	1	Residential Well	Annual
Delaney	152	PBG	1	1	Residential Well	Annual
Mittenzwei	800	PBG	1	1	Residential Well	Annual
Judd	862	PBG	1	1	Residential Well	Annual
Krumenauer	875	PBG	1	1	Residential Well	Annual

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
PDS-3	911	PBG	1	1	Residential Well	Annual
Ramaker-J	917	PBG	1	1	Residential Well	Annual
Schlender	931	PBG	1	1	Residential Well	Annual
Apel	998	PBG	1	1	Residential Well	Annual
Totals			39	54		

September 2019
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	VOC	DNT	Well Type	Sample Frequency
ELN-8203A	210	DBG			1	Monitoring Well	Semi-Annual
ELN-8203B	211	DBG			1	Monitoring Well	Semi-Annual
ELN-8203C	212	DBG			1	Monitoring Well	Semi-Annual
ELM-8901	216	DBG			1	Monitoring Well	Semi-Annual
ELM-8907	220	DBG			1	Monitoring Well	Semi-Annual
ELM-8908	221	DBG			1	Monitoring Well	Semi-Annual
ELM-8909	222	DBG			1	Monitoring Well	Semi-Annual
ELN-8902B	224	DBG			1	Monitoring Well	Semi-Annual
ELN-9107A	227	DBG			1	Monitoring Well	Semi-Annual
ELN-9107B	228	DBG			1	Monitoring Well	Semi-Annual
ELN-9402AR	231	DBG			1	Monitoring Well	Semi-Annual
ELM-9501	234	DBG			1	Monitoring Well	Semi-Annual
S1134R	236	DBG			1	Monitoring Well	Semi-Annual
DBM-8201	301	DBG			1	Monitoring Well	Semi-Annual
DBM-8202	302	DBG			1	Monitoring Well	Semi-Annual
DBM-8903	306	DBG			1	Monitoring Well	Semi-Annual
DBN-9501A	314	DBG			1	Monitoring Well	Semi-Annual
DBN-9501B	315	DBG			1	Monitoring Well	Semi-Annual
DBN-9501C	316	DBG			1	Monitoring Well	Semi-Annual
DBN-9501E	317	DBG			1	Monitoring Well	Semi-Annual
ELN-0801B	455	DBG			1	Monitoring Well	Semi-Annual
ELN-0801C	456	DBG			1	Monitoring Well	Semi-Annual
ELN-0801E	457	DBG			1	Monitoring Well	Semi-Annual
ELN-1001B	460	DBG			1	Monitoring Well	Semi-Annual
ELN-1001C	461	DBG			1	Monitoring Well	Semi-Annual
ELN-1001E	462	DBG			1	Monitoring Well	Semi-Annual
ELN-1002A	463	DBG			1	Monitoring Well	Semi-Annual
ELN-1002B	464	DBG			1	Monitoring Well	Semi-Annual
ELN-1002C	465	DBG			1	Monitoring Well	Semi-Annual
ELN-1002E	466	DBG			1	Monitoring Well	Semi-Annual
ELN-1003A	467	DBG			1	Monitoring Well	Quarterly
ELN-1003B	468	DBG			1	Monitoring Well	Quarterly
ELN-1003C	469	DBG			1	Monitoring Well	Quarterly
ELN-1003E	470	DBG			1	Monitoring Well	Quarterly
DBN-1001B	472	DBG			1	Monitoring Well	Semi-Annual
DBN-1001C	473	DBG			1	Monitoring Well	Semi-Annual
DBN-1001E	474	DBG			1	Monitoring Well	Semi-Annual
DBN-1002C	476	DBG			1	Monitoring Well	Semi-Annual
DBN-1002E	477	DBG			1	Monitoring Well	Semi-Annual
S1121	755	DBG			1	Monitoring Well	Semi-Annual
ELN-1502A	533	DBG			1	Monitoring Well	Semi-Annual
ELN-1502C	534	DBG			1	Monitoring Well	Semi-Annual
ELN-1503A	535	DBG			1	Monitoring Well	Semi-Annual
ELN-1503C	536	DBG			1	Monitoring Well	Semi-Annual
ELN-1504B	537	DBG			1	Monitoring Well	Quarterly
RIM-0703	440	NC Area			1	Monitoring Well	Annual
RIM-0705	442	NC Area			1	Monitoring Well	Semi-Annual
RIM-1002	478	NC Area			1	Monitoring Well	Semi-Annual
RIN-1007C	479	NC Area			1	Monitoring Well	Annual
RIN-1001A	480	NC Area			1	Monitoring Well	Semi-Annual
RIN-1001C	481	NC Area			1	Monitoring Well	Annual

September 2019
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	VOC	DNT	Well Type	Sample Frequency
S1125	504	NC Area			1	Monitoring Well	Semi-Annual
PBM-9801	360	PBG		1	1	Monitoring Well	Annual
PBM-0001	367	PBG	1	1	1	Monitoring Well	Semi-Annual
PBM-0002	368	PBG	1	1	1	Monitoring Well	Semi-Annual
PBM-0006	372	PBG	1	1	1	Monitoring Well	Semi-Annual
PBM-0008	374	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9101C	561	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9102C	569	PBG		1	1	Monitoring Well	Annual
SWN-9102D	570	PBG		1	1	Monitoring Well	Annual
SWN-9103B	571	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9103C	572	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9103D	573	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9103E	574	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9104C	575	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9104D	576	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9105B	577	PBG		1	1	Monitoring Well	Annual
SWN-9105C	578	PBG		1	1	Monitoring Well	Annual
SWN-9105D	579	PBG		1	1	Monitoring Well	Annual
PBN-1003C	592	PBG		1	1	Monitoring Well	Annual
PBN-1001C	595	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8202A	613	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8202B	614	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8202C	615	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8205A	622	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8205B	623	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8205C	624	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8502A	632	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8503A	633	PBG		1	1	Monitoring Well	Semi-Annual
PBM-8907	637	PBG		1	1	Monitoring Well	Annual
PBN-8902C	645	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8903B	646	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8903C	647	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8912A	654	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8912B	655	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9112C	665	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9112D	666	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9301B	668	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9301C	669	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9303B	673	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9303C	674	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9303D	675	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9304D	687	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9902D	691	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903A	692	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903B	693	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903C	694	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903D	695	PBG		1	1	Monitoring Well	Semi-Annual
S1147	709	PBG		1	1	Monitoring Well	Semi-Annual
S1148	710	PBG		1	1	Monitoring Well	Semi-Annual
SPN-8903B	718	PBG		1	1	Monitoring Well	Semi-Annual
SPN-8903C	719	PBG		1	1	Monitoring Well	Semi-Annual

September 2019
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	VOC	DNT	Well Type	Sample Frequency
SPN-8904B	720	PBG		1	1	Monitoring Well	Semi-Annual
SPN-8904C	721	PBG		1	1	Monitoring Well	Semi-Annual
SPN-9103D	725	PBG		1	1	Monitoring Well	Semi-Annual
SPN-9104D	726	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302A	770	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302B	771	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302C	772	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302D	773	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303A	774	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303B	775	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303C	776	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303D	777	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304A	778	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304B	779	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304C	780	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304D	781	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1401A	782	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1401B	783	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1401C	784	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1404B	791	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1404C	792	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1404D	793	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8902BR	795	PBG		1	1	Monitoring Well	Semi-Annual
PBM-9001D	981	PBG		1	1	Monitoring Well	Semi-Annual
Totals			3	74	126		

November 2019
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
SEN-0501A	580	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501B	581	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501D	582	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502A	583	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502D	584	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503A	585	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503B	586	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503D	587	Central	1	1	Monitoring Well	Semi-Annual
RIN-1004B	498	Central		1	Monitoring Well	Semi-Annual
WE-ZE512	437	Central	1	1	Residential Well	Quarterly
Purcell-D	163	DBG	1	1	Residential Well	Quarterly
ELN-1003A	467	DBG		1	Monitoring Well	Quarterly
ELN-1003B	468	DBG		1	Monitoring Well	Quarterly
ELN-1003C	469	DBG		1	Monitoring Well	Quarterly
ELN-1003E	470	DBG		1	Monitoring Well	Quarterly
ELN-1504B	537	DBG		1	Monitoring Well	Quarterly
Totals			10	16		

April 2020
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	Sulfate	VOC	DNT	Well Type	Sample Frequency
WE-ZE512	437	Central			1	1	Residential Well	Quarterly
Purcell-D	163	DBG			1	1	Residential Well	Quarterly
ELN-8203A	210	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-8203B	211	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-8203C	212	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8901	216	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8907	220	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8908	221	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-8909	222	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-8902B	224	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-9107A	227	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-9107B	228	DBG		1	1	1	Monitoring Well	Semi-Annual
ELN-9402AR	231	DBG		1	1	1	Monitoring Well	Semi-Annual
ELM-9501	234	DBG			1	1	Monitoring Well	Semi-Annual
S1134R	236	DBG		1	1	1	Monitoring Well	Semi-Annual
DBM-8201	301	DBG		1	1	1	Monitoring Well	Semi-Annual
DBM-8202	302	DBG		1	1	1	Monitoring Well	Semi-Annual
DBM-8903	306	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501A	314	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501B	315	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501C	316	DBG			1	1	Monitoring Well	Semi-Annual
DBN-9501E	317	DBG			1	1	Monitoring Well	Semi-Annual
ELN-0801B	455	DBG			1	1	Monitoring Well	Semi-Annual
ELN-0801C	456	DBG			1	1	Monitoring Well	Semi-Annual
ELN-0801E	457	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1001B	460	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1001C	461	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1001E	462	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002A	463	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002B	464	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002C	465	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1002E	466	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1003A	467	DBG			1	1	Monitoring Well	Quarterly
ELN-1003B	468	DBG			1	1	Monitoring Well	Quarterly
ELN-1003C	469	DBG			1	1	Monitoring Well	Quarterly
ELN-1003E	470	DBG			1	1	Monitoring Well	Quarterly
DBN-1001B	472	DBG			1	1	Monitoring Well	Semi-Annual
DBN-1001C	473	DBG			1	1	Monitoring Well	Semi-Annual
DBN-1001E	474	DBG			1	1	Monitoring Well	Semi-Annual
DBN-1002C	476	DBG		1	1	1	Monitoring Well	Semi-Annual
DBN-1002E	477	DBG		1	1	1	Monitoring Well	Semi-Annual
S1121	755	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1502A	533	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1502C	534	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1503A	535	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1503C	536	DBG			1	1	Monitoring Well	Semi-Annual
ELN-1504B	537	DBG			1	1	Monitoring Well	Quarterly
RIM-0705	442	NC Area				1	Monitoring Well	Semi-Annual
RIM-1002	478	NC Area				1	Monitoring Well	Semi-Annual
RIN-1001A	480	NC Area				1	Monitoring Well	Semi-Annual
S1125	504	NC Area				1	Monitoring Well	Semi-Annual
PBM-0001	367	PBG	1		1	1	Monitoring Well	Semi-Annual
PBM-0002	368	PBG	1		1	1	Monitoring Well	Semi-Annual
PBM-0006	372	PBG	1		1	1	Monitoring Well	Semi-Annual

Well Name	Well ID	Plume Area	Nitrates	Sulfate	VOC	DNT	Well Type	Sample Frequency
PBM-0008	374	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9101C	561	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103B	571	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103C	572	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103D	573	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9103E	574	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9104C	575	PBG			1	1	Monitoring Well	Semi-Annual
SWN-9104D	576	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1001C	595	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8202A	613	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8202B	614	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8202C	615	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8205A	622	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8205B	623	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8205C	624	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8502A	632	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8503A	633	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8902C	645	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8903B	646	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8903C	647	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8912A	654	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8912B	655	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9112C	665	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9112D	666	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9301B	668	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9301C	669	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9303B	673	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9303C	674	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9303D	675	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9304D	687	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9902D	691	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903A	692	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903B	693	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903C	694	PBG			1	1	Monitoring Well	Semi-Annual
PBN-9903D	695	PBG			1	1	Monitoring Well	Semi-Annual
S1147	709	PBG			1	1	Monitoring Well	Semi-Annual
S1148	710	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8903B	718	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8903C	719	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8904B	720	PBG			1	1	Monitoring Well	Semi-Annual
SPN-8904C	721	PBG			1	1	Monitoring Well	Semi-Annual
SPN-9103D	725	PBG			1	1	Monitoring Well	Semi-Annual
SPN-9104D	726	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302A	770	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302B	771	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302C	772	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1302D	773	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303A	774	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303B	775	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303C	776	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1303D	777	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1304A	778	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1304B	779	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1304C	780	PBG			1	1	Monitoring Well	Semi-Annual

April 2020
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	Sulfate	VOC	DNT	Well Type	Sample Frequency
PBN-1304D	781	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1401A	782	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1401B	783	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1401C	784	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1404B	791	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1404C	792	PBG			1	1	Monitoring Well	Semi-Annual
PBN-1404D	793	PBG			1	1	Monitoring Well	Semi-Annual
PBN-8902BR	795	PBG			1	1	Monitoring Well	Semi-Annual
PBM-9001D	981	PBG			1	1	Monitoring Well	Semi-Annual
Totals			3	16	113	117		

June 2020
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
Purcell-D	163	DBG	1	1	Residential Well	Quarterly
ELN-1003A	467	DBG		1	Monitoring Well	Quarterly
ELN-1003B	468	DBG		1	Monitoring Well	Quarterly
ELN-1003C	469	DBG		1	Monitoring Well	Quarterly
ELN-1003E	470	DBG		1	Monitoring Well	Quarterly
ELN-1504B	537	DBG		1	Monitoring Well	Quarterly
WE-ZE512	437	Central	1	1	Residential Well	Quarterly
SEN-0501A	580	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501B	581	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501D	582	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502A	583	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502D	584	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503A	585	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503B	586	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503D	587	Central	1	1	Monitoring Well	Semi-Annual
NLN-1001A	331	Central		1	Monitoring Well	Annual
NLN-1001C	332	Central		1	Monitoring Well	Annual
NLN-8203A	258	Central		1	Monitoring Well	Annual
NLN-8203B	259	Central		1	Monitoring Well	Annual
NLN-8203C	260	Central		1	Monitoring Well	Annual
NPM-8901	506	Central		1	Monitoring Well	Annual
RIM-1003	491	Central		1	Monitoring Well	Annual
RIM-1004	494	Central		1	Monitoring Well	Annual
RIN-0701C	443	Central		1	Monitoring Well	Annual
RIN-0702C	444	Central		1	Monitoring Well	Annual
RIN-0703C	445	Central		1	Monitoring Well	Annual
RIN-1002A	492	Central		1	Monitoring Well	Annual
RIN-1002C	493	Central		1	Monitoring Well	Annual
RIN-1003A	495	Central		1	Monitoring Well	Annual
RIN-1004B	498	Central		1	Monitoring Well	Semi-Annual
RIN-1005A	496	Central		1	Monitoring Well	Annual
RIN-1005C	497	Central		1	Monitoring Well	Annual
RPM-8901	507	Central		1	Monitoring Well	Annual
S1111	751	Central		1	Monitoring Well	Annual
RIN-1501B	538	Central		1	Monitoring Well	Annual
RIN-1501C	539	Central		1	Monitoring Well	Annual
RIN-1501D	540	Central		1	Monitoring Well	Annual
RIN-1502B	541	Central		1	Monitoring Well	Annual
RIN-1502C	542	Central		1	Monitoring Well	Annual
RIN-1502D	543	Central		1	Monitoring Well	Annual
Totals			10	40		

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
Purcell-D	163	DBG	1	1	Residential Well	Quarterly
Anderson-R	411	DBG	1	1	Residential Well	Annual
Curto	412	DBG	1	1	Residential Well	Annual
Wenger	414	DBG	1	1	Residential Well	Annual
Grosse	415	DBG	1	1	Residential Well	Annual
Gruber-D	417	DBG	1	1	Residential Well	Annual
Hendershot	418	DBG	1	1	Residential Well	Annual
Howery	419	DBG	1	1	Residential Well	Annual
Osterland	422	DBG	1	1	Residential Well	Annual
Melum	423	DBG	1	1	Residential Well	Annual
Raschein	424	DBG	1	1	Residential Well	Annual
Revers	425	DBG	1	1	Residential Well	Annual
Roll	426	DBG	1	1	Residential Well	Annual
Reif	427	DBG	1	1	Residential Well	Annual
Schumann	428	DBG	1	1	Residential Well	Annual
Spear	803	DBG	1	1	Residential Well	Annual
Brey	817	DBG	1	1	Residential Well	Annual
Gibbs	839	DBG	1	1	Residential Well	Annual
Groth	842	DBG	1	1	Residential Well	Annual
Lukens	860	DBG	1	1	Residential Well	Annual
Kopras	874	DBG	1	1	Residential Well	Annual
Nowotarski	891	DBG	1	1	Residential Well	Annual
Olah	904	DBG	1	1	Residential Well	Annual
Purcell-G	916	DBG	1	1	Residential Well	Annual
Zurbachen-A	967	DBG	1	1	Residential Well	Annual
USDA 3	126	Central		1	Residential Well	Annual
USDA 6	128	Central		1	Residential Well	Annual
USDA 1	828	Central		1	Residential Well	Annual
USDA 2	829	Central		1	Residential Well	Annual
WE-TM599	129	Central		1	Residential Well	Annual
WE-RM383	153	Central		1	Residential Well	Annual
WE-RR542	156	Central		1	Residential Well	Annual
WE-QR441	157	Central	1	1	Residential Well	Annual
WE-QN039	158	Central	1	1	Residential Well	Annual
WE-RD430	159	Central		1	Residential Well	Annual
WE-SQ017	164	Central	1	1	Residential Well	Annual
WE-SQ001	165	Central	1	1	Residential Well	Annual
WE-RR598	169	Central		1	Residential Well	Annual
WE-SQ002	170	Central		1	Residential Well	Annual
WE-TF023	174	Central		1	Residential Well	Annual
WE-UK125	431	Central		1	Residential Well	Annual
WE-ZE512	437	Central	1	1	Residential Well	Quarterly
WE-UA297	433	Central		1	Residential Well	Annual
WE-XD828	434	Central		1	Residential Well	Annual
WE-XK342	435	Central		1	Residential Well	Annual
WE-YW972	436	Central	1	1	Residential Well	Annual
Delaney	152	PBG	1	1	Residential Well	Annual
Mittenzwei	800	PBG	1	1	Residential Well	Annual
Judd	862	PBG	1	1	Residential Well	Annual
Krumenauer	875	PBG	1	1	Residential Well	Annual

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
PDS-3	911	PBG	1	1	Residential Well	Annual
Ramaker-J	917	PBG	1	1	Residential Well	Annual
Schlender	931	PBG	1	1	Residential Well	Annual
Apel	998	PBG	1	1	Residential Well	Annual
Totals			39	54		

September 2020
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	Nitrates	VOC	DNT	Well Type	Sample Frequency
ELN-8203A	210	DBG			1	Monitoring Well	Semi-Annual
ELN-8203B	211	DBG			1	Monitoring Well	Semi-Annual
ELN-8203C	212	DBG			1	Monitoring Well	Semi-Annual
ELM-8901	216	DBG			1	Monitoring Well	Semi-Annual
ELM-8907	220	DBG			1	Monitoring Well	Semi-Annual
ELM-8908	221	DBG			1	Monitoring Well	Semi-Annual
ELM-8909	222	DBG			1	Monitoring Well	Semi-Annual
ELN-8902B	224	DBG			1	Monitoring Well	Semi-Annual
ELN-9107A	227	DBG			1	Monitoring Well	Semi-Annual
ELN-9107B	228	DBG			1	Monitoring Well	Semi-Annual
ELN-9402AR	231	DBG			1	Monitoring Well	Semi-Annual
ELM-9501	234	DBG			1	Monitoring Well	Semi-Annual
S1134R	236	DBG			1	Monitoring Well	Semi-Annual
DBM-8201	301	DBG			1	Monitoring Well	Semi-Annual
DBM-8202	302	DBG			1	Monitoring Well	Semi-Annual
DBM-8903	306	DBG			1	Monitoring Well	Semi-Annual
DBN-9501A	314	DBG			1	Monitoring Well	Semi-Annual
DBN-9501B	315	DBG			1	Monitoring Well	Semi-Annual
DBN-9501C	316	DBG			1	Monitoring Well	Semi-Annual
DBN-9501E	317	DBG			1	Monitoring Well	Semi-Annual
ELN-0801B	455	DBG			1	Monitoring Well	Semi-Annual
ELN-0801C	456	DBG			1	Monitoring Well	Semi-Annual
ELN-0801E	457	DBG			1	Monitoring Well	Semi-Annual
ELN-0802A	458	DBG		1	1	Monitoring Well	Biennial
ELN-0802C	459	DBG		1	1	Monitoring Well	Biennial
ELN-1001B	460	DBG			1	Monitoring Well	Semi-Annual
ELN-1001C	461	DBG			1	Monitoring Well	Semi-Annual
ELN-1001E	462	DBG			1	Monitoring Well	Semi-Annual
ELN-1002A	463	DBG			1	Monitoring Well	Semi-Annual
ELN-1002B	464	DBG			1	Monitoring Well	Semi-Annual
ELN-1002C	465	DBG			1	Monitoring Well	Semi-Annual
ELN-1002E	466	DBG			1	Monitoring Well	Semi-Annual
ELN-1003A	467	DBG			1	Monitoring Well	Quarterly
ELN-1003B	468	DBG			1	Monitoring Well	Quarterly
ELN-1003C	469	DBG			1	Monitoring Well	Quarterly
ELN-1003E	470	DBG			1	Monitoring Well	Quarterly
DBN-1001B	472	DBG			1	Monitoring Well	Semi-Annual
DBN-1001C	473	DBG			1	Monitoring Well	Semi-Annual
DBN-1001E	474	DBG			1	Monitoring Well	Semi-Annual
DBN-1002C	476	DBG			1	Monitoring Well	Semi-Annual
DBN-1002E	477	DBG			1	Monitoring Well	Semi-Annual
S1121	755	DBG			1	Monitoring Well	Semi-Annual
ELN-1502A	533	DBG			1	Monitoring Well	Semi-Annual
ELN-1502C	534	DBG			1	Monitoring Well	Semi-Annual
ELN-1503A	535	DBG			1	Monitoring Well	Semi-Annual
ELN-1503C	536	DBG			1	Monitoring Well	Semi-Annual
ELN-1504B	537	DBG			1	Monitoring Well	Quarterly
RIM-0703	440	NC Area			1	Monitoring Well	Annual
RIM-0705	442	NC Area			1	Monitoring Well	Semi-Annual
RIM-1002	478	NC Area			1	Monitoring Well	Semi-Annual
RIN-1007C	479	NC Area			1	Monitoring Well	Annual
RIN-1001A	480	NC Area			1	Monitoring Well	Semi-Annual
RIN-1001C	481	NC Area			1	Monitoring Well	Annual

Well Name	Well ID	Plume Area	Nitrates	VOC	DNT	Well Type	Sample Frequency
S1125	504	NC Area			1	Monitoring Well	Semi-Annual
PBM-9801	360	PBG		1	1	Monitoring Well	Annual
PBM-0001	367	PBG	1	1	1	Monitoring Well	Semi-Annual
PBM-0002	368	PBG	1	1	1	Monitoring Well	Semi-Annual
PBM-0006	372	PBG	1	1	1	Monitoring Well	Semi-Annual
PBM-0008	374	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9101C	561	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9102B	562	PBG		1	1	Monitoring Well	Biennial
PBN-9102C	563	PBG		1	1	Monitoring Well	Biennial
SWN-9102C	569	PBG		1	1	Monitoring Well	Annual
SWN-9102D	570	PBG		1	1	Monitoring Well	Annual
SWN-9103B	571	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9103C	572	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9103D	573	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9103E	574	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9104C	575	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9104D	576	PBG		1	1	Monitoring Well	Semi-Annual
SWN-9105B	577	PBG		1	1	Monitoring Well	Annual
SWN-9105C	578	PBG		1	1	Monitoring Well	Annual
SWN-9105D	579	PBG		1	1	Monitoring Well	Annual
PBN-1003C	592	PBG		1	1	Monitoring Well	Annual
PBN-1001C	595	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8202A	613	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8202B	614	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8202C	615	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8205A	622	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8205B	623	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8205C	624	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8502A	632	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8503A	633	PBG		1	1	Monitoring Well	Semi-Annual
PBM-8907	637	PBG		1	1	Monitoring Well	Annual
PBM-8909	639	PBG		1	1	Monitoring Well	Biennial
PBN-8902C	645	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8903B	646	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8903C	647	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8912A	654	PBG		1	1	Monitoring Well	Semi-Annual
PBN-8912B	655	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9112C	665	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9112D	666	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9301B	668	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9301C	669	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9303B	673	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9303C	674	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9303D	675	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9304D	687	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9902D	691	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903A	692	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903B	693	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903C	694	PBG		1	1	Monitoring Well	Semi-Annual
PBN-9903D	695	PBG		1	1	Monitoring Well	Semi-Annual
S1147	709	PBG		1	1	Monitoring Well	Semi-Annual
S1148	710	PBG		1	1	Monitoring Well	Semi-Annual
SPN-8903B	718	PBG		1	1	Monitoring Well	Semi-Annual

Well Name	Well ID	Plume Area	Nitrates	VOC	DNT	Well Type	Sample Frequency
SPN-8903C	719	PBG		1	1	Monitoring Well	Semi-Annual
SPN-8904B	720	PBG		1	1	Monitoring Well	Semi-Annual
SPN-8904C	721	PBG		1	1	Monitoring Well	Semi-Annual
SPN-9103D	725	PBG		1	1	Monitoring Well	Semi-Annual
SPN-9104D	726	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302A	770	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302B	771	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302C	772	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1302D	773	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303A	774	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303B	775	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303C	776	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1303D	777	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304A	778	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304B	779	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304C	780	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1304D	781	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1401A	782	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1401B	783	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1401C	784	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1404B	791	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1404C	792	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1404D	793	PBG		1	1	Monitoring Well	Semi-Annual
PBN-1405F	794	PBG		1	1	Monitoring Well	Biennial
PBN-8902BR	795	PBG		1	1	Monitoring Well	Semi-Annual
PBM-9001D	981	PBG		1	1	Monitoring Well	Semi-Annual
PBM-9002D	982	PBG		1	1	Monitoring Well	Biennial
Totals			3	81	133		

November 2020
Groundwater Sampling Schedule

Well Name	Well ID	Plume Area	VOC	DNT	Well Type	Sample Frequency
SEN-0501A	580	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501B	581	Central	1	1	Monitoring Well	Semi-Annual
SEN-0501D	582	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502A	583	Central	1	1	Monitoring Well	Semi-Annual
SEN-0502D	584	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503A	585	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503B	586	Central	1	1	Monitoring Well	Semi-Annual
SEN-0503D	587	Central	1	1	Monitoring Well	Semi-Annual
RIN-1004B	498	Central		1	Monitoring Well	Semi-Annual
WE-ZE512	437	Central	1	1	Residential Well	Quarterly
Purcell-D	163	DBG	1	1	Residential Well	Quarterly
ELN-1003A	467	DBG		1	Monitoring Well	Quarterly
ELN-1003B	468	DBG		1	Monitoring Well	Quarterly
ELN-1003C	469	DBG		1	Monitoring Well	Quarterly
ELN-1003E	470	DBG		1	Monitoring Well	Quarterly
ELN-1504B	537	DBG		1	Monitoring Well	Quarterly
Totals			10	16		

Appendix E

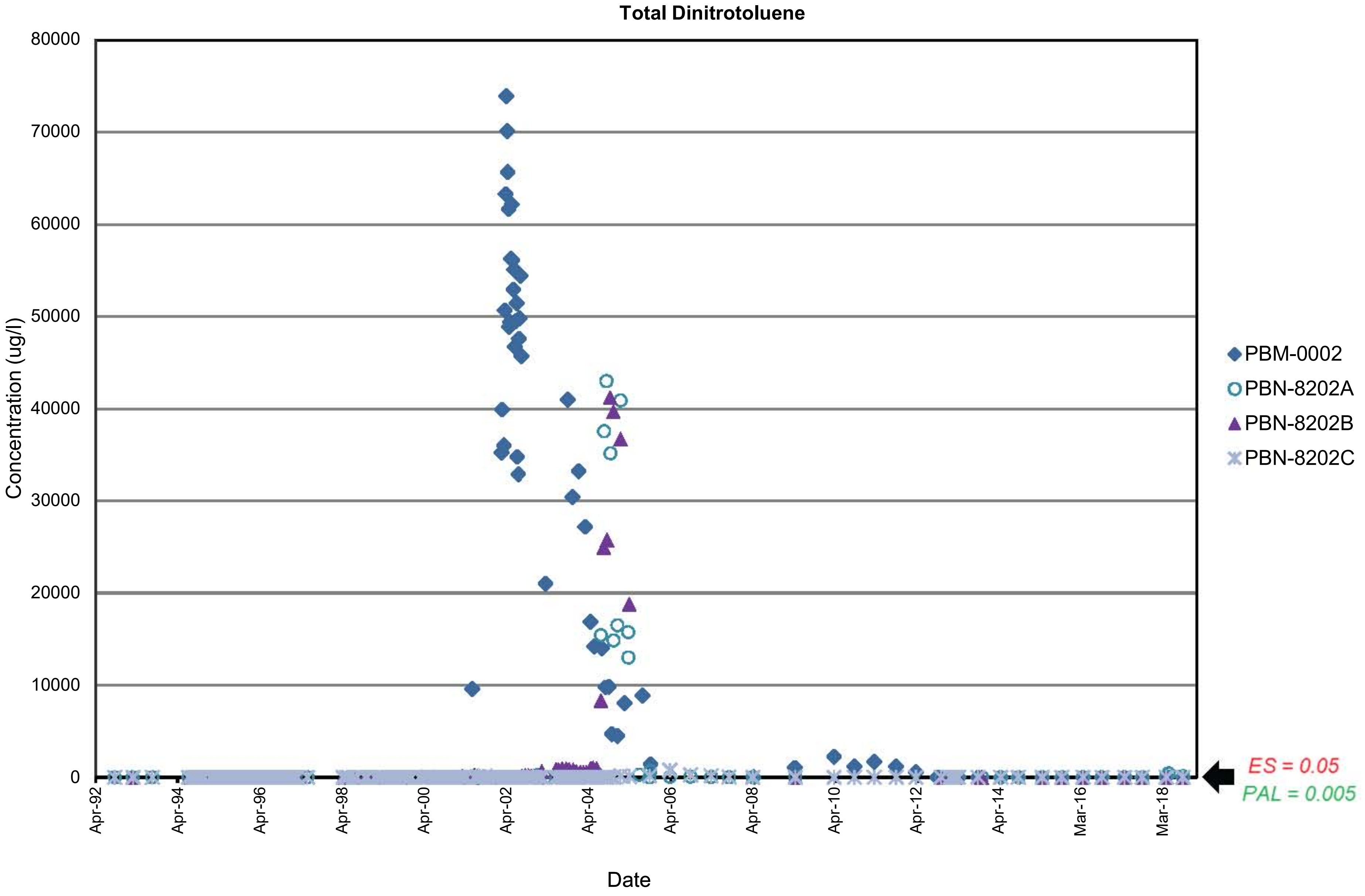
Plume Concentration Over Time Graphs

Concentration Graphs
Propellant Burning Ground Plume

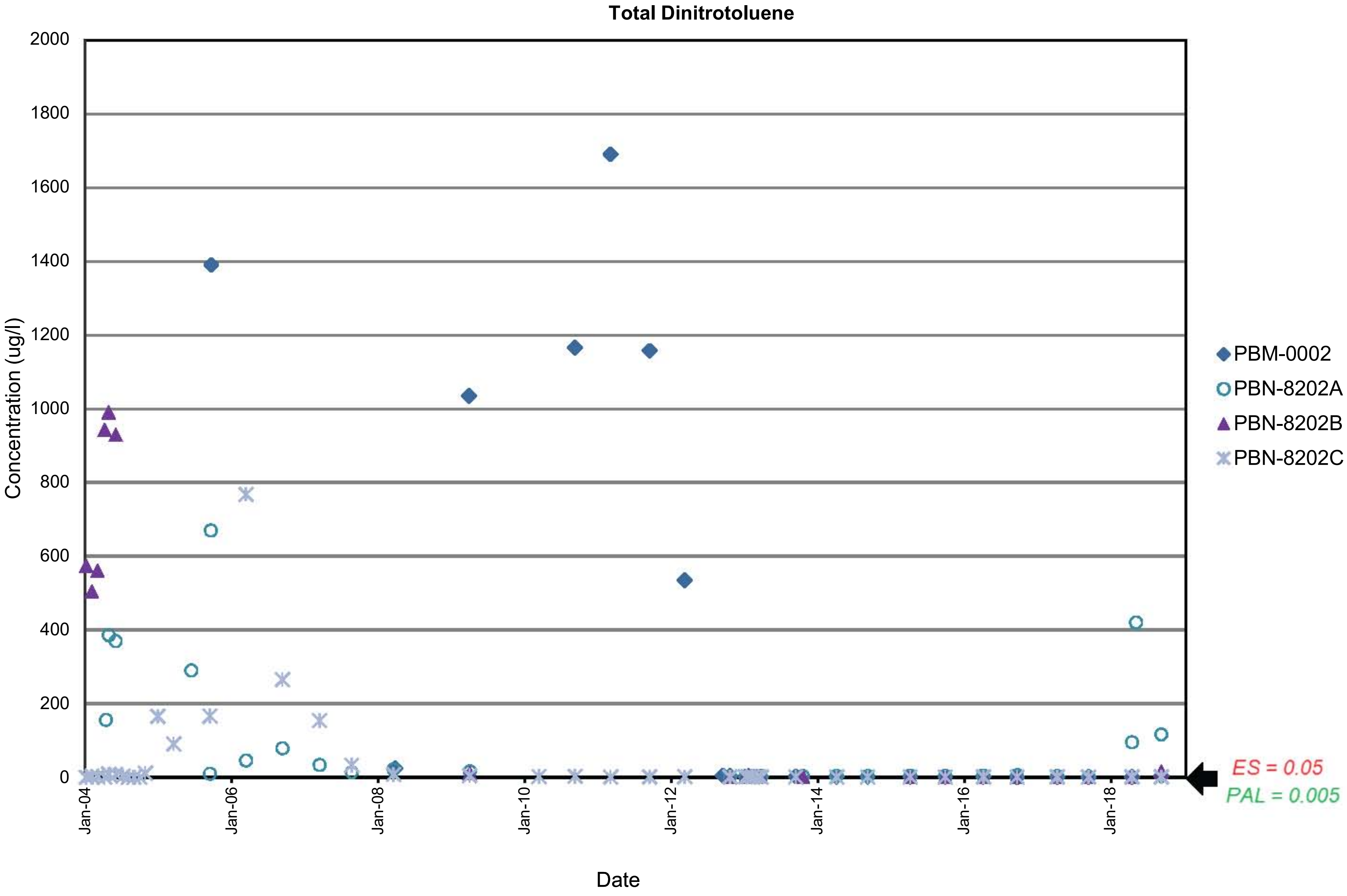
Source Area Wells	Compound	Year Range	Page
PBM-0002, PBN-8202A, B, C	DNT	1992 - 2018	1
PBM-0002, PBN-8202A, B, C	DNT	2004 - 2018	2
PBM-0002, PBN-8202A, B, C	CTET	1988 - 2018	3
PBM-0002, PBN-8202A, B, C	Chloroform	1988 - 2018	4
PBM-0002, PBN-8202A, B, C	TCE	1988 - 2018	5
PBM-0008	DNT	2000 - 2018	6
PBM-0008	DNT	2010 - 2018	7
PBN-8205A, B, C	DNT	1989 - 2018	8
PBN-8205A, B, C	CTET	1982 - 2018	9
PBN-8205A, B, C	Chloroform	1983 - 2018	10
PBN-8205A, B, C	TCE	1982 - 2018	11

On-Site Downgradient Wells	Compound	Year Range	Page
PBN-8502A, 8902BR, 8902C	DNT	1989 - 2018	12
PBN-8502A, 8902BR, 8902C	CTET	1988 - 2018	13
PBN-8502A, 8902BR, 8902C	Chloroform	1988 - 2018	14
PBN-8502A, 8902BR, 8902C	TCE	1988 - 2018	15
PBN-8912A, B, 9112C, D	DNT	1989 - 2018	16
PBN-8912A, B, 9112C, D	CTET	1989 - 2018	17
PBN-8912A, B, 9112C, D	Chloroform	1989 - 2018	18
PBN-8912A, B, 9112C, D	TCE	1989 - 2018	19
S1147, SPN-8903B, C, 9103D	CTET	1988 - 2018	20
S1147, SPN-8903B, C, 9103D	Chloroform	1988 - 2018	21
S1147, SPN-8903B, C, 9103D	TCE	1988 - 2018	22
S1148, SPN-8904B, C, 9104D	DNT	2010 - 2018	23
S1148, SPN-8904B, C, 9104D	CTET	1988 - 2018	24
S1148, SPN-8904B, C, 9104D	Chloroform	1988 - 2018	25
S1148, SPN-8904B, C, 9104D	TCE	1988 - 2018	26
PBN-1001C	Ethyl Ether	2010 - 2018	27
PBN-9304D	Ethyl Ether	2013 - 2018	28

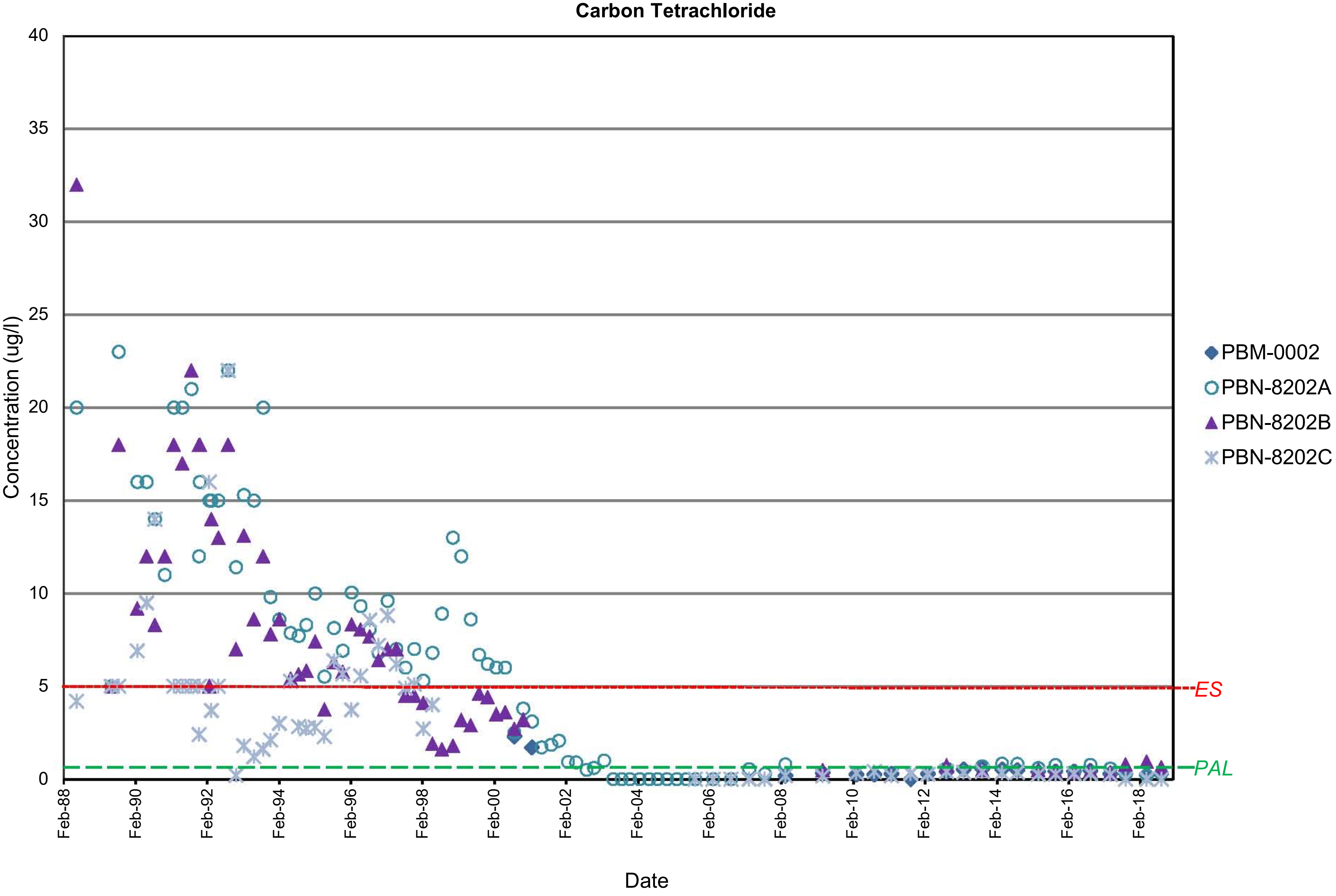
Off-Site Downgradient Wells	Compound	Year Range	Page
PBN-9903D	Ethyl Ether	2005 - 2018	29
PBN-9903A, B, C, D	DNT	2000 - 2018	30
PBN-9903A, B, C, D	CTET	2000 - 2018	31
PBN-9903A, B, C, D	Chloroform	2000 - 2018	32
PBN-9903A, B, C, D	TCE	2000 - 2018	33
SWN-9102C, D	DNT	1991 - 2018	34
SWN-9102C, D	CTET	1991 - 2018	35
SWN-9102C, D	Chloroform	1991 - 2018	36
SWN-9102C, D	TCE	1991 - 2018	37
SWN-9103B, C, D, E	DNT	1991 - 2018	38
SWN-9103B, C, D, E	CTET	1991 - 2018	39
SWN-9103B, C, D, E	Chloroform	1991 - 2018	40
SWN-9103B, C, D, E	TCE	1991 - 2018	41
SWN-9104C, D	DNT	1991 - 2018	42
SWN-9104C, D	CTET	1991 - 2018	43
SWN-9104C, D	Chloroform	1991 - 2018	44
SWN-9104C, D	TCE	1991 - 2018	45
PBN-9101C, PBM-9001D	DNT	1991 - 2018	46
PBN-9101C, PBM-9001D	CTET	1991 - 2018	47
PBN-9101C, PBM-9001D	Chloroform	1991 - 2018	48
PBN-9101C, PBM-9001D	TCE	1991 - 2018	49
PBN-9102B, C, PBM-9002D	DNT	1991 - 2018	50
PBN-9102B, C, PBM-9002D	CTET	1991 - 2018	51
PBN-9102B, C, PBM-9002D	Chloroform	1991 - 2018	52
PBN-9102B, C, PBM-9002D	TCE	1991 - 2018	53


Total Dinitrotoluene
Concentration (ug/l)
80000
70000
60000
50000
40000
30000
20000
10000
0
Apr-92
Apr-94
Apr-96
Apr-98
Apr-00
Apr-02
Apr-04
Apr-06
Apr-08
Apr-10
Apr-12
Apr-14
Mar-16
Mar-18
Date
◆ PBM-0002
○ PBN-8202A
▲ PBN-8202B
✕ PBN-8202C
ES = 0.05
PAL = 0.005

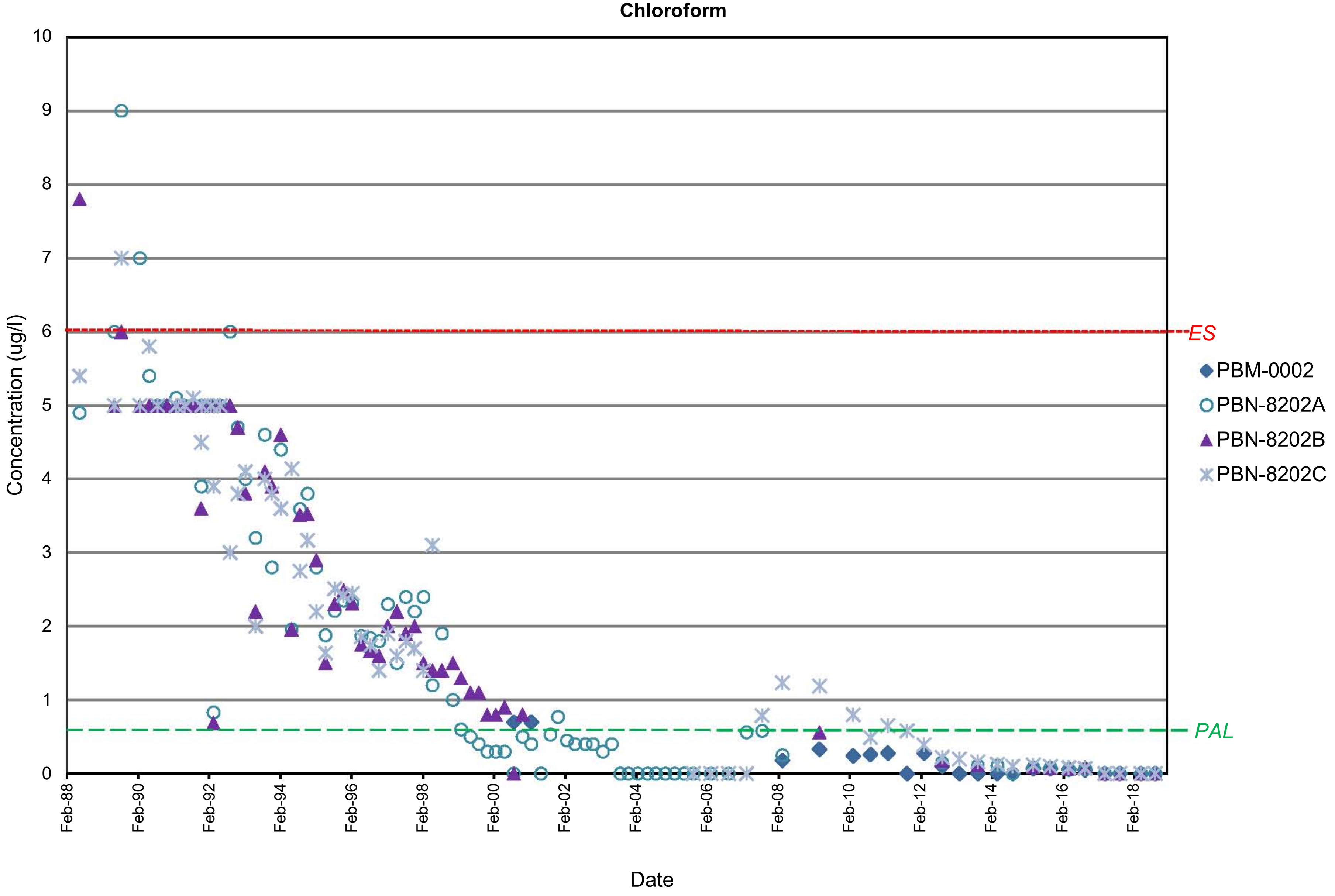
BAAP Groundwater Data Propellant Burning Ground Source Area

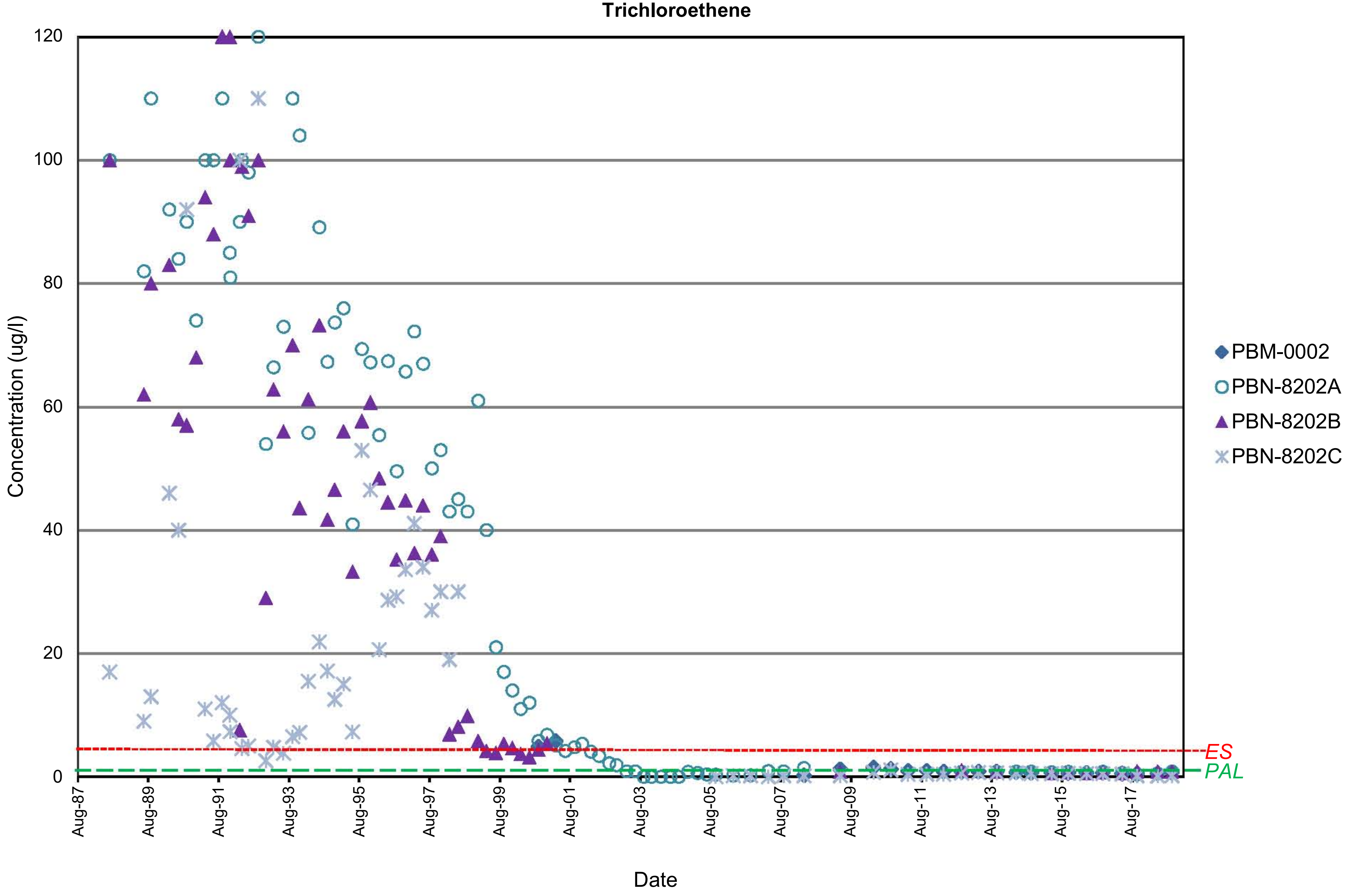


BAAP Groundwater Data | Propellant Burning Ground | Source Area

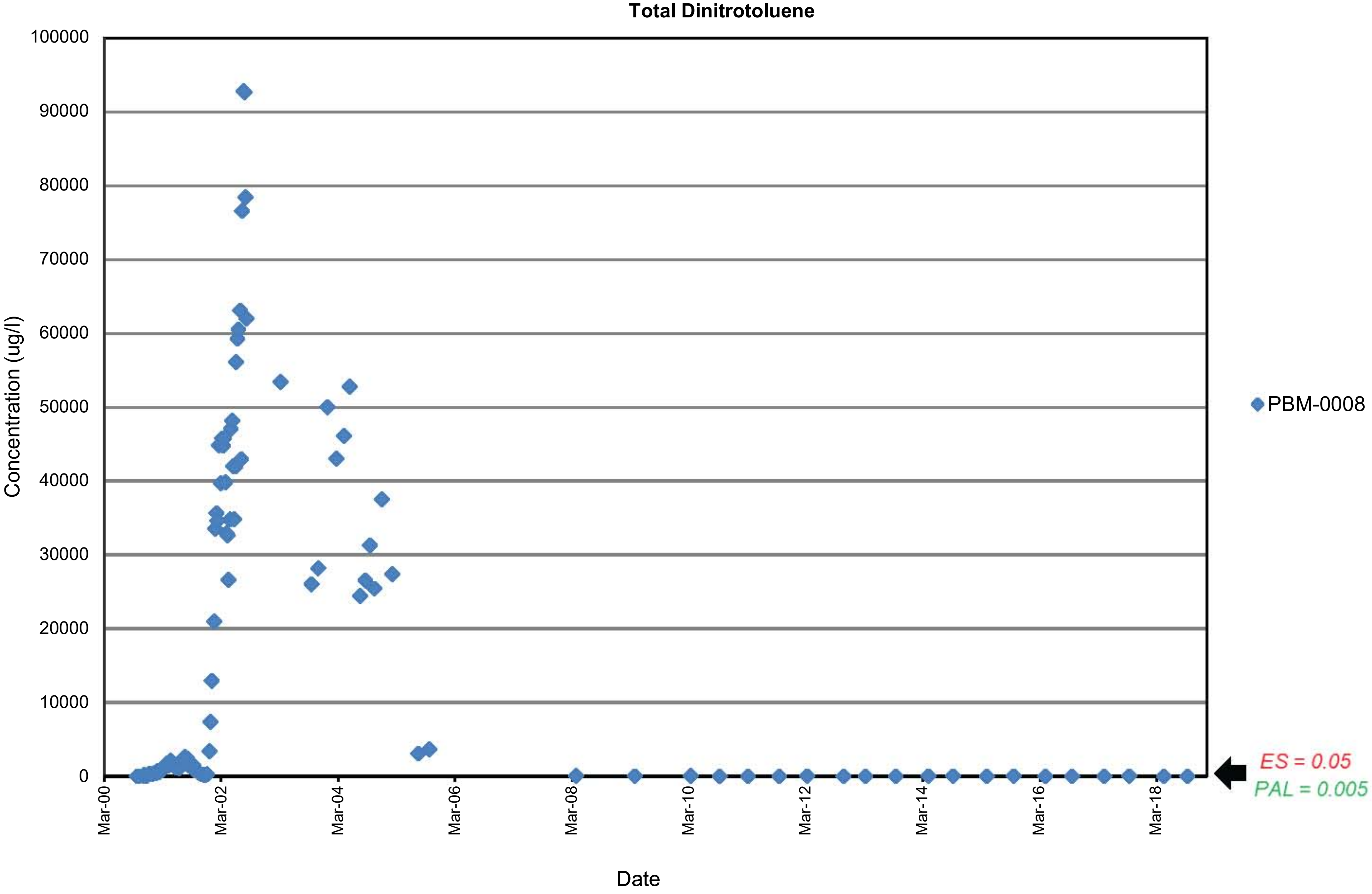


BAAP Groundwater Data Propellant Burning Ground Source Area

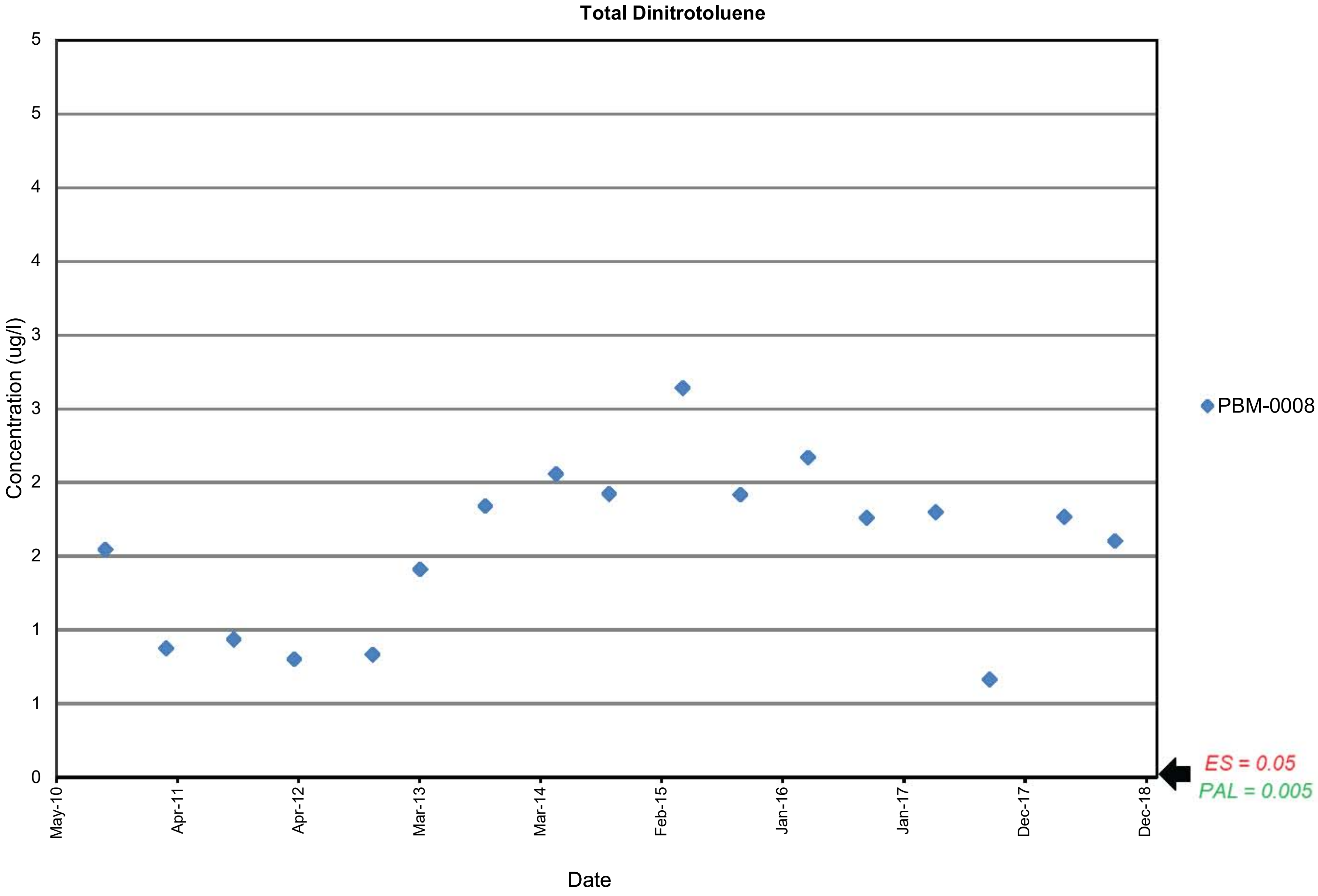



Trichloroethene
Concentration (ug/l)
120
100
80
60
40
20
0
Aug-87
Aug-89
Aug-91
Aug-93
Aug-95
Aug-97
Aug-99
Aug-01
Aug-03
Aug-05
Aug-07
Aug-09
Aug-11
Aug-13
Aug-15
Aug-17
Date
ES
PAL
◆ PBM-0002
○ PBN-8202A
▲ PBN-8202B
✳ PBN-8202C

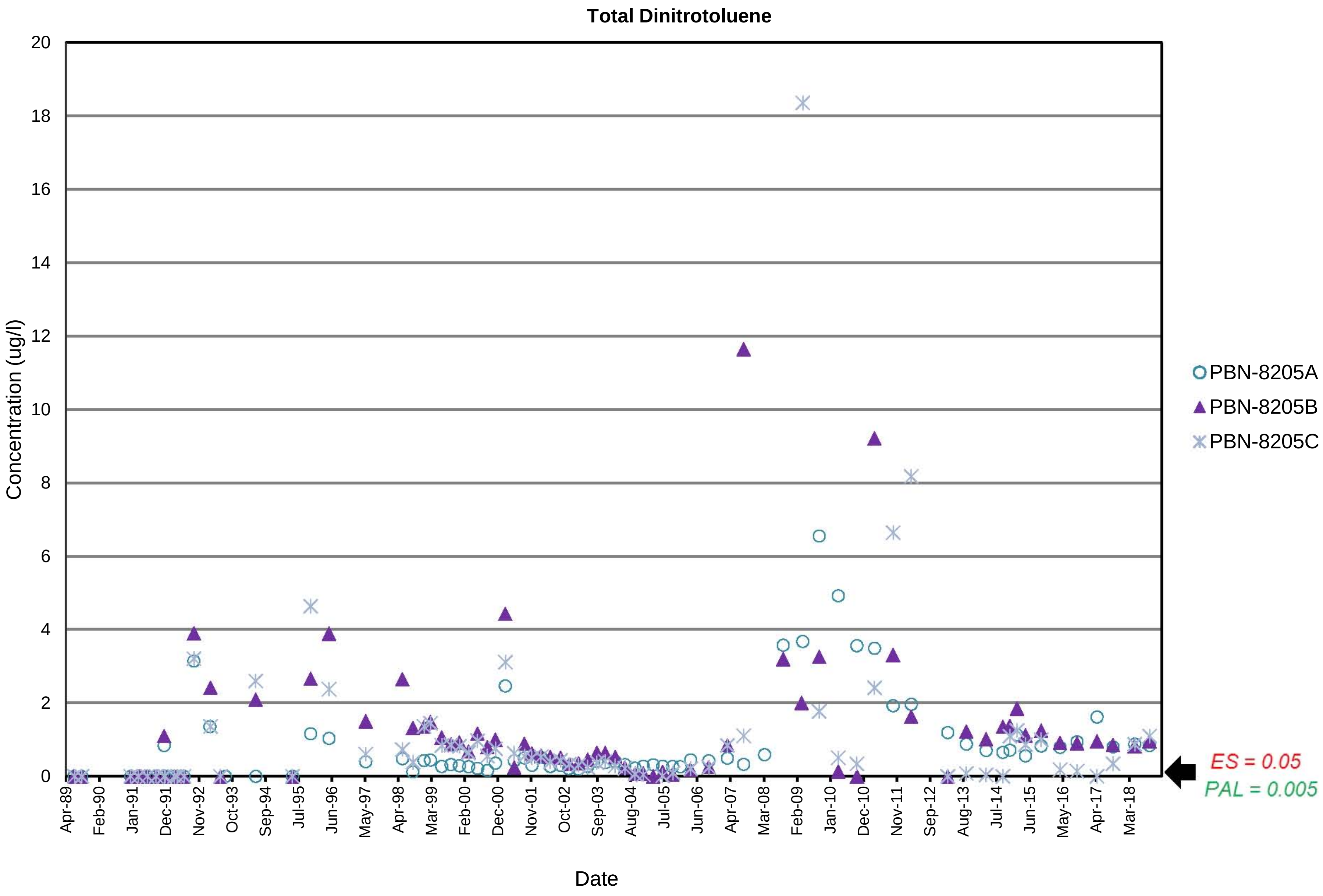
BAAP Groundwater Data | Propellant Burning Ground | Source Area

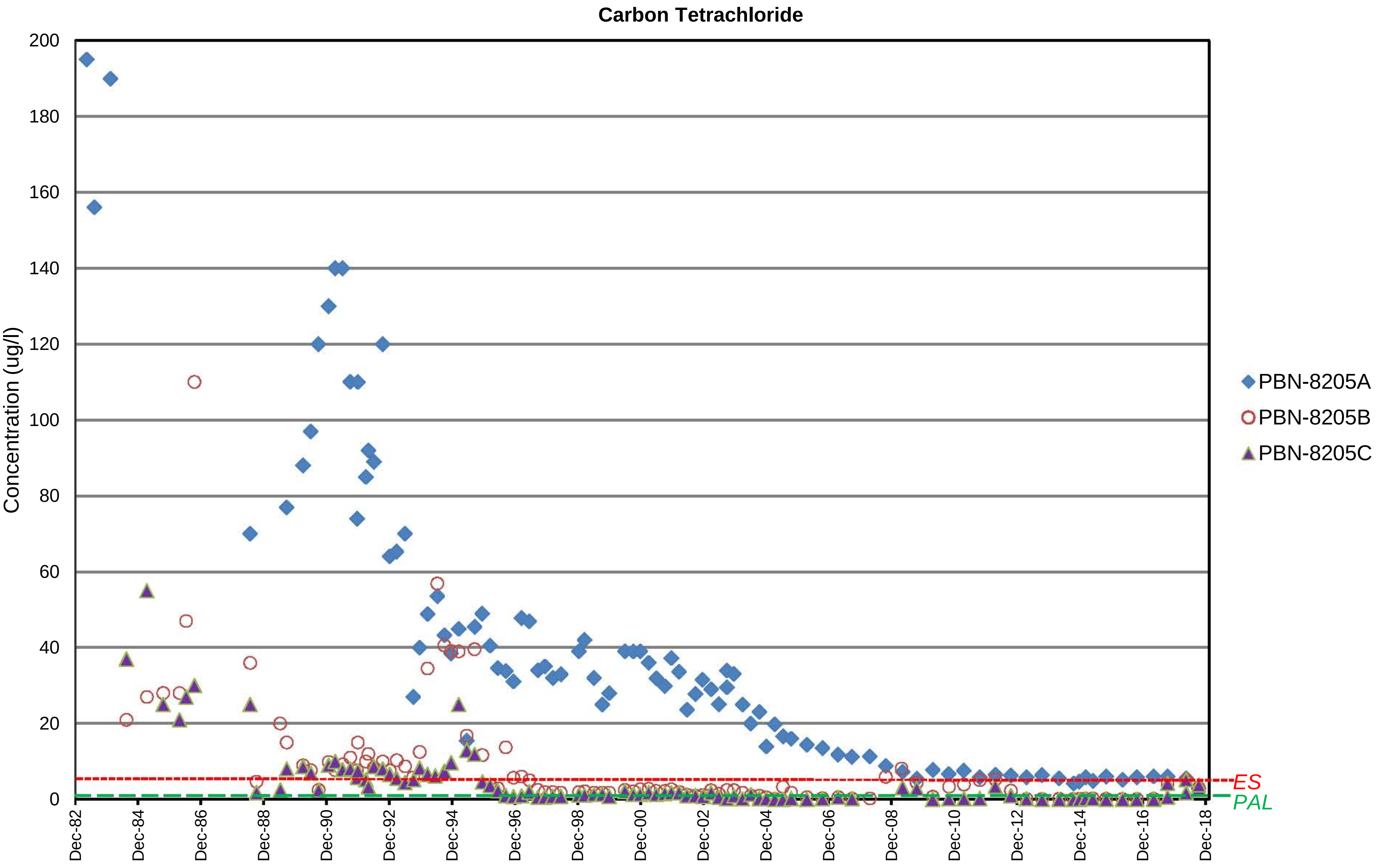


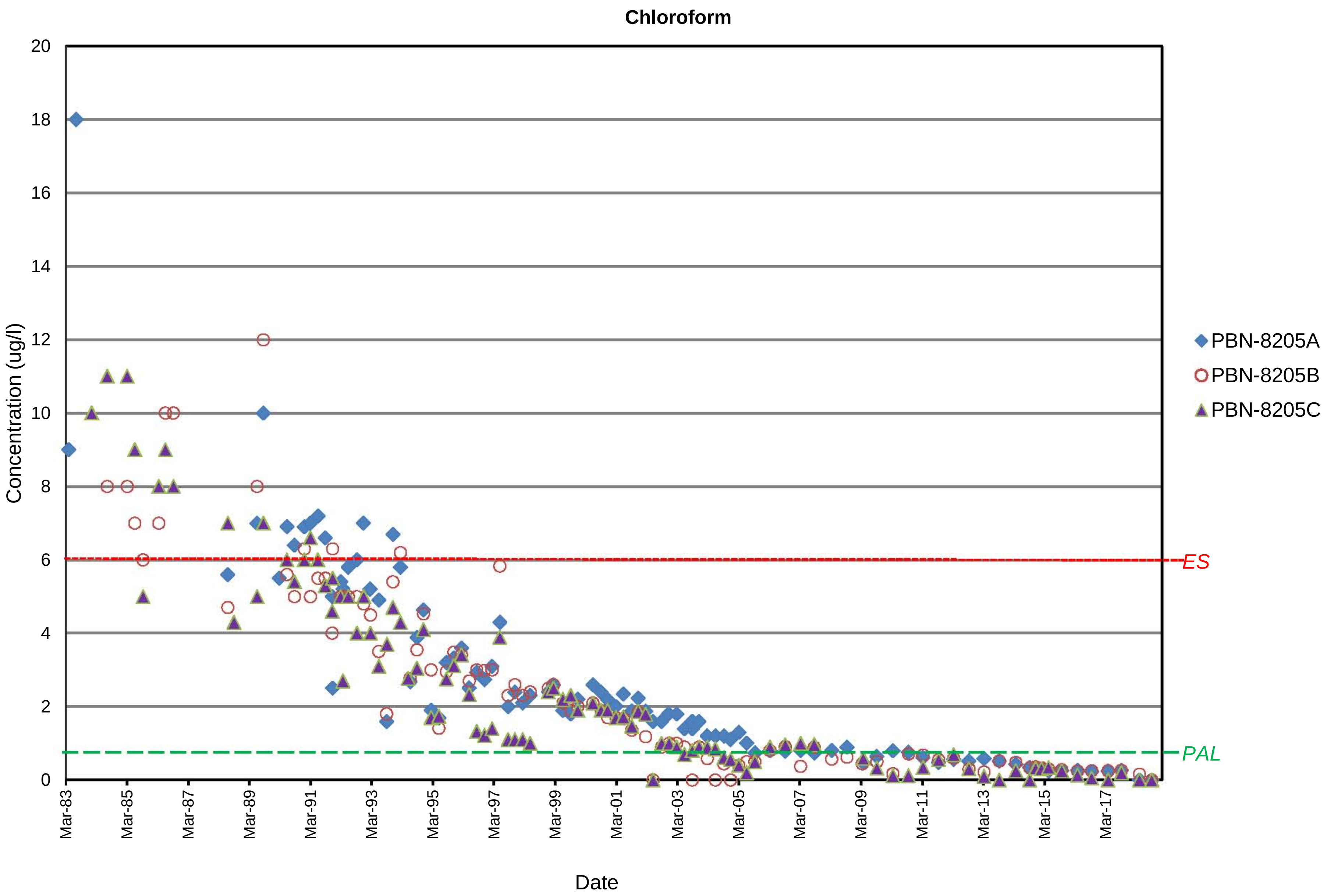
BAAP Groundwater Data Propellant Burning Ground Source Area



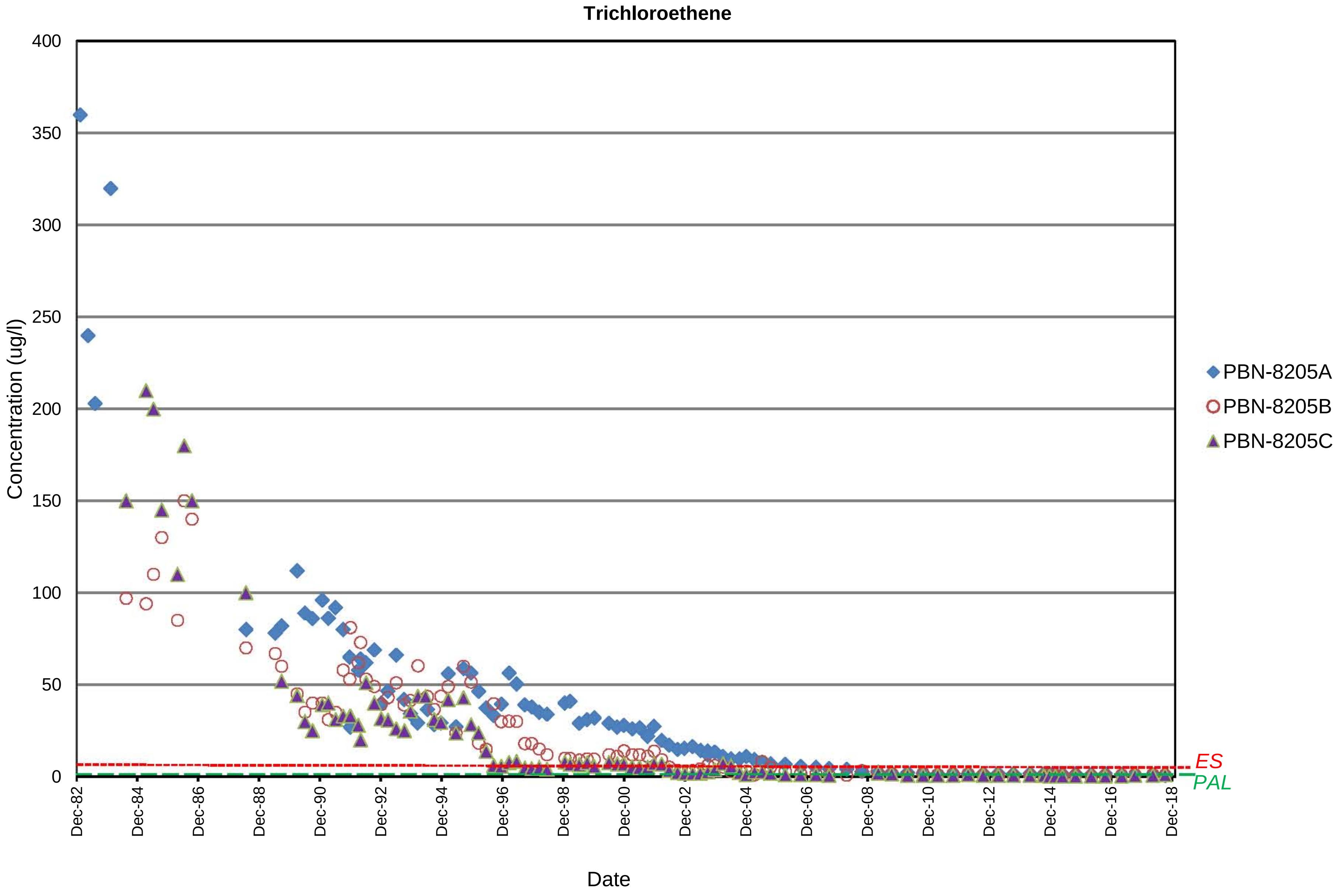
BAAP Groundwater Data | Propellant Burning Ground | Plume Center



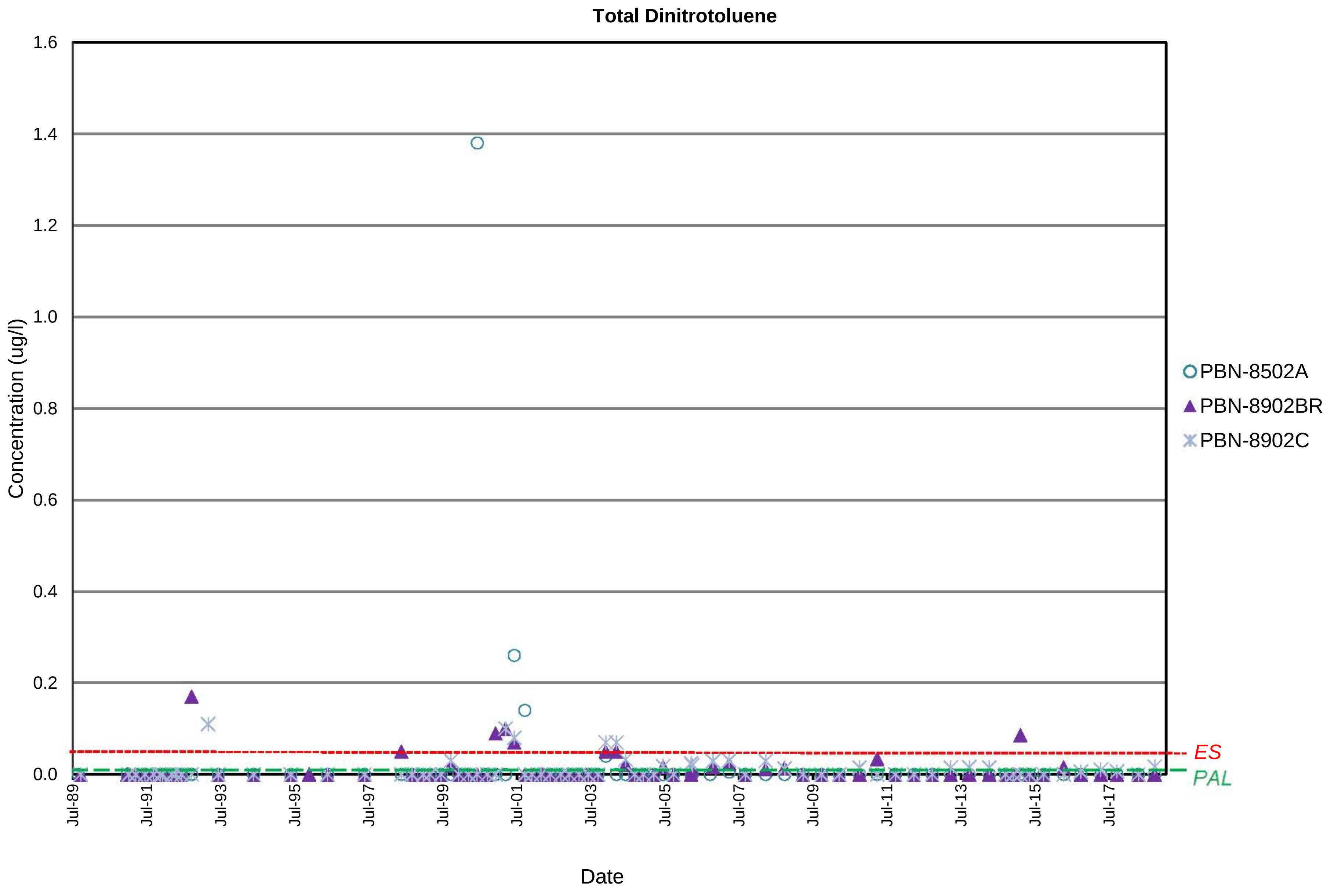

Carbon Tetrachloride
Concentration (ug/l)
200
180
160
140
120
100
80
60
40
20
0
Dec-82
Dec-84
Dec-86
Dec-88
Dec-90
Dec-92
Dec-94
Dec-96
Dec-98
Dec-00
Dec-02
Dec-04
Dec-06
Dec-08
Dec-10
Dec-12
Dec-14
Dec-16
Dec-18
Date
PBN-8205A
PBN-8205B
PBN-8205C
ES
PAL


Chloroform
Concentration (ug/l)
20
18
16
14
12
10
8
6
4
2
0
ES
PAL
Mar-83
Mar-85
Mar-87
Mar-89
Mar-91
Mar-93
Mar-95
Mar-97
Mar-99
Mar-01
Mar-03
Mar-05
Mar-07
Mar-09
Mar-11
Mar-13
Mar-15
Mar-17
Date
◆ PBN-8205A
○ PBN-8205B
▲ PBN-8205C

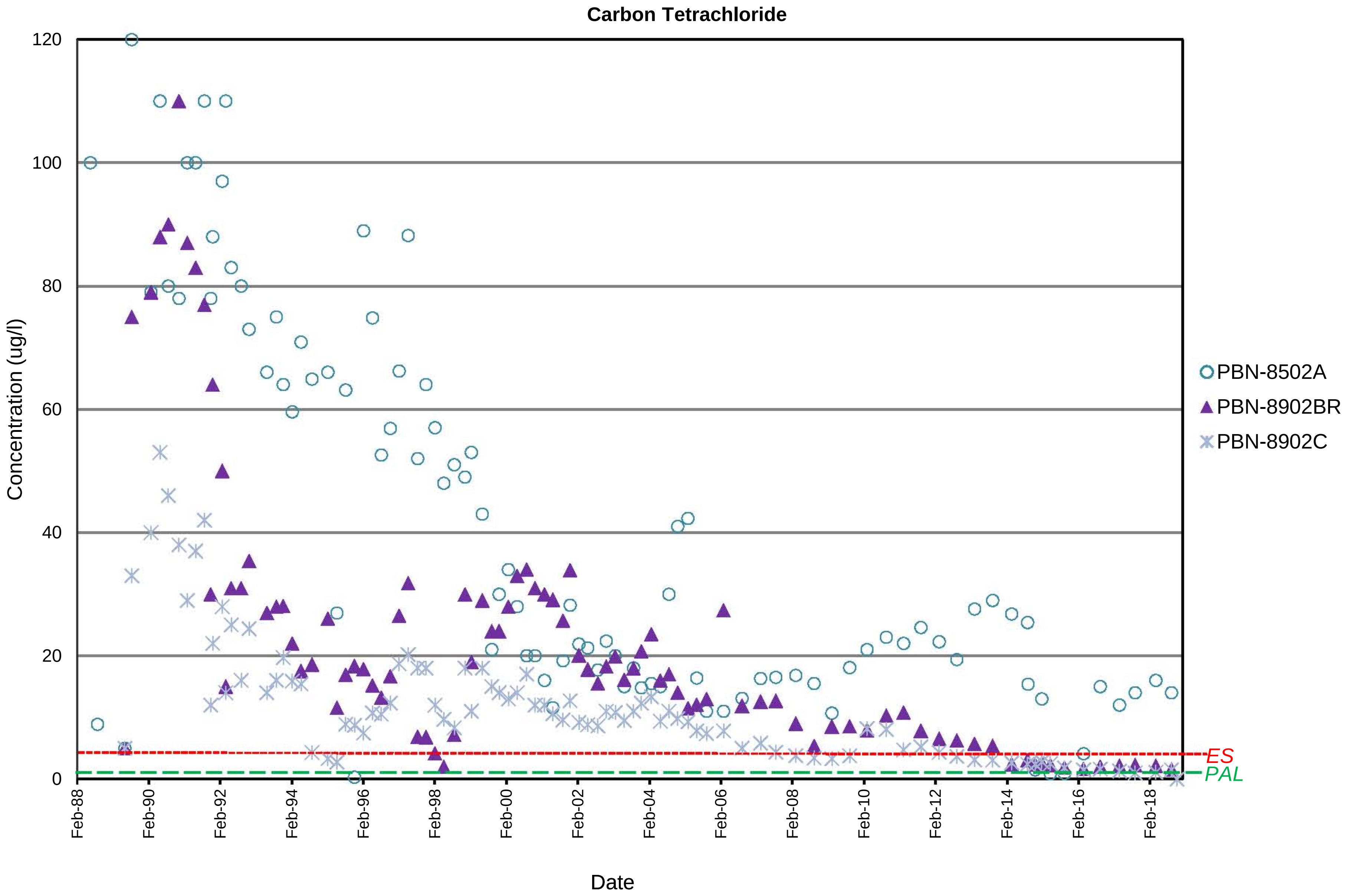
BAAP Groundwater Data | Propellant Burning Ground | Plume Center

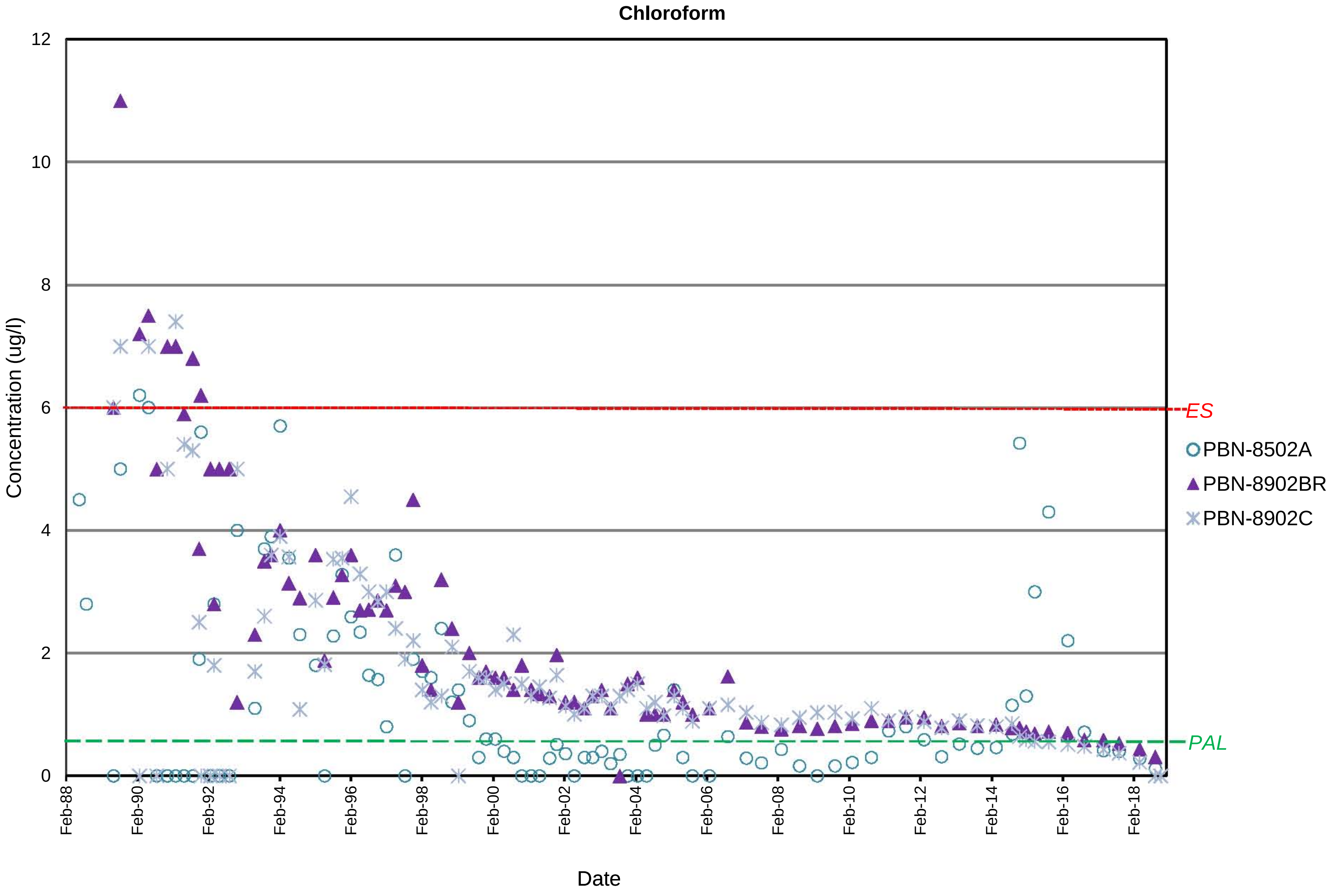


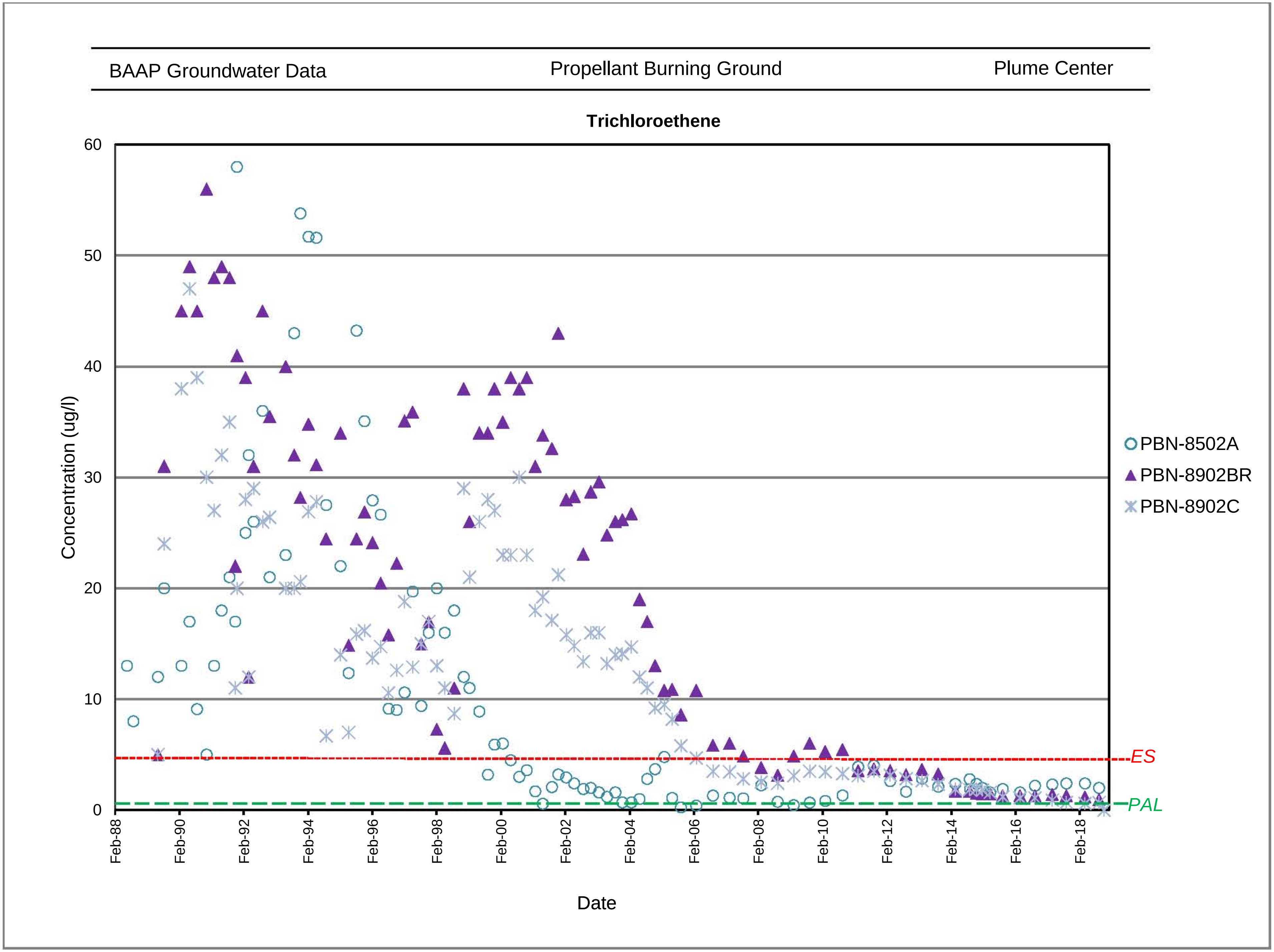
BAAP Groundwater Data | Propellant Burning Ground | Source Area



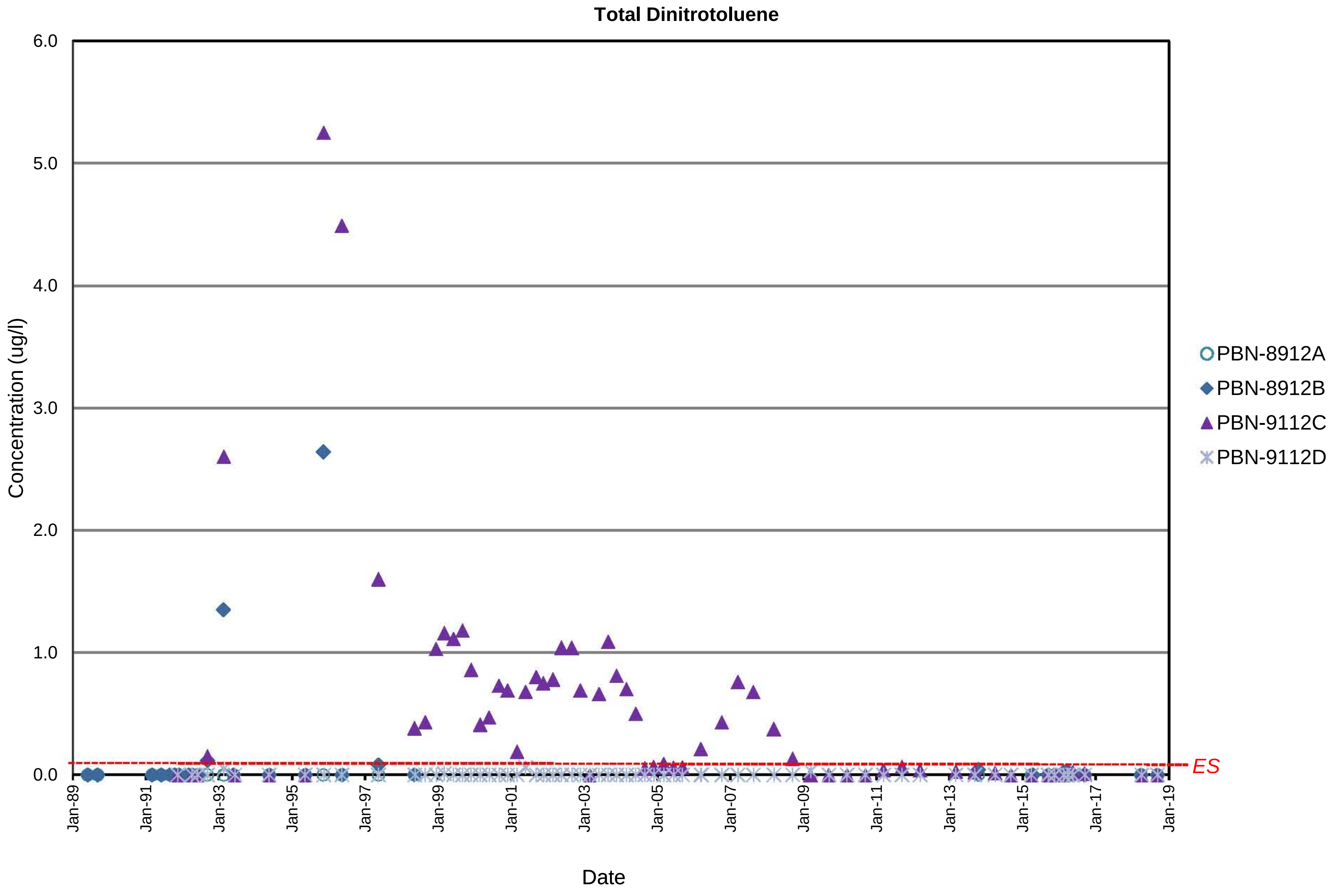
BAAP Groundwater Data Propellant Burning Ground Plume Center

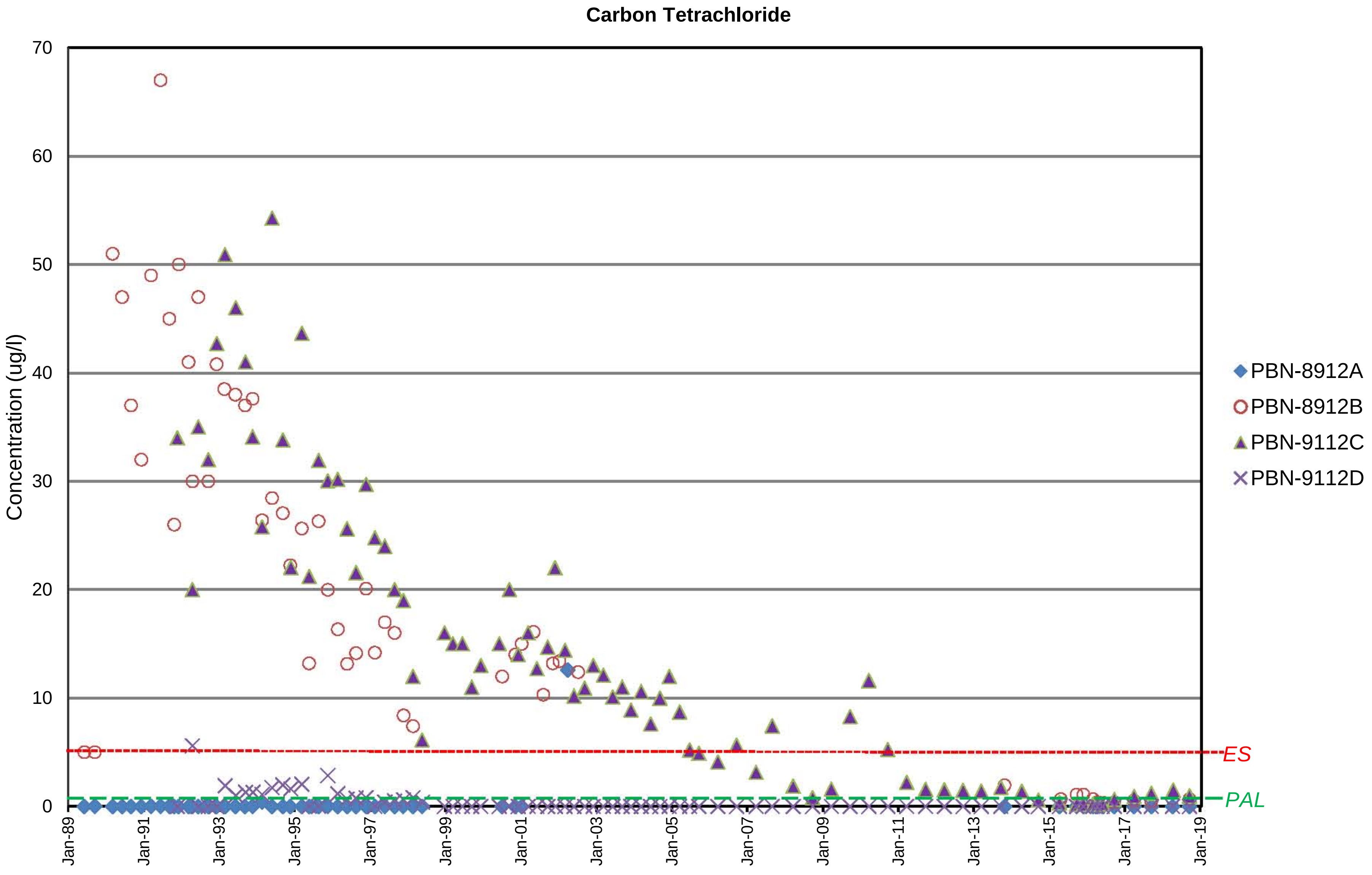


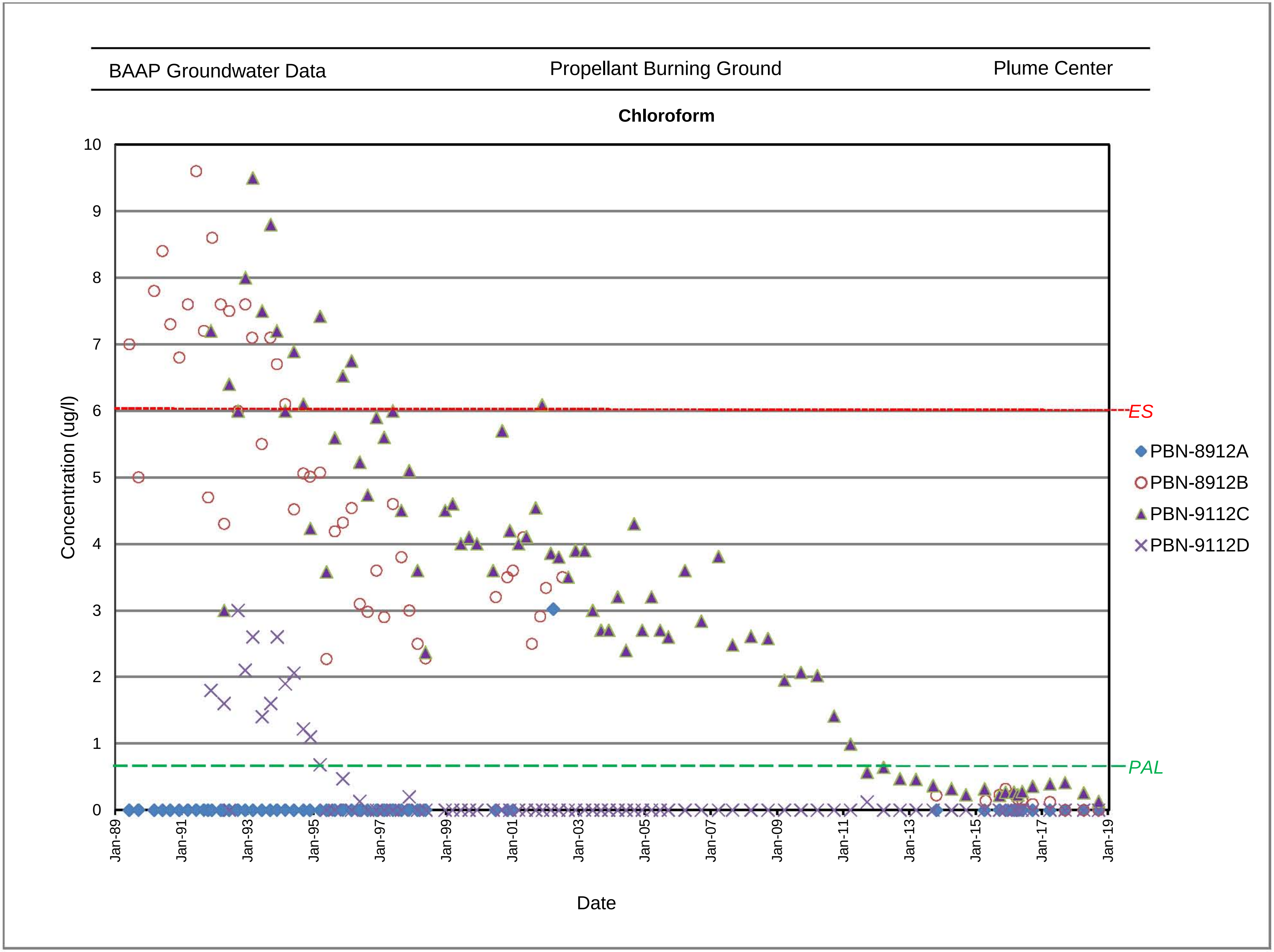

Chloroform
Concentration (ug/l)
0
2
4
6
8
10
12
Date
Feb-88
Feb-90
Feb-92
Feb-94
Feb-96
Feb-98
Feb-00
Feb-02
Feb-04
Feb-06
Feb-08
Feb-10
Feb-12
Feb-14
Feb-16
Feb-18
ES
PAL
○ PBN-8502A
▲ PBN-8902BR
✳ PBN-8902C


BAAP Groundwater Data
Propellant Burning Ground
Plume Center
Trichloroethene
Concentration (ug/l)
0
10
20
30
40
50
60
Date
Feb-88
Feb-90
Feb-92
Feb-94
Feb-96
Feb-98
Feb-00
Feb-02
Feb-04
Feb-06
Feb-08
Feb-10
Feb-12
Feb-14
Feb-16
Feb-18
ES
PAL
PBN-8502A
PBN-8902BR
PBN-8902C

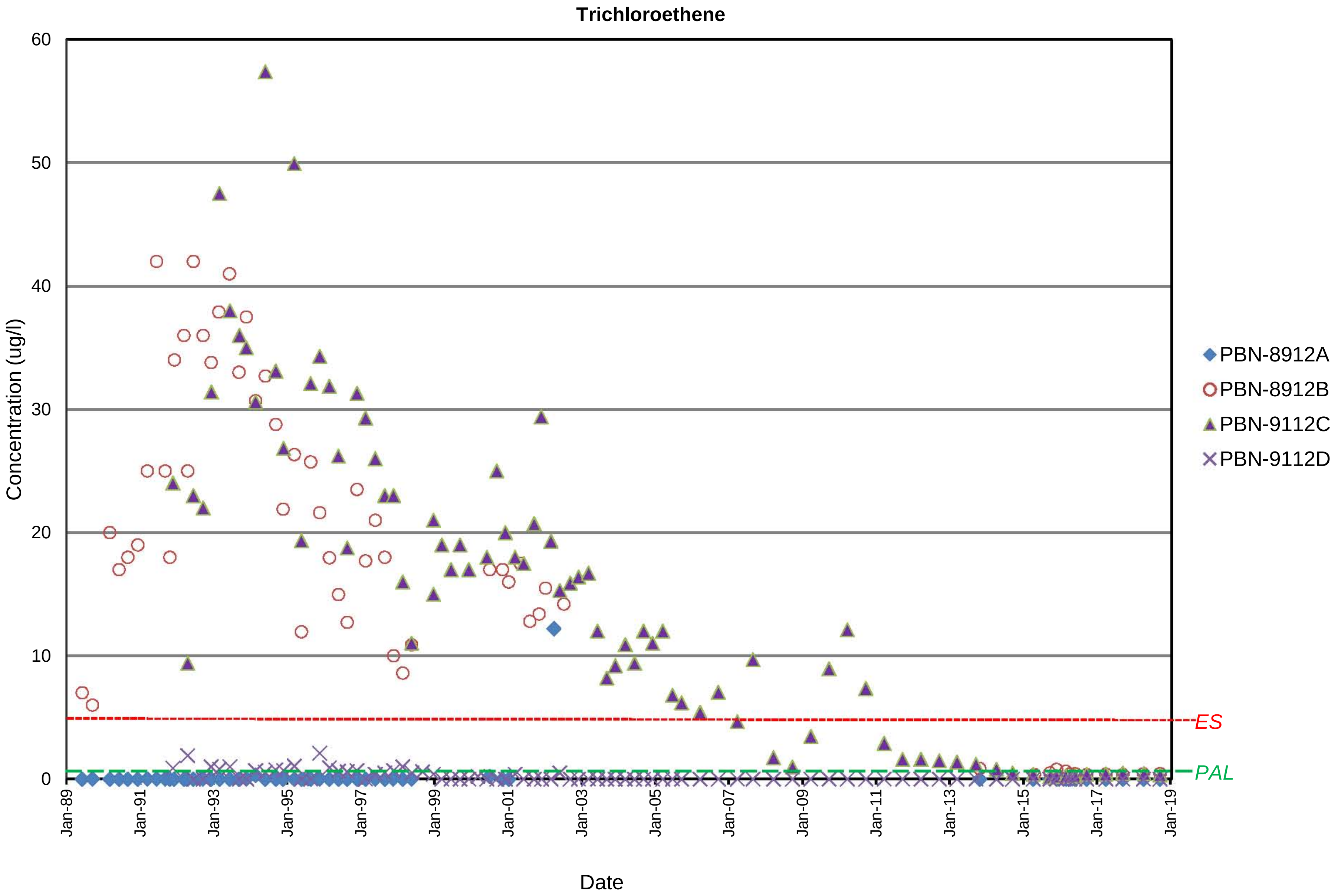
BAAP Groundwater Data | Propellant Burning Ground | Plume Center



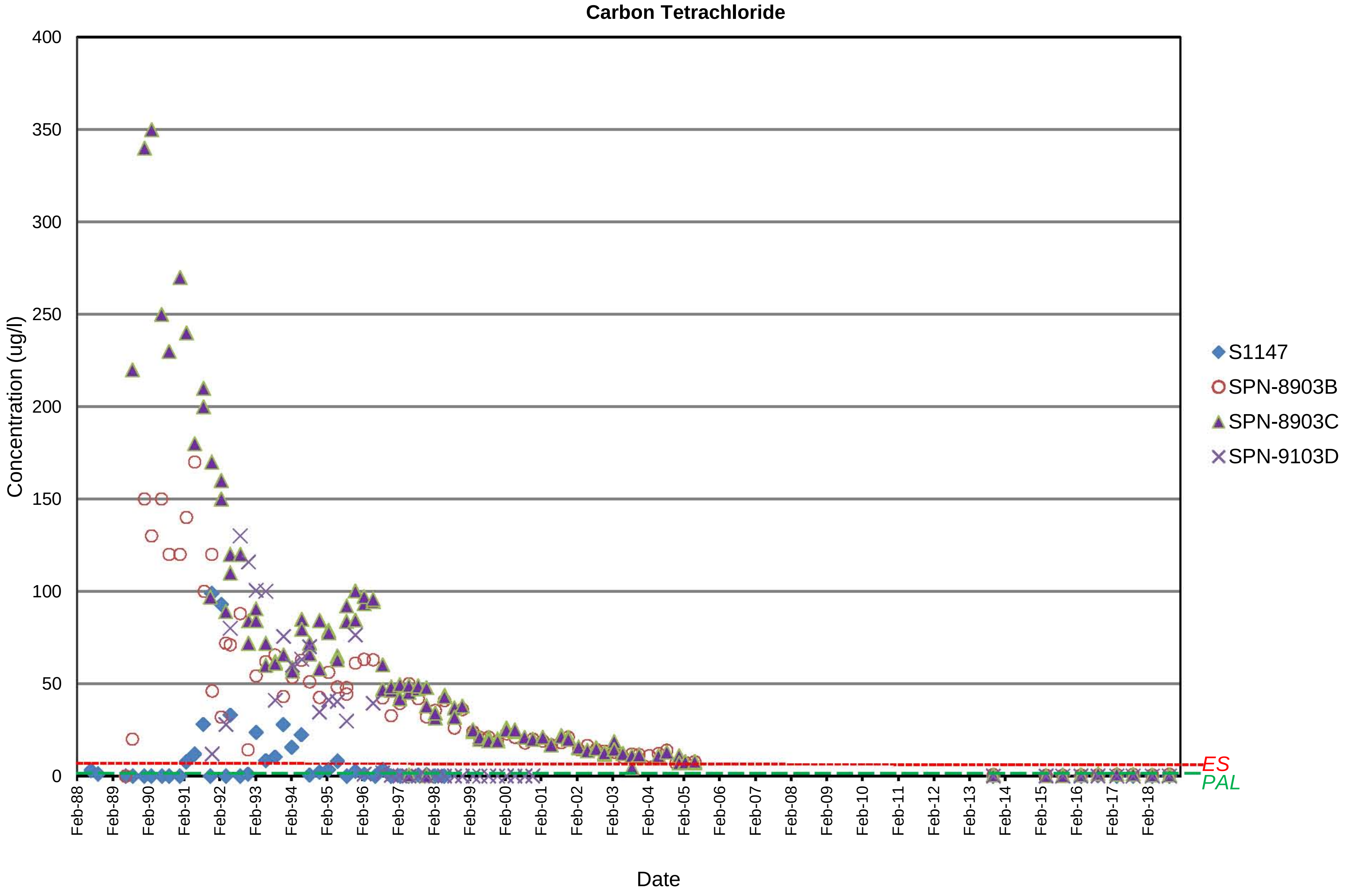

Carbon Tetrachloride
Concentration (ug/l)
70
60
50
40
30
20
10
0
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
Jan-11
Jan-13
Jan-15
Jan-17
Jan-19
Date
ES
PAL
PBN-8912A
PBN-8912B
PBN-9112C
PBN-9112D

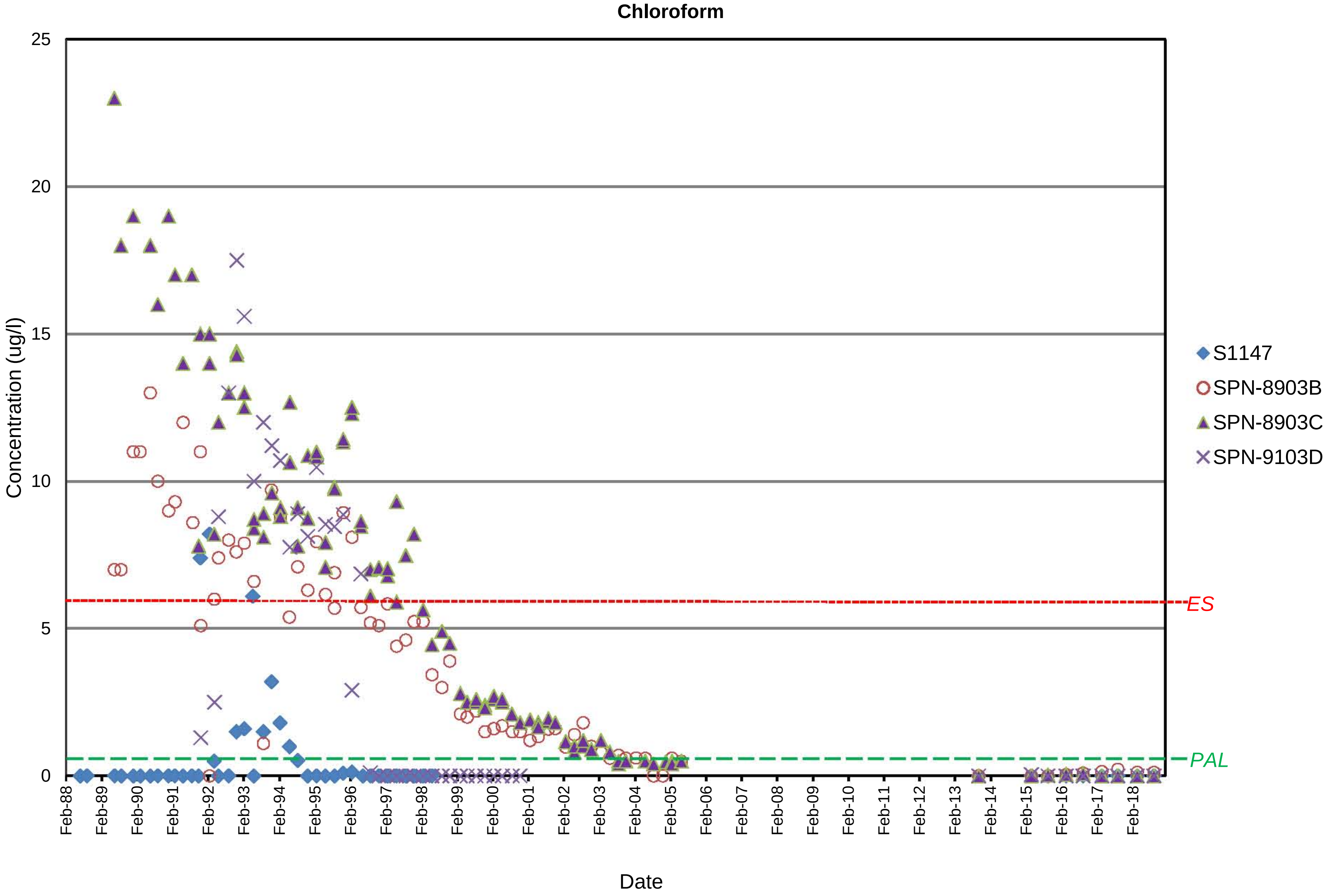

BAAP Groundwater Data
Propellant Burning Ground
Plume Center
Chloroform
Concentration (ug/l)
10
9
8
7
6
5
4
3
2
1
0
ES
PAL
PBN-8912A
PBN-8912B
PBN-9112C
PBN-9112D
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
Jan-11
Jan-13
Jan-15
Jan-17
Jan-19
Date

BAAP Groundwater Data Propellant Burning Ground Plume Center

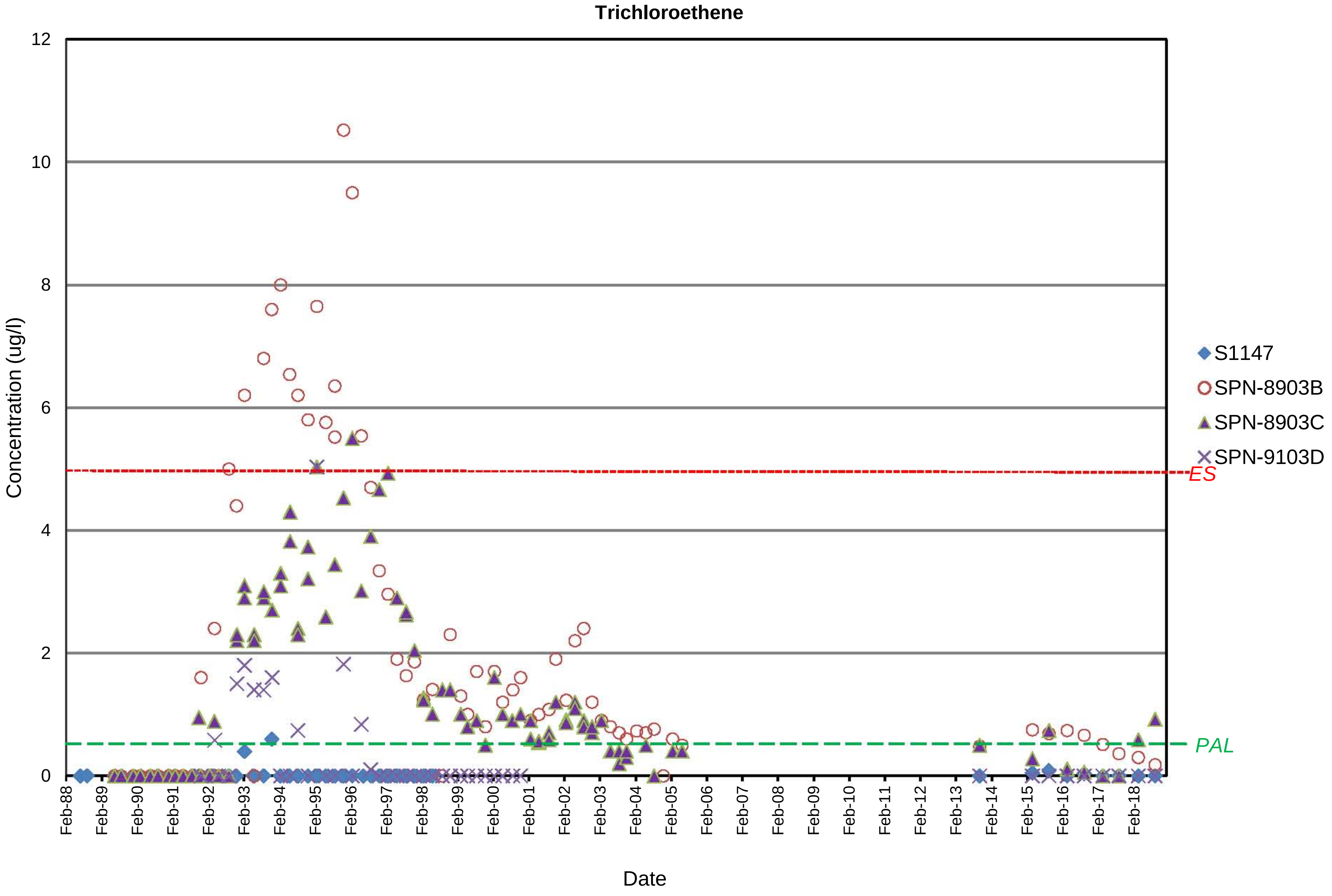


BAAP Groundwater Data Propellant Burning Ground Plume Edge - Onsite

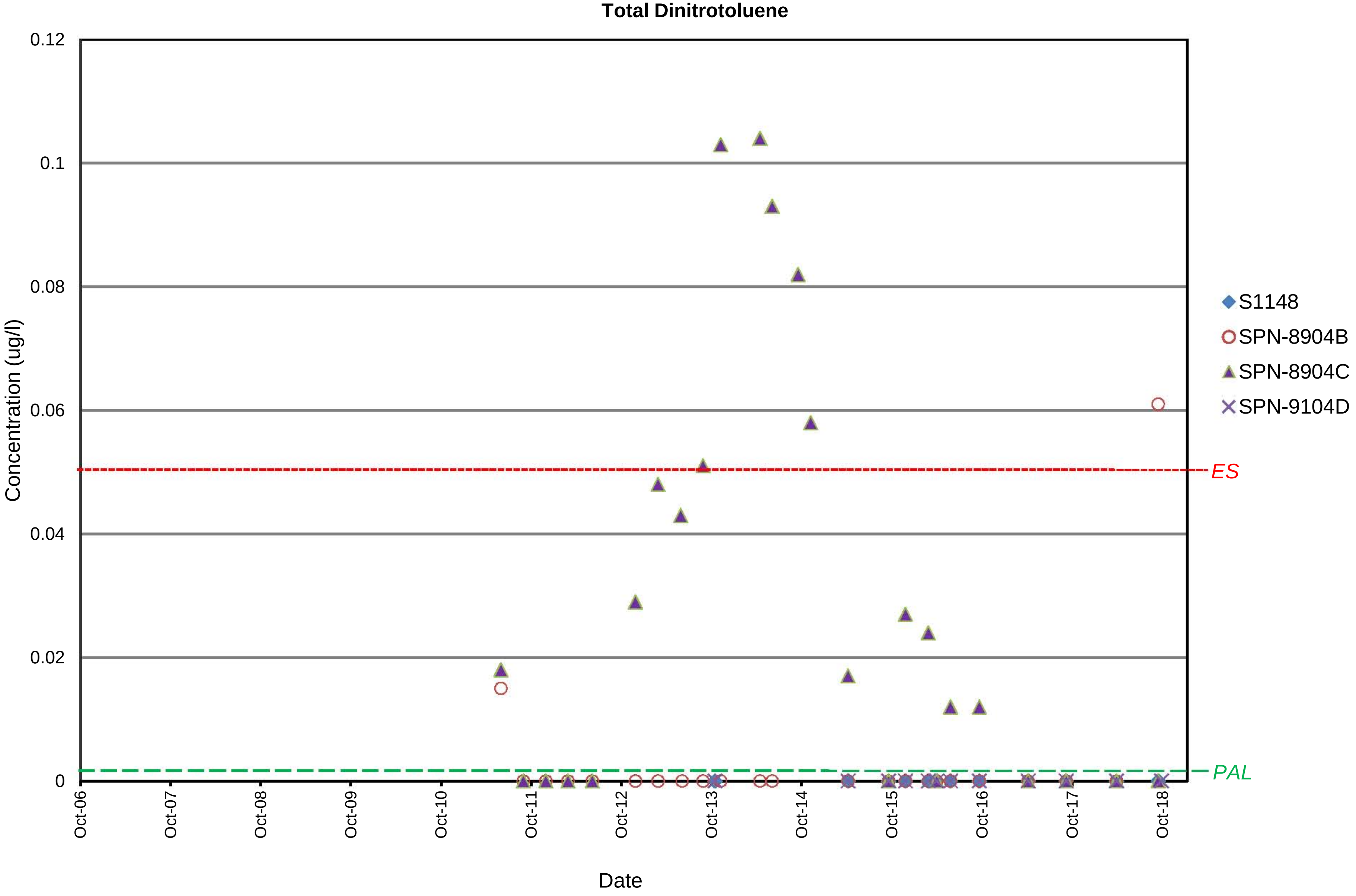



Chloroform
Concentration (ug/l)
25
20
15
10
5
0
Date
Feb-88
Feb-89
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
ES
PAL
S1147
SPN-8903B
SPN-8903C
SPN-9103D

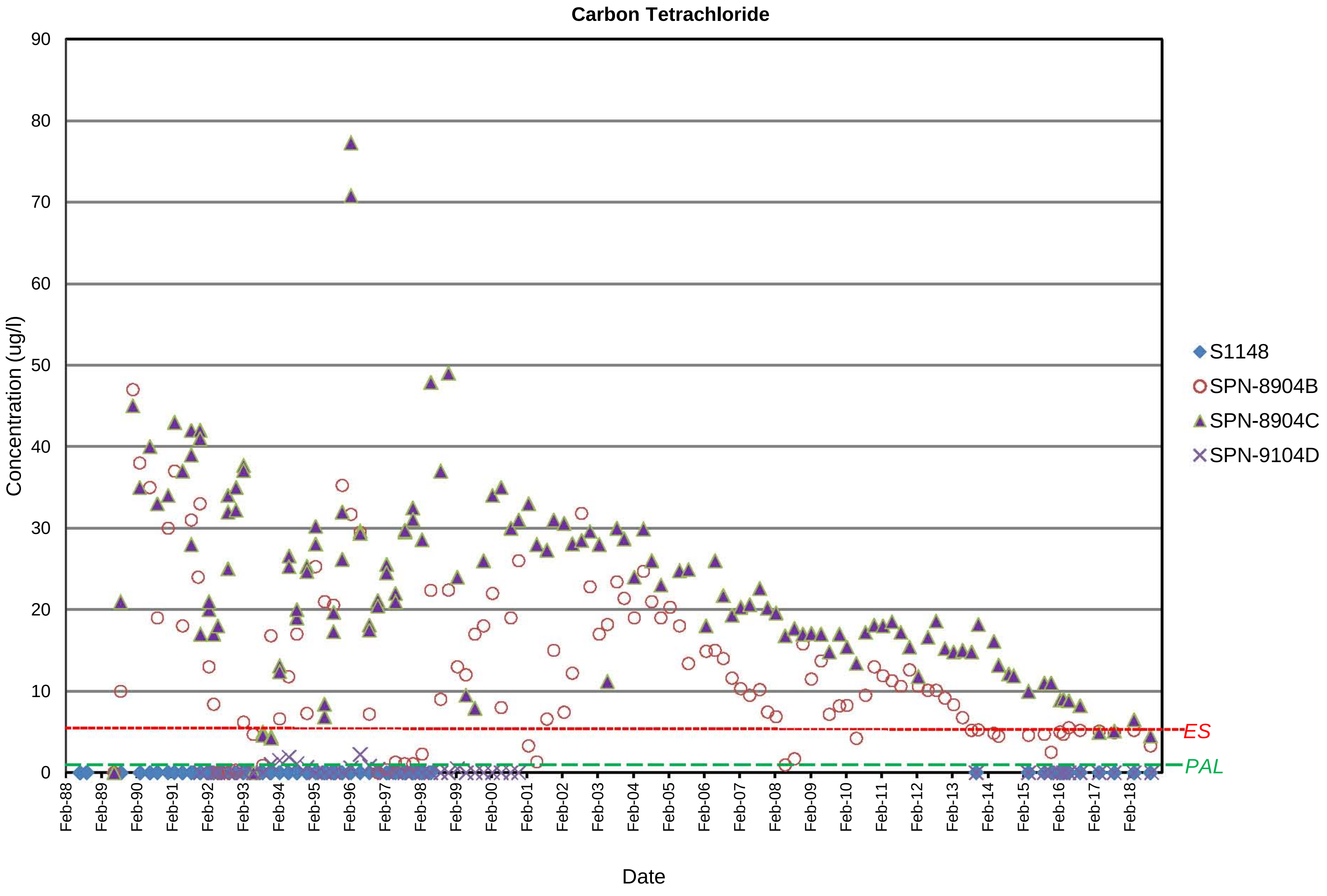
BAAP Groundwater Data Propellant Burning Ground Plume Edge - Onsite



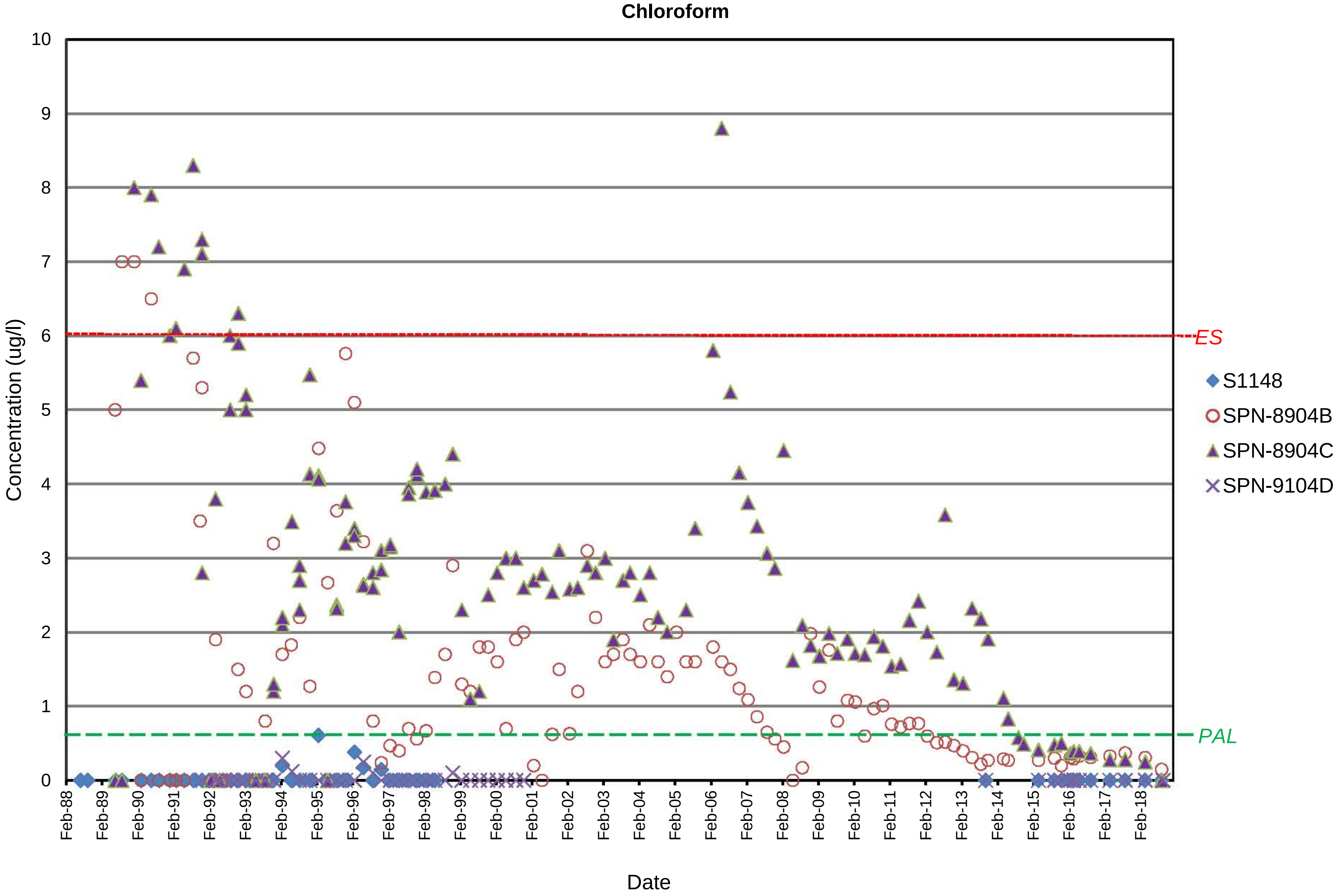
BAAP Groundwater Data Propellant Burning Ground Plume Center - Onsite

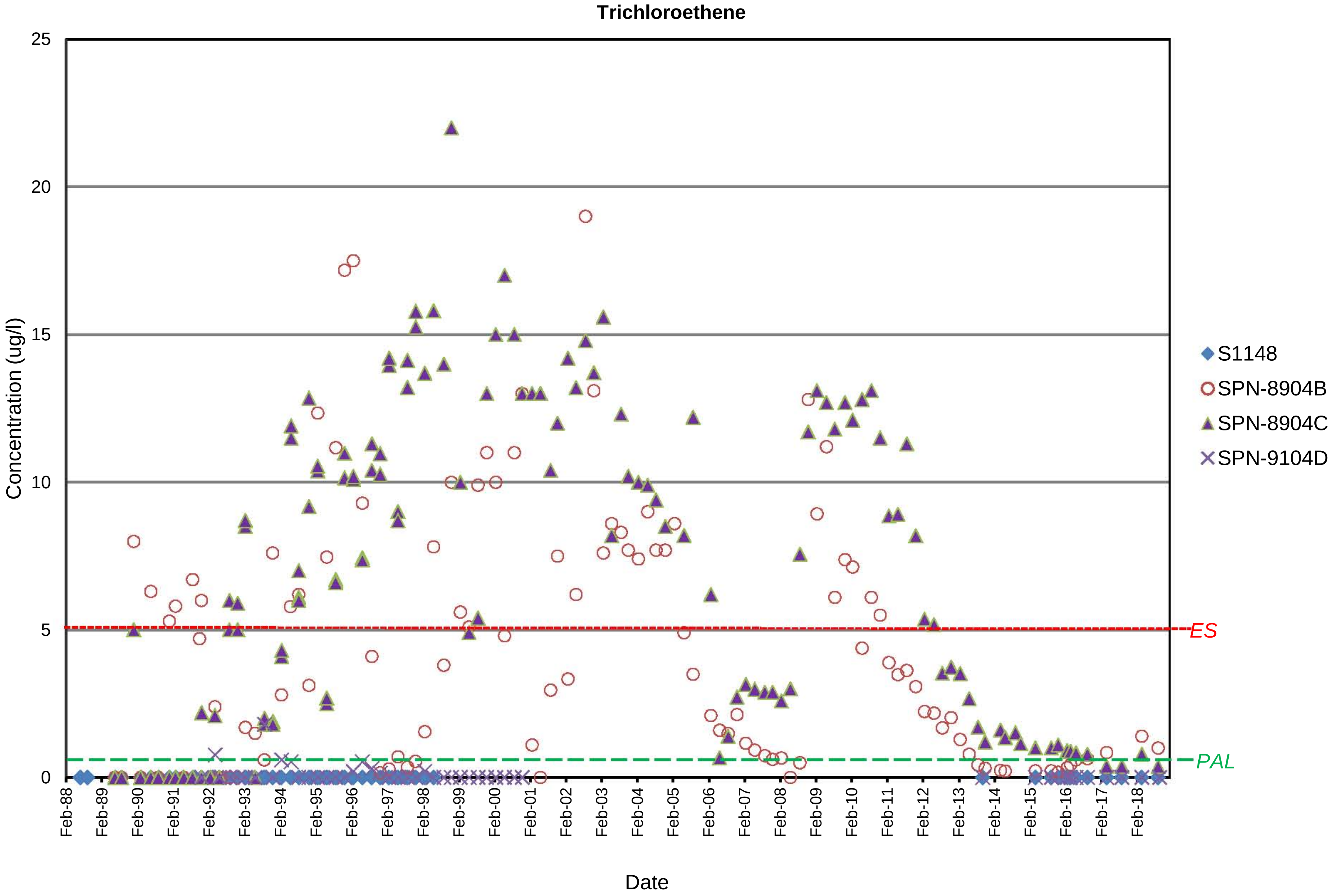


BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Onsite

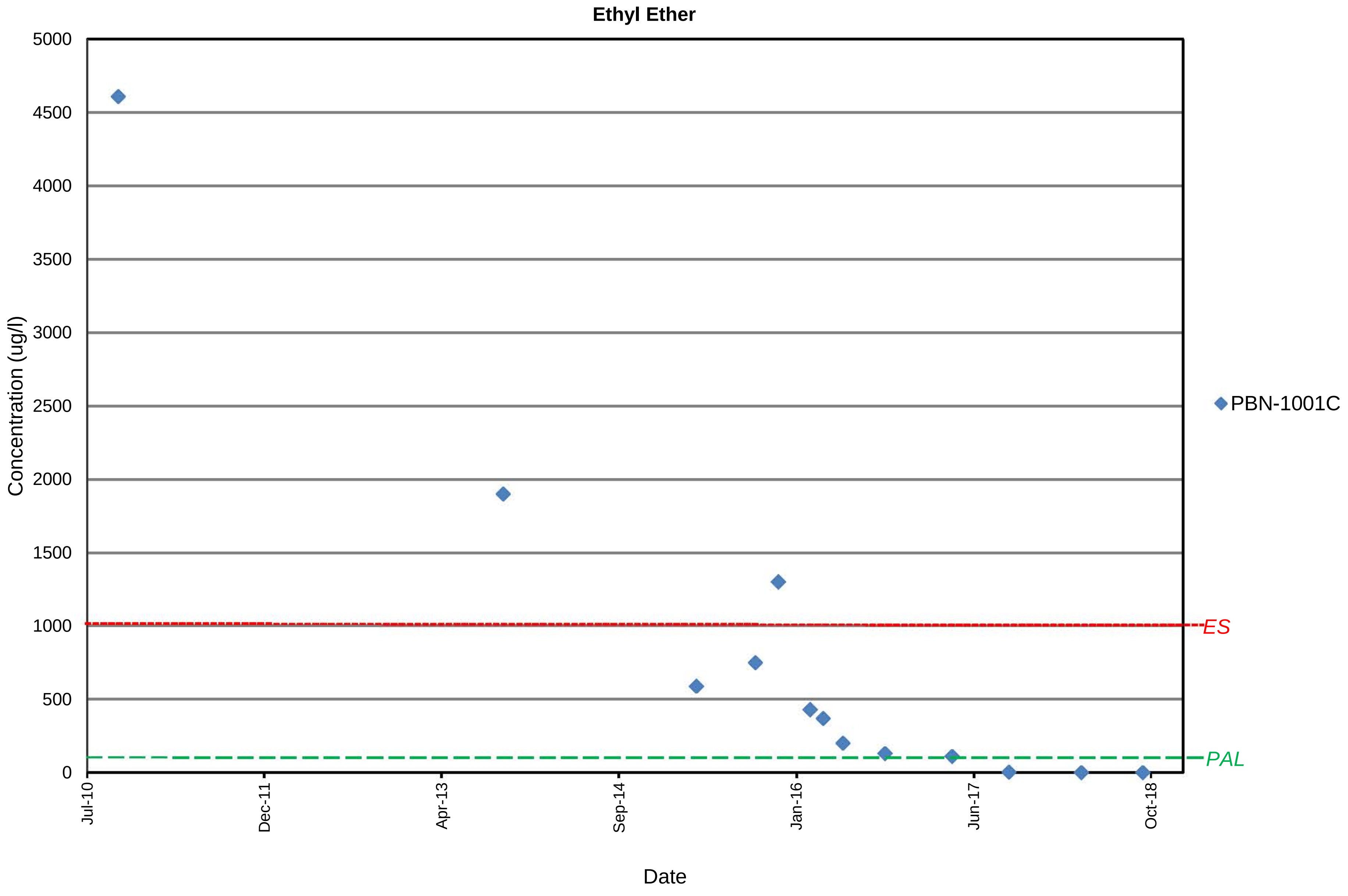


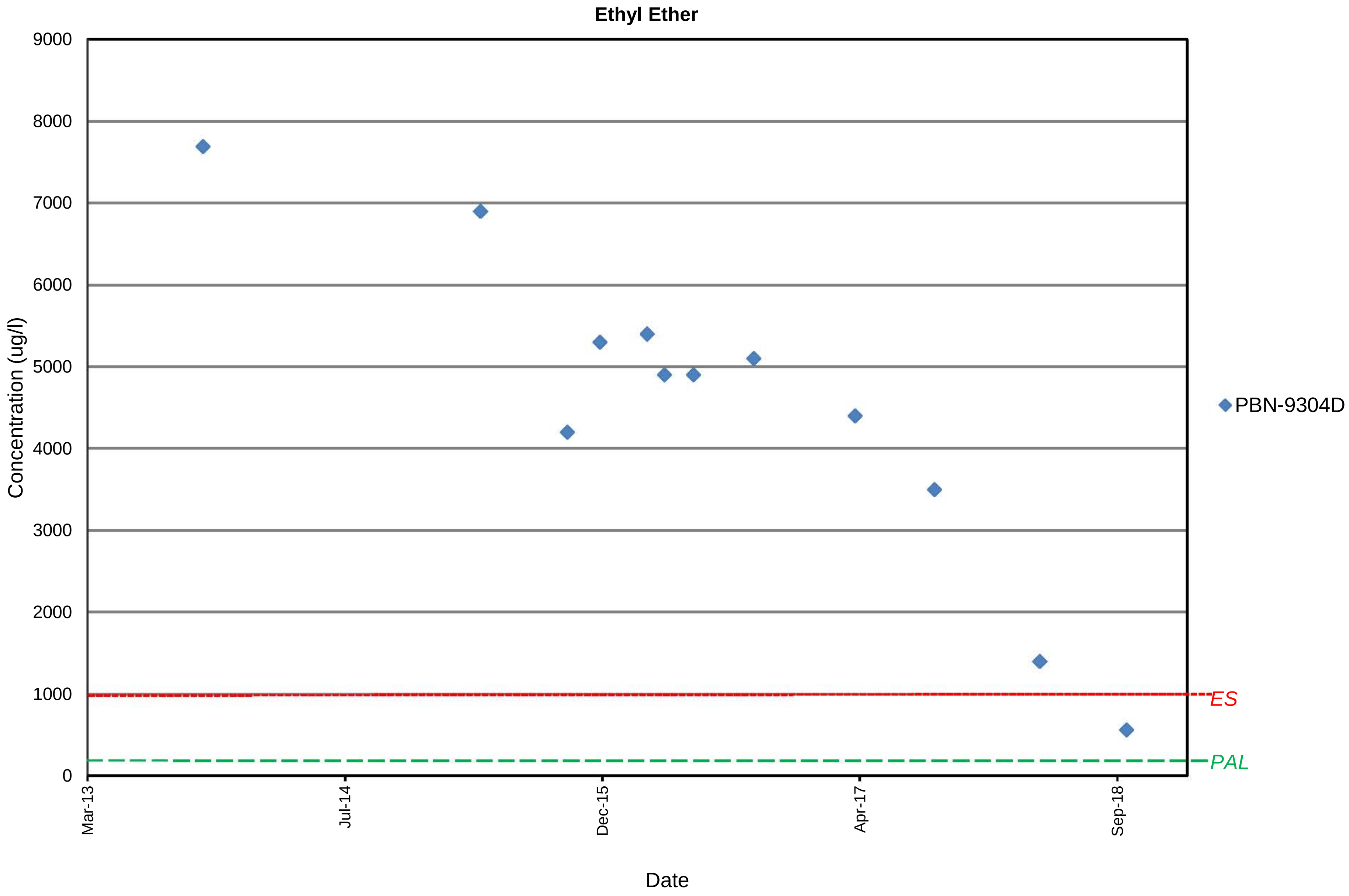
BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Onsite



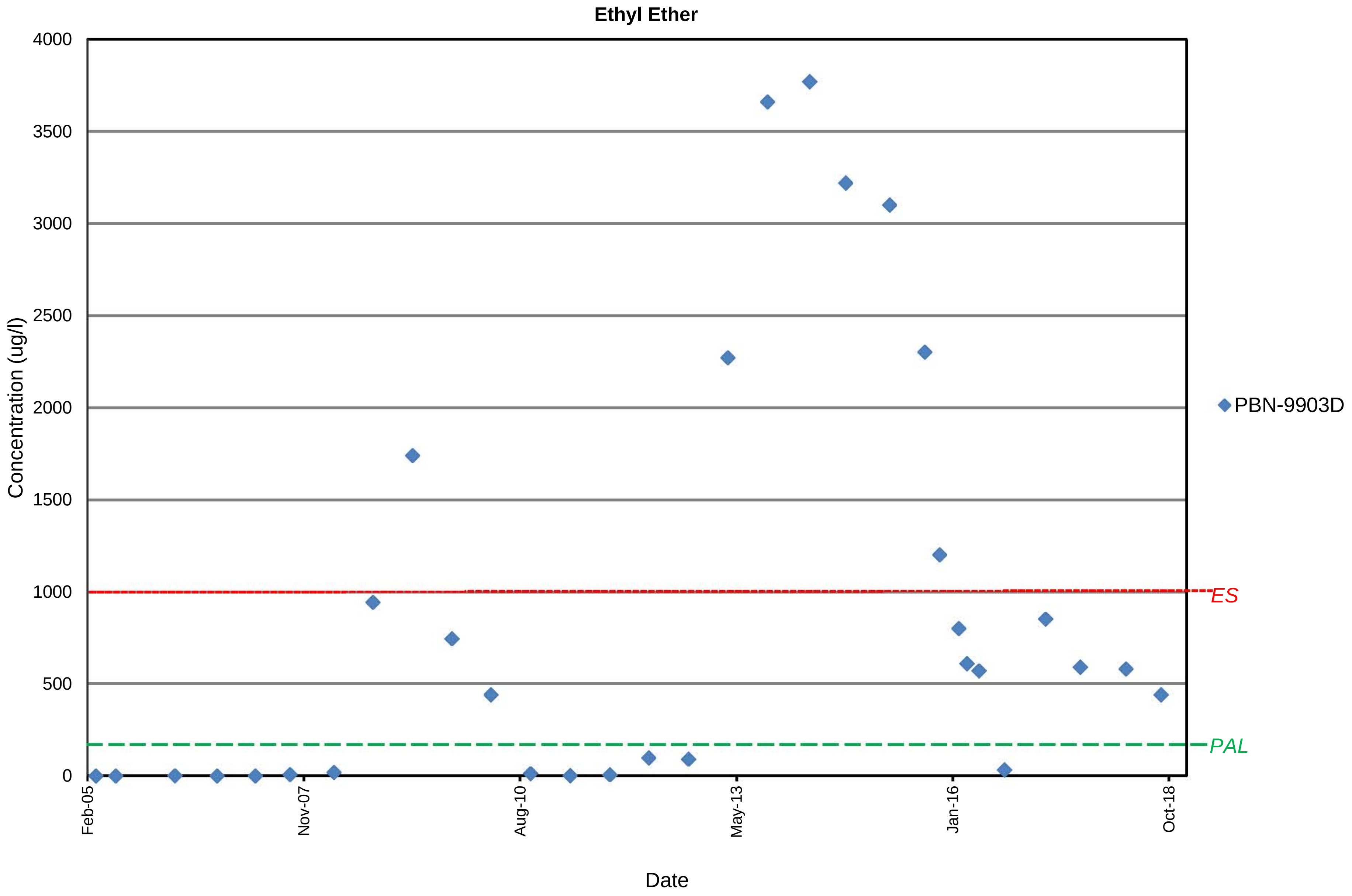

Trichloroethene
Concentration (ug/l)
25
20
15
10
5
0
Feb-88
Feb-89
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
Date
ES
PAL
◆ S1148
○ SPN-8904B
▲ SPN-8904C
× SPN-9104D

BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Onsite

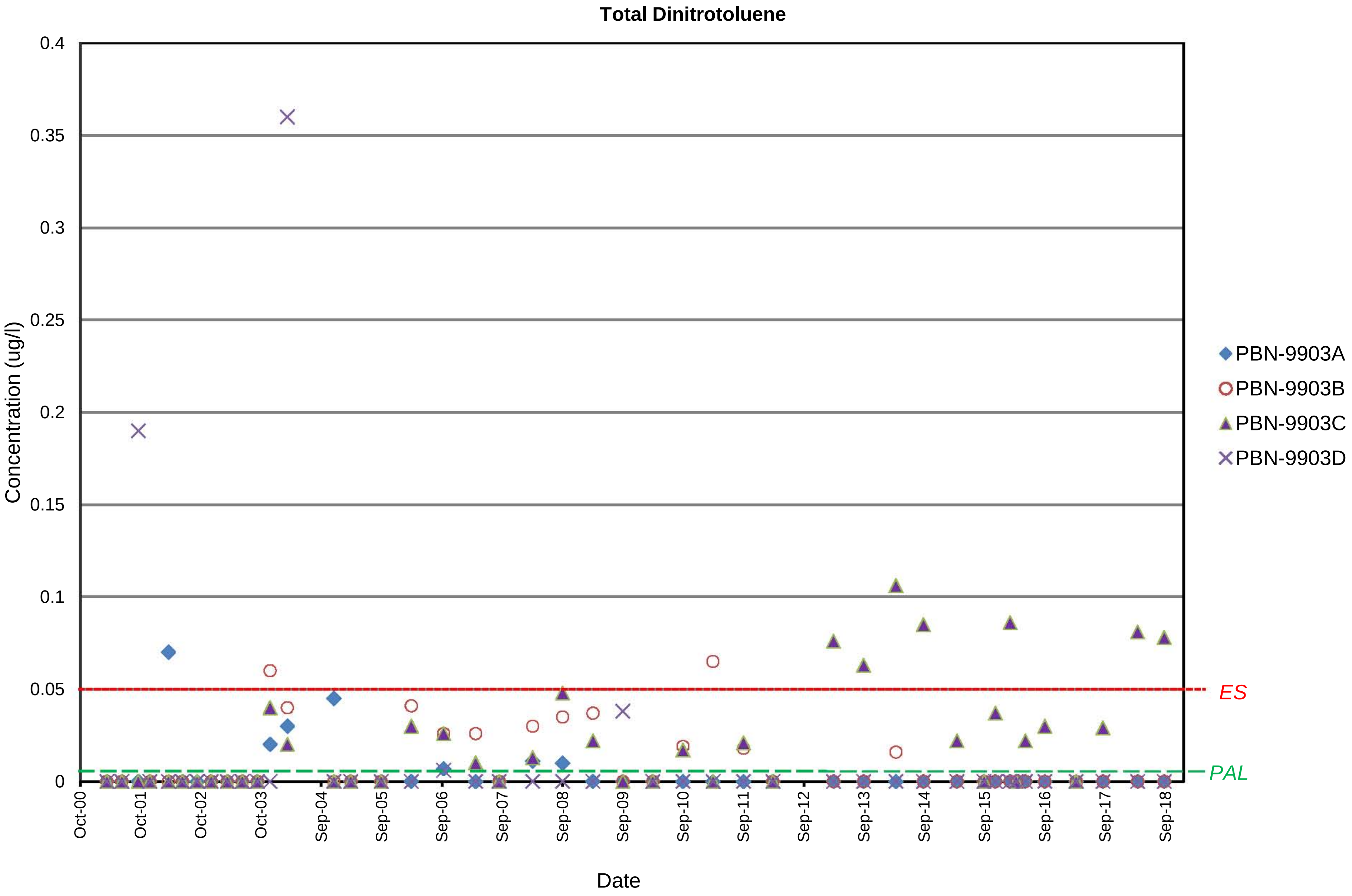



Ethyl Ether
Concentration (ug/l)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Mar-13
Jul-14
Dec-15
Apr-17
Sep-18
Date
◆ PBN-9304D
ES
PAL

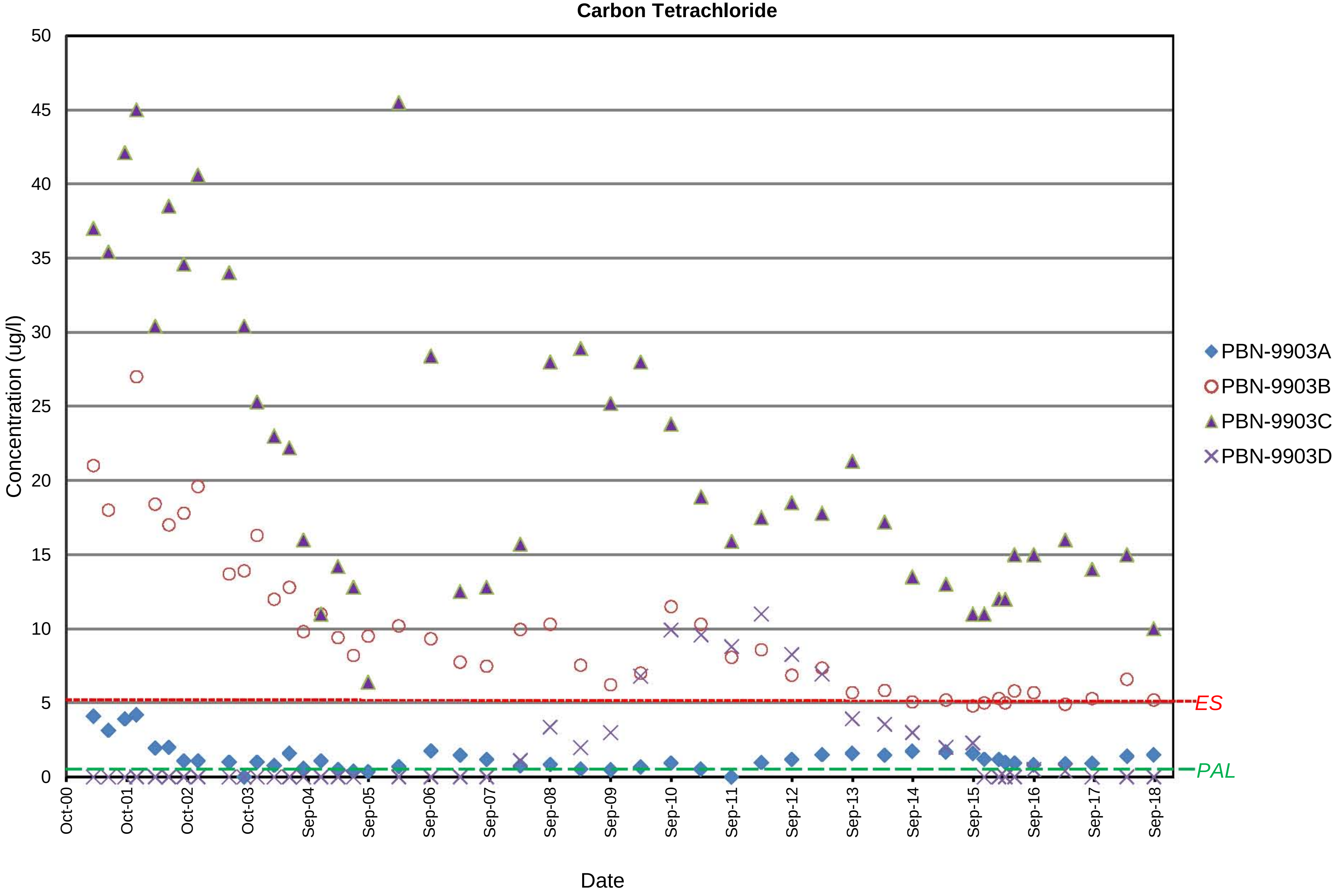
BAAP Groundwater Data Propellant Burning Ground Plume Center - Offsite



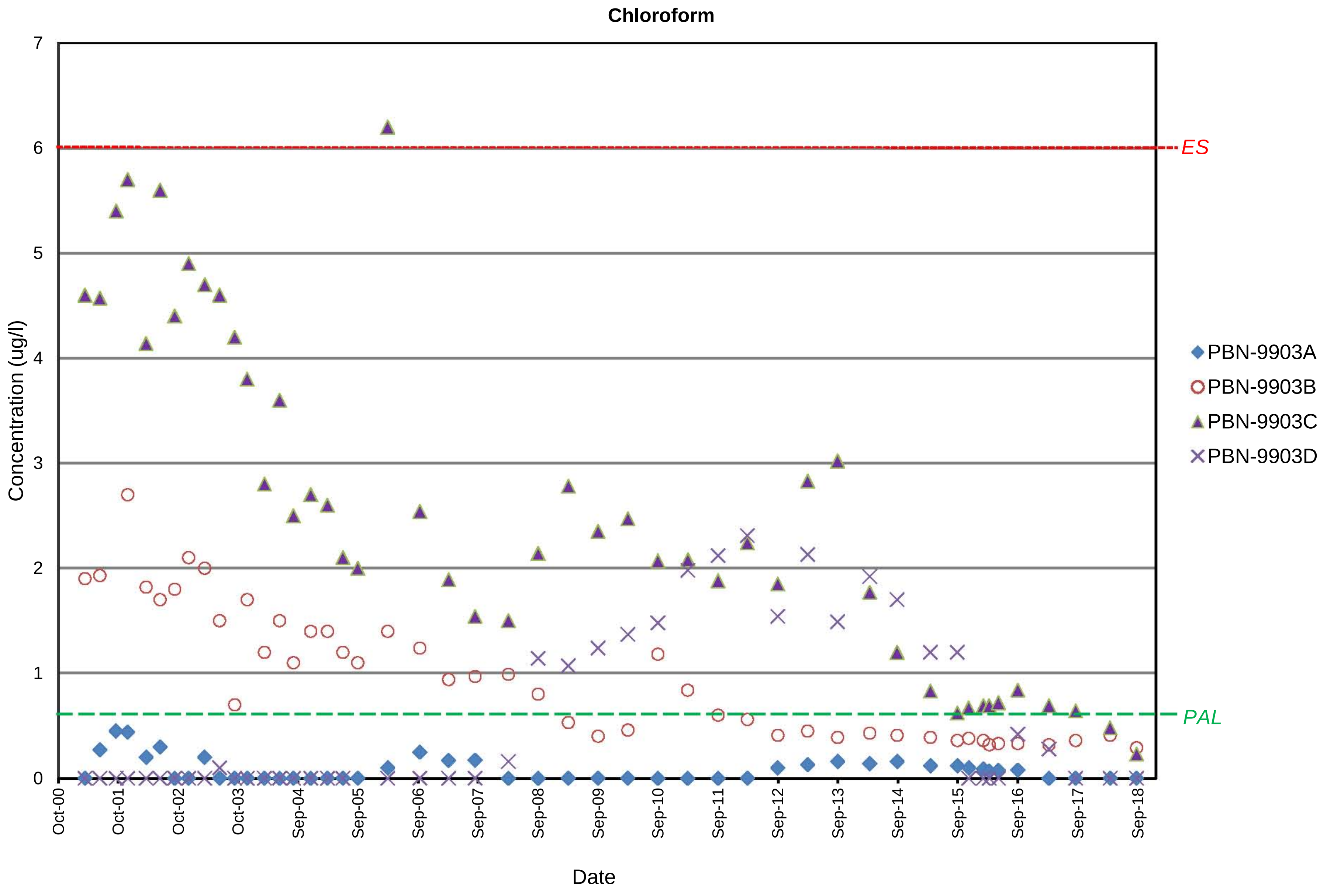
BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Offsite



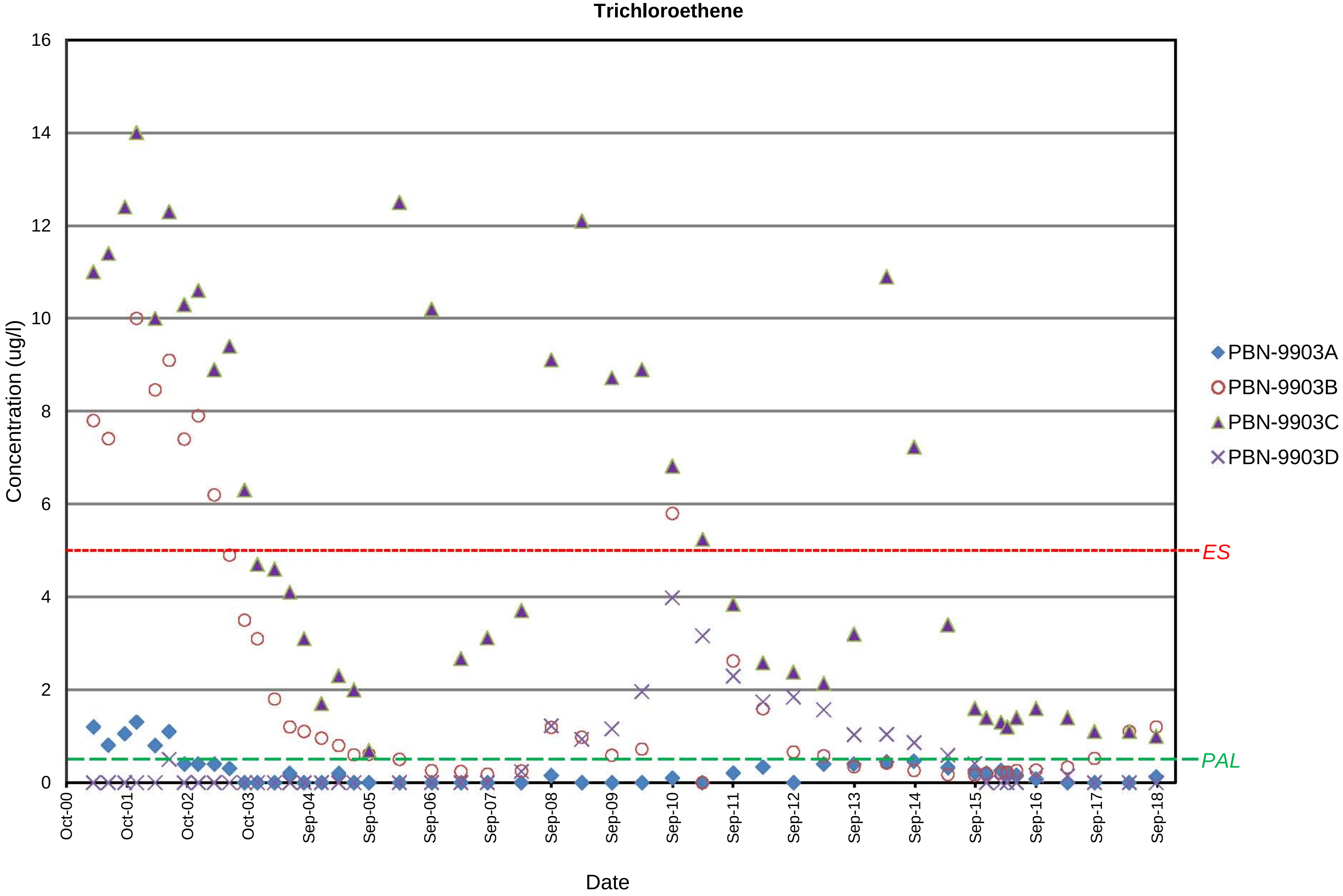
BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Offsite



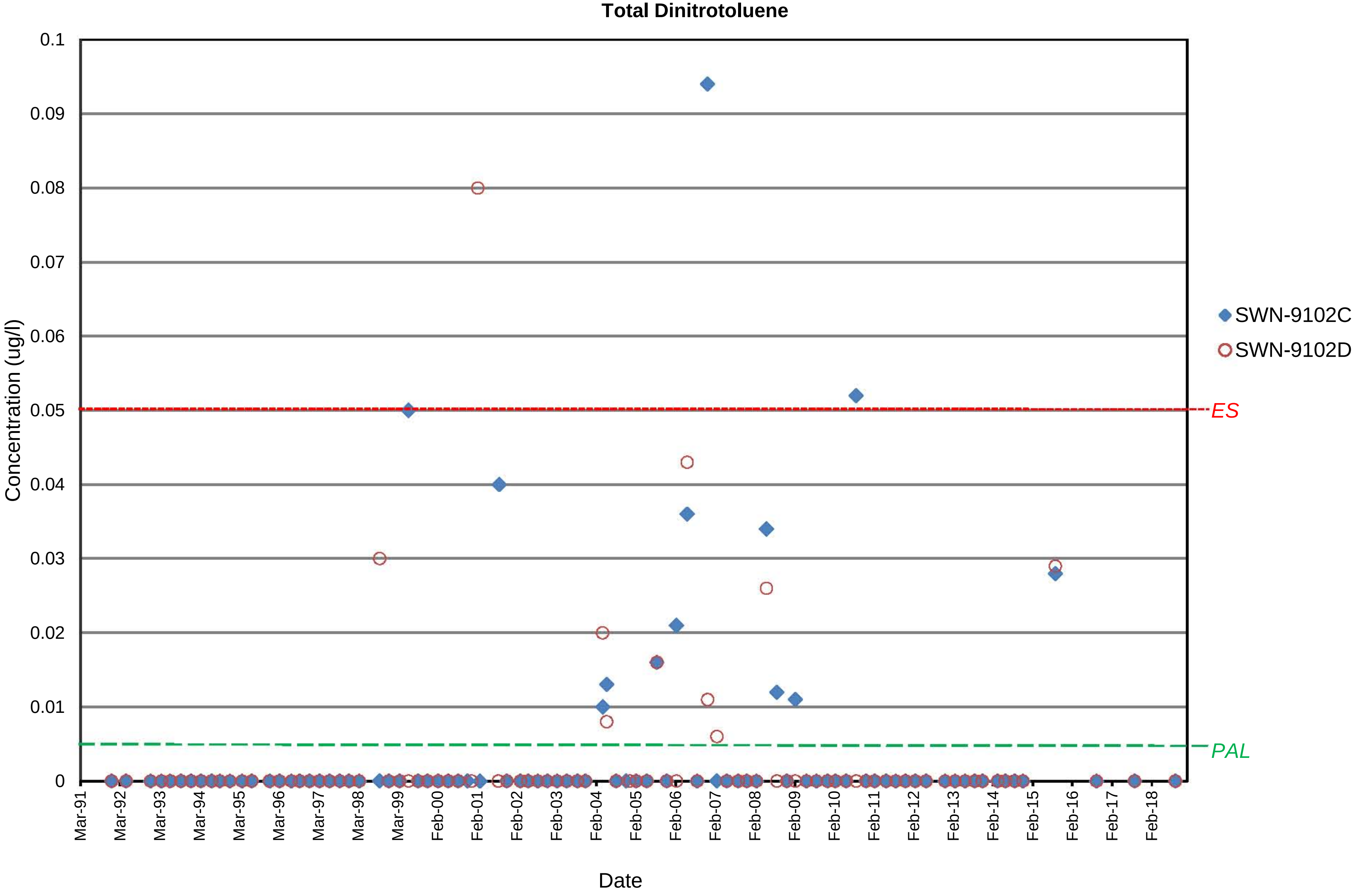
BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Offsite



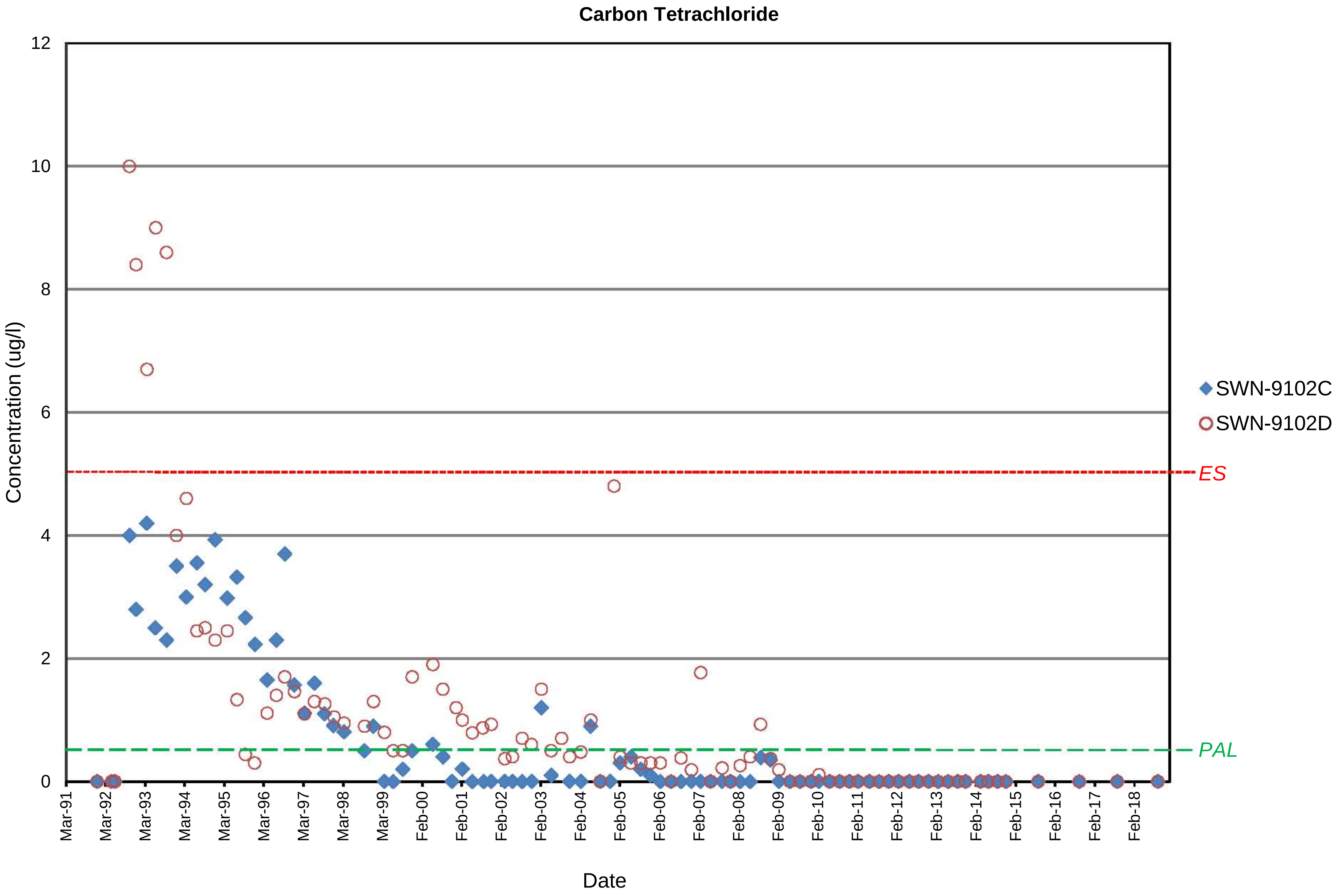
BAAP Groundwater Data Propellant Burning Ground Plume Center - Offsite



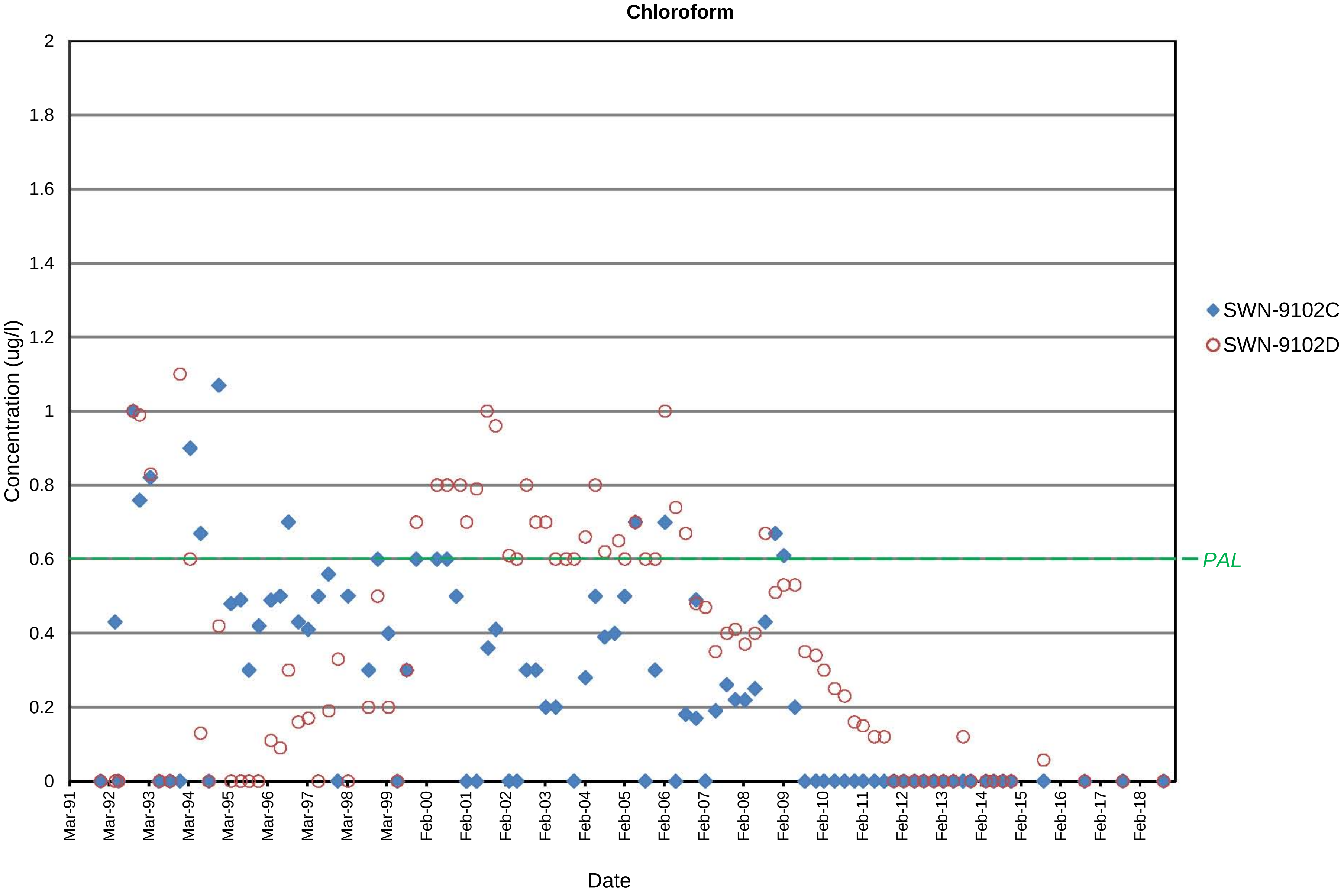
BAAP Groundwater Data Propellant Burning Ground Plume Edge - Offsite



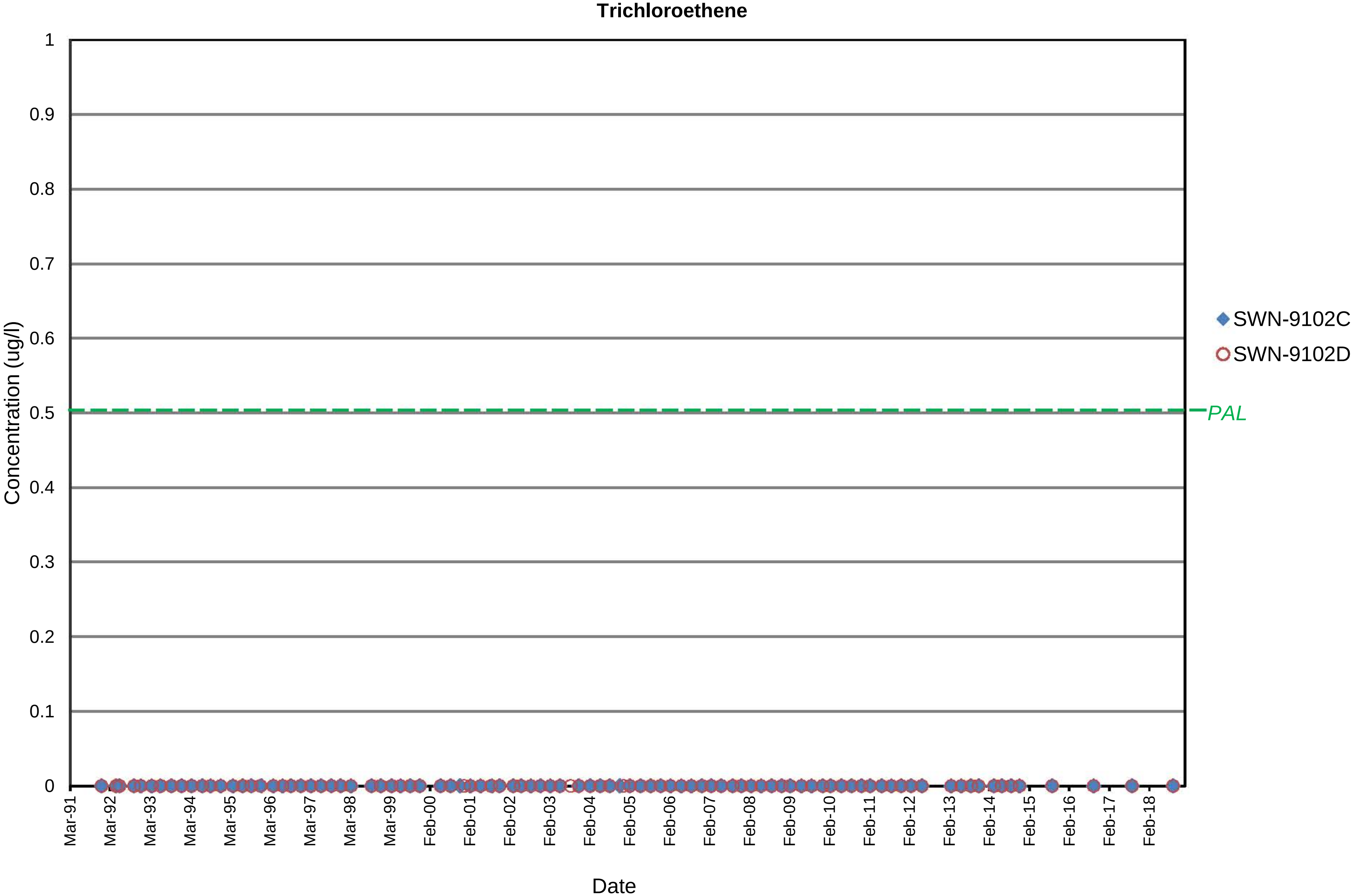
BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite

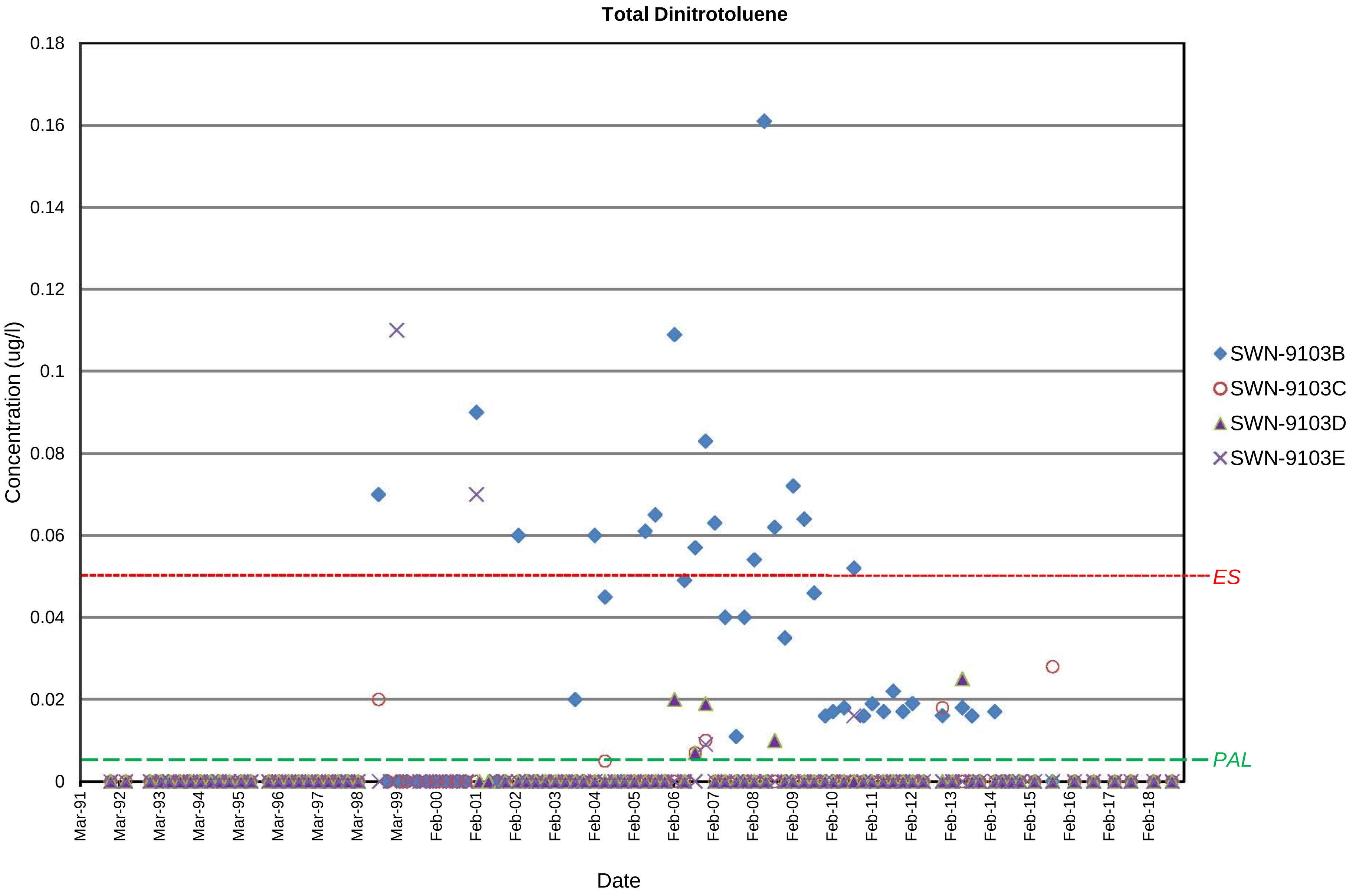


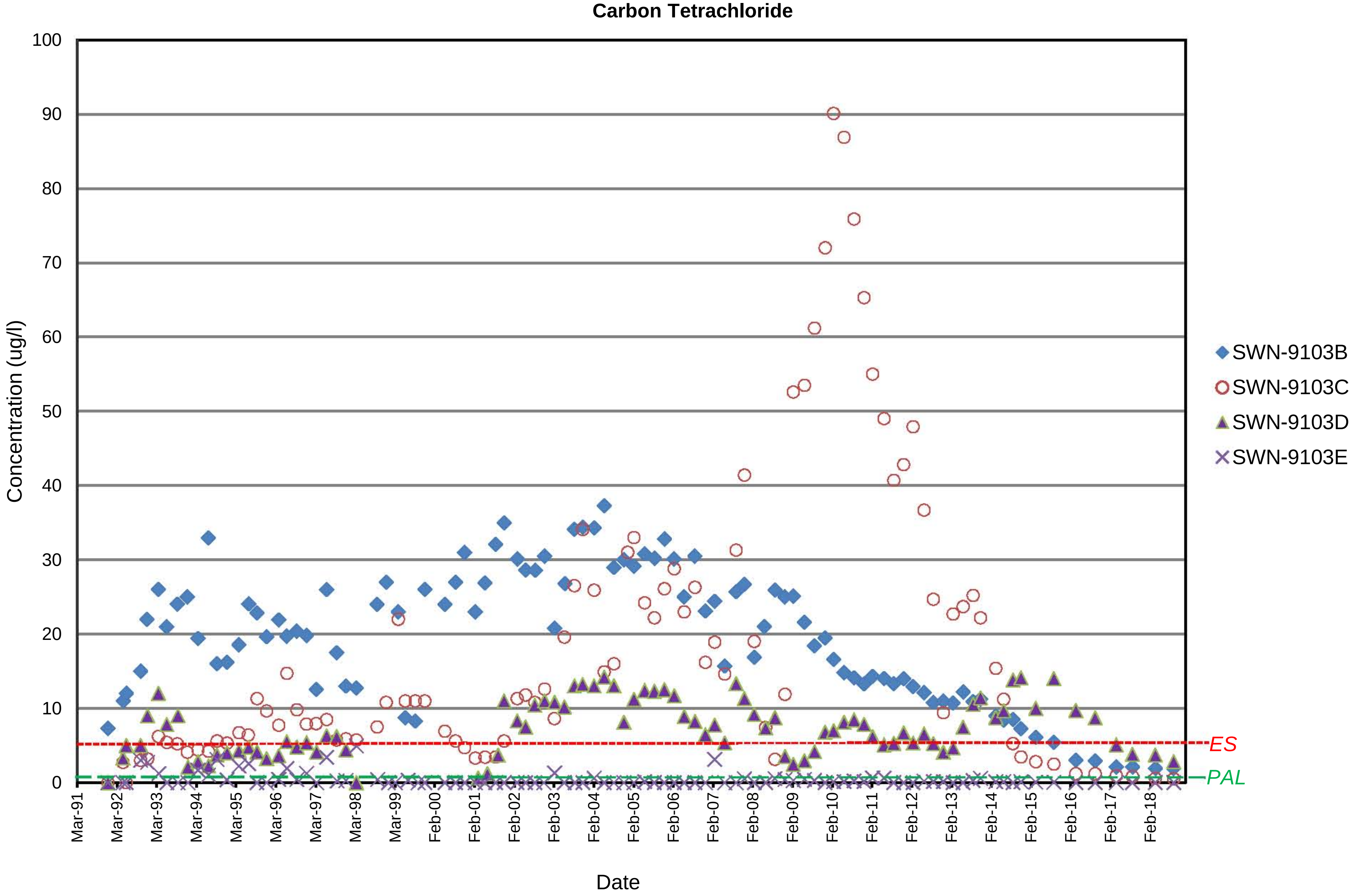
BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite



BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite

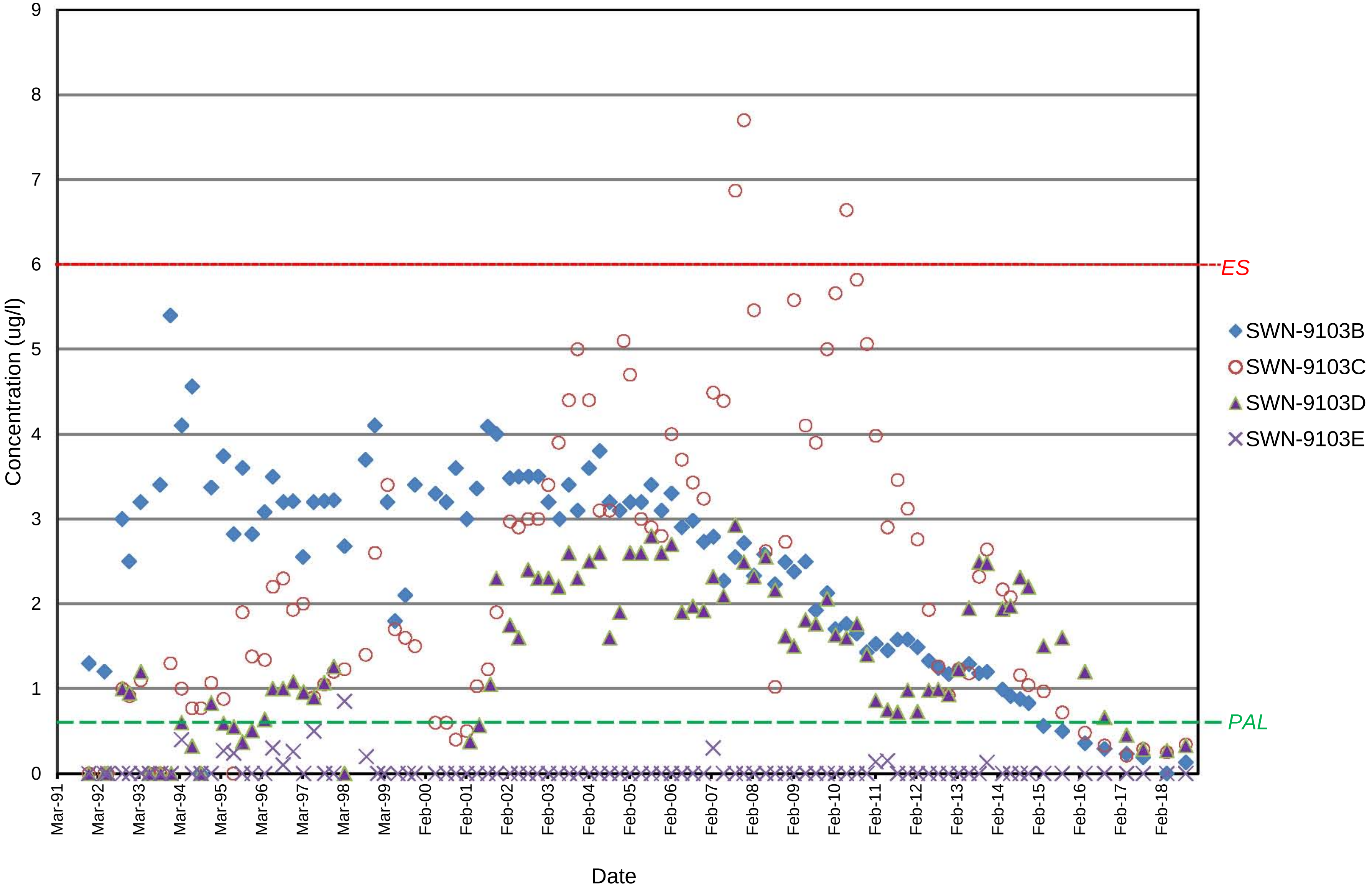



Total Dinitrotoluene
Concentration (ug/l)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
Date
ES
PAL
◆ SWN-9103B
○ SWN-9103C
▲ SWN-9103D
× SWN-9103E


Carbon Tetrachloride
Concentration (ug/l)
0
10
20
30
40
50
60
70
80
90
100
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
Date
ES
PAL
◆ SWN-9103B
○ SWN-9103C
▲ SWN-9103D
× SWN-9103E

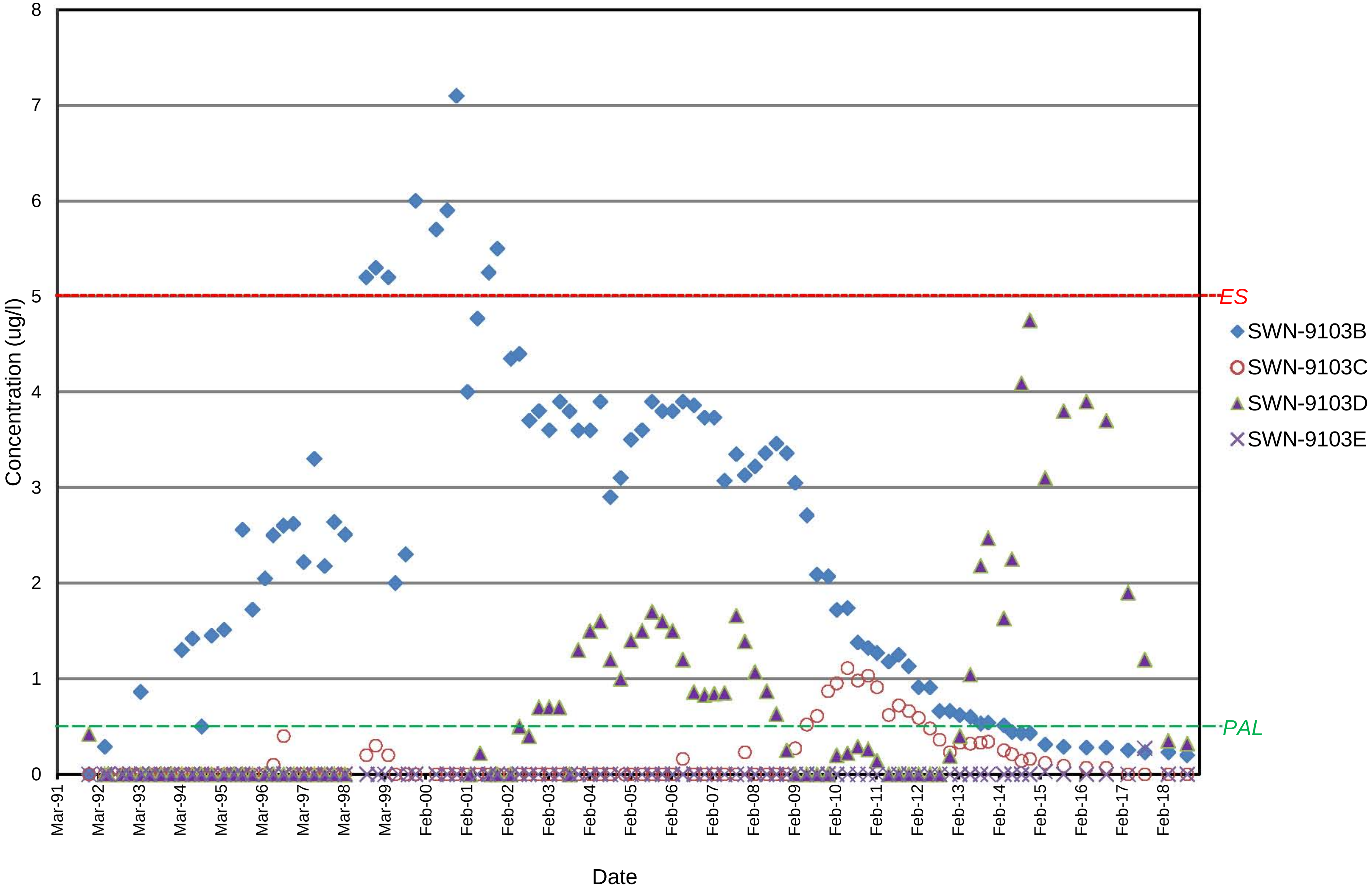
BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Offsite

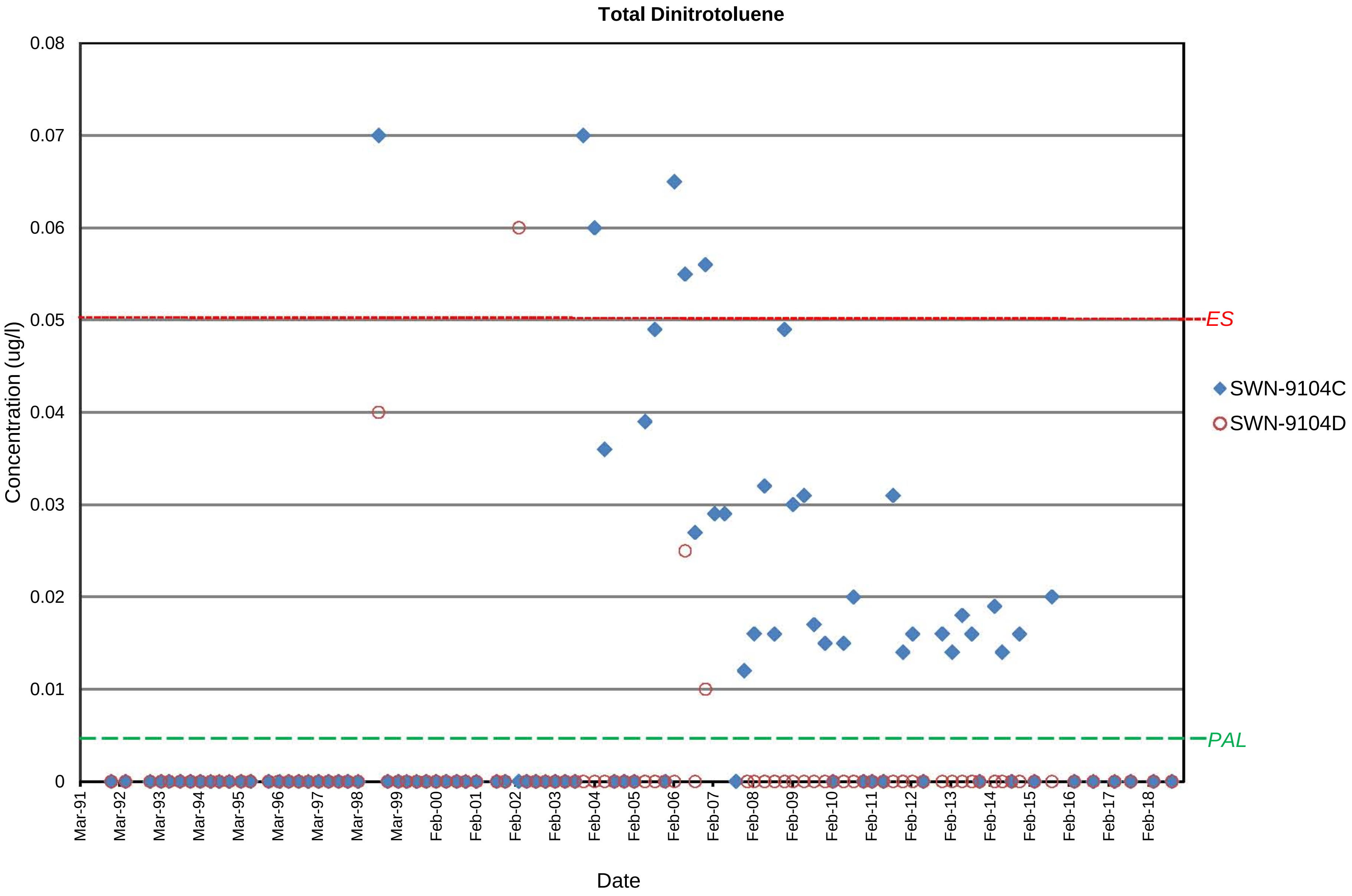
Chloroform



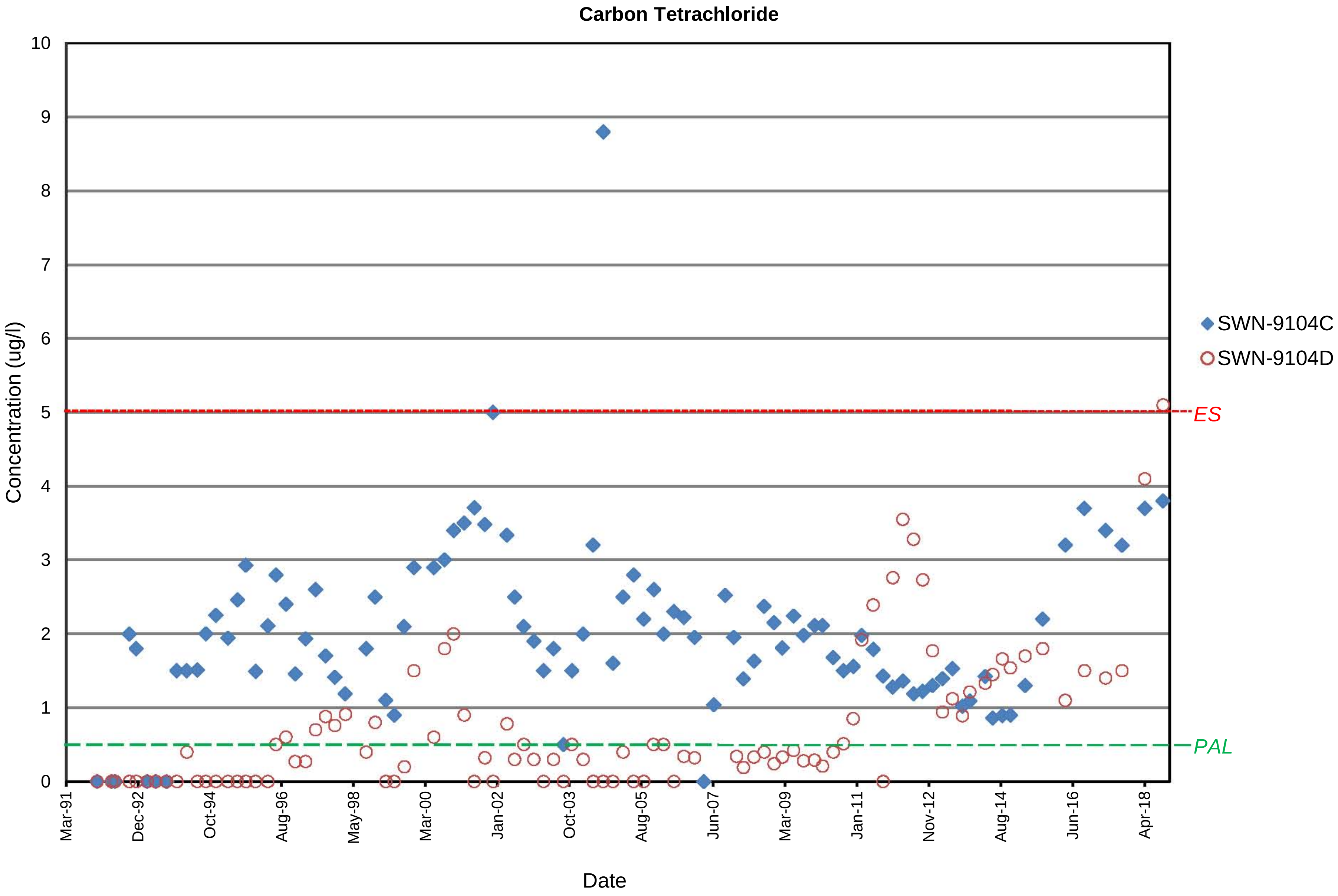
BAAP Groundwater Data Propellant Burning Ground Plume Center - Offsite

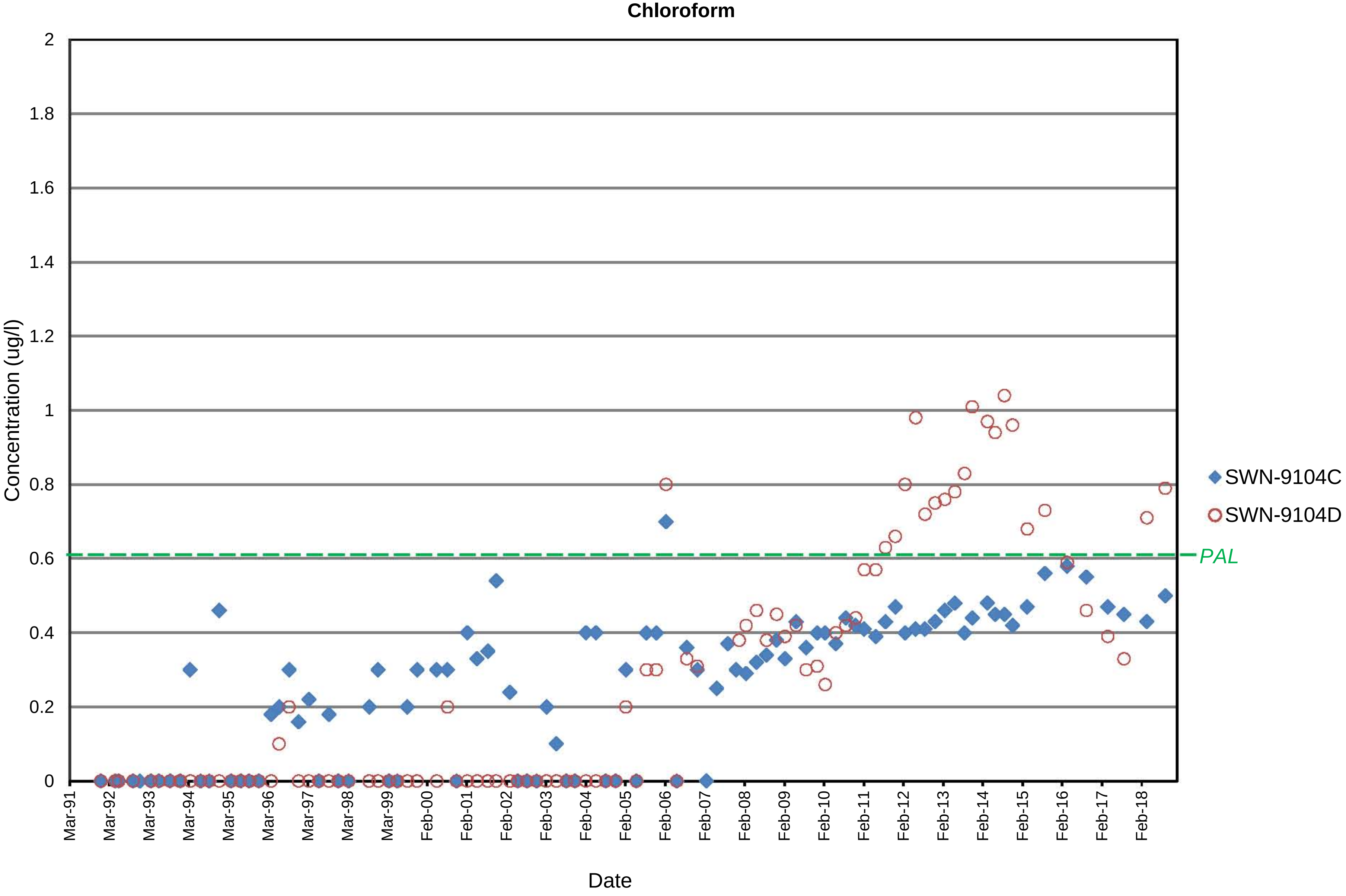
Trichloroethene



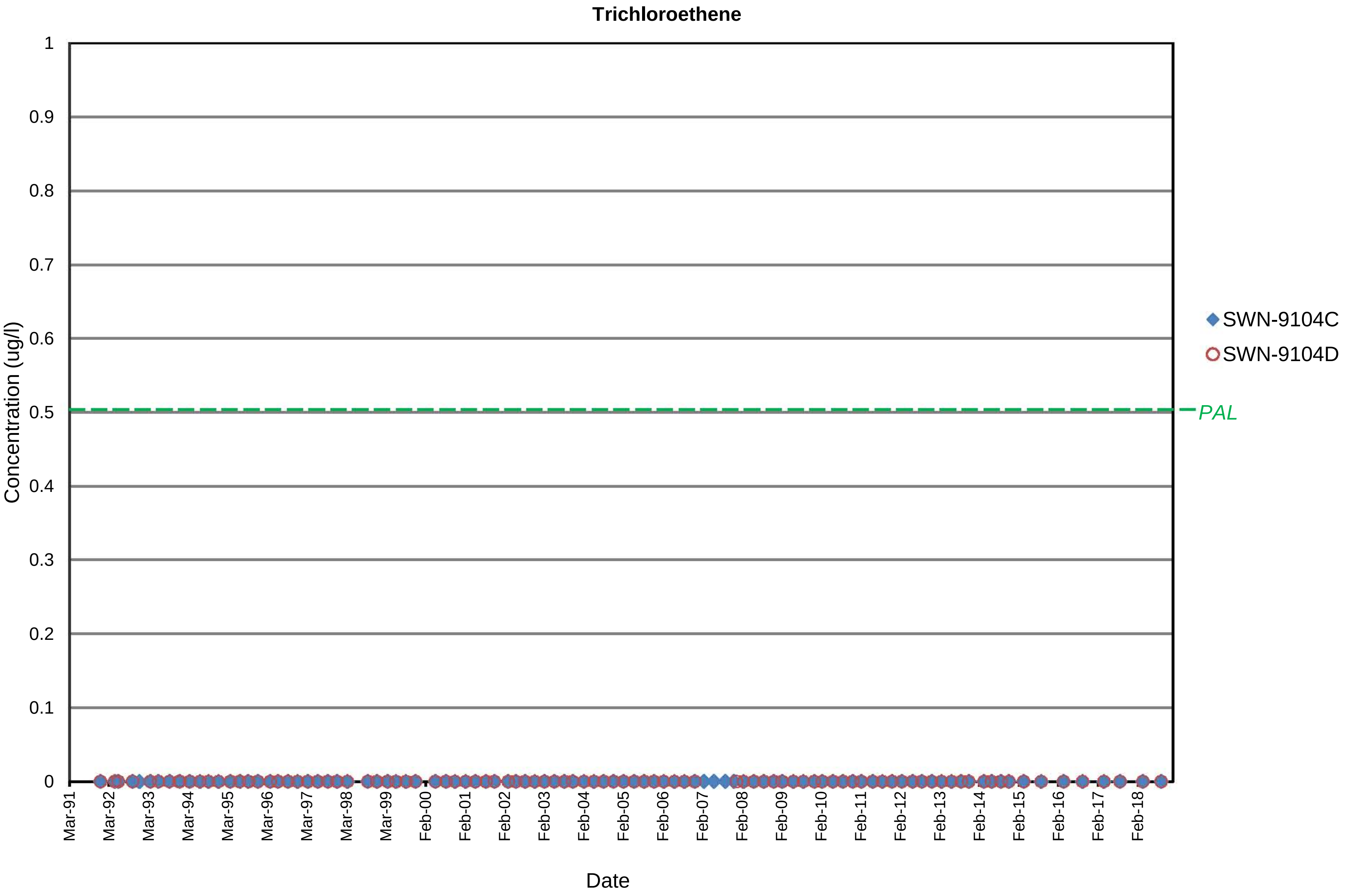

Total Dinitrotoluene
Concentration (ug/l)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
ES
PAL
SWN-9104C
SWN-9104D
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
Date

BAAP Groundwater Data | Propellant Burning Ground | Plume Center - Offsite

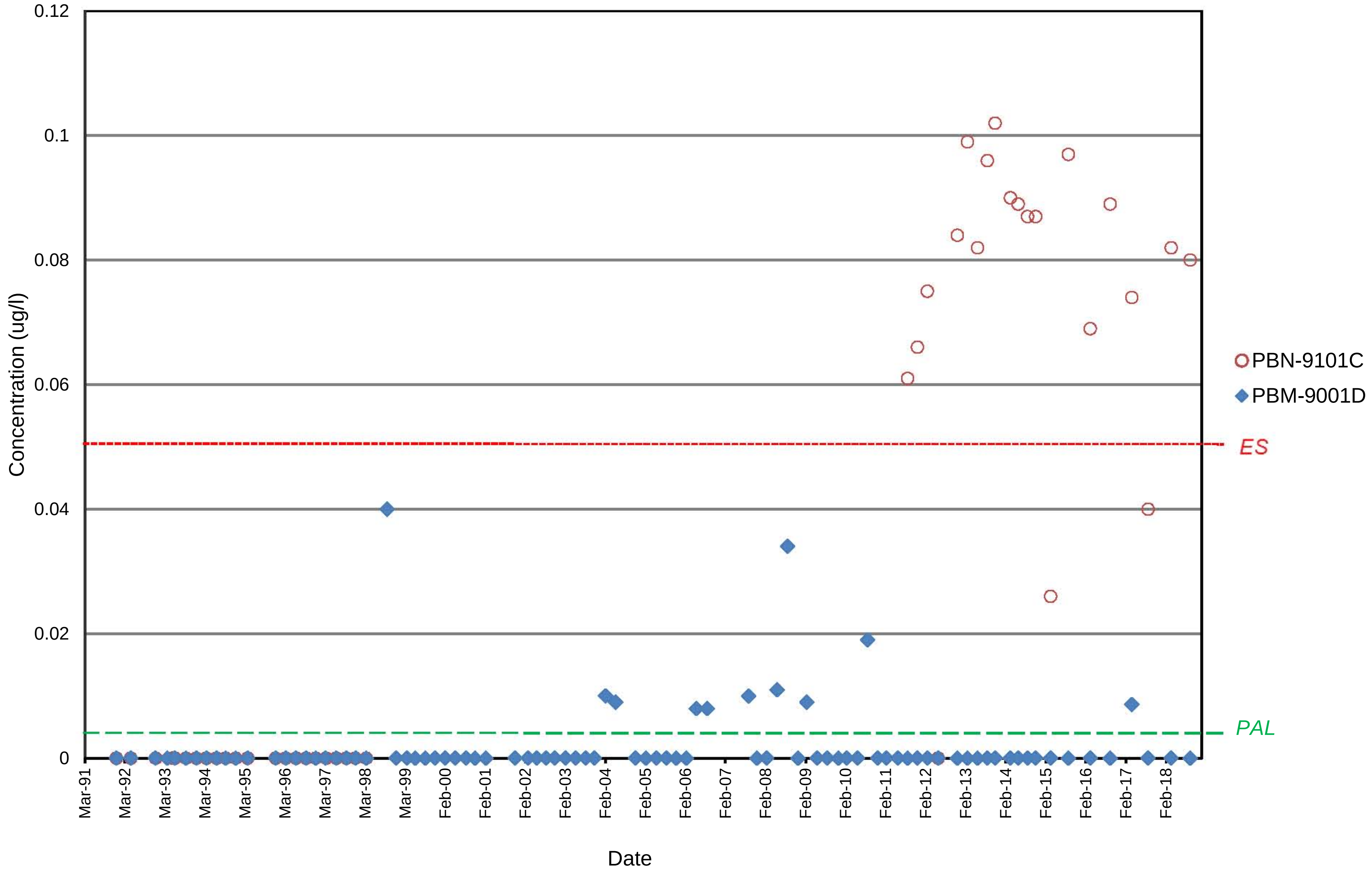



Chloroform
Concentration (ug/l)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Date
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
SWN-9104C
SWN-9104D
PAL

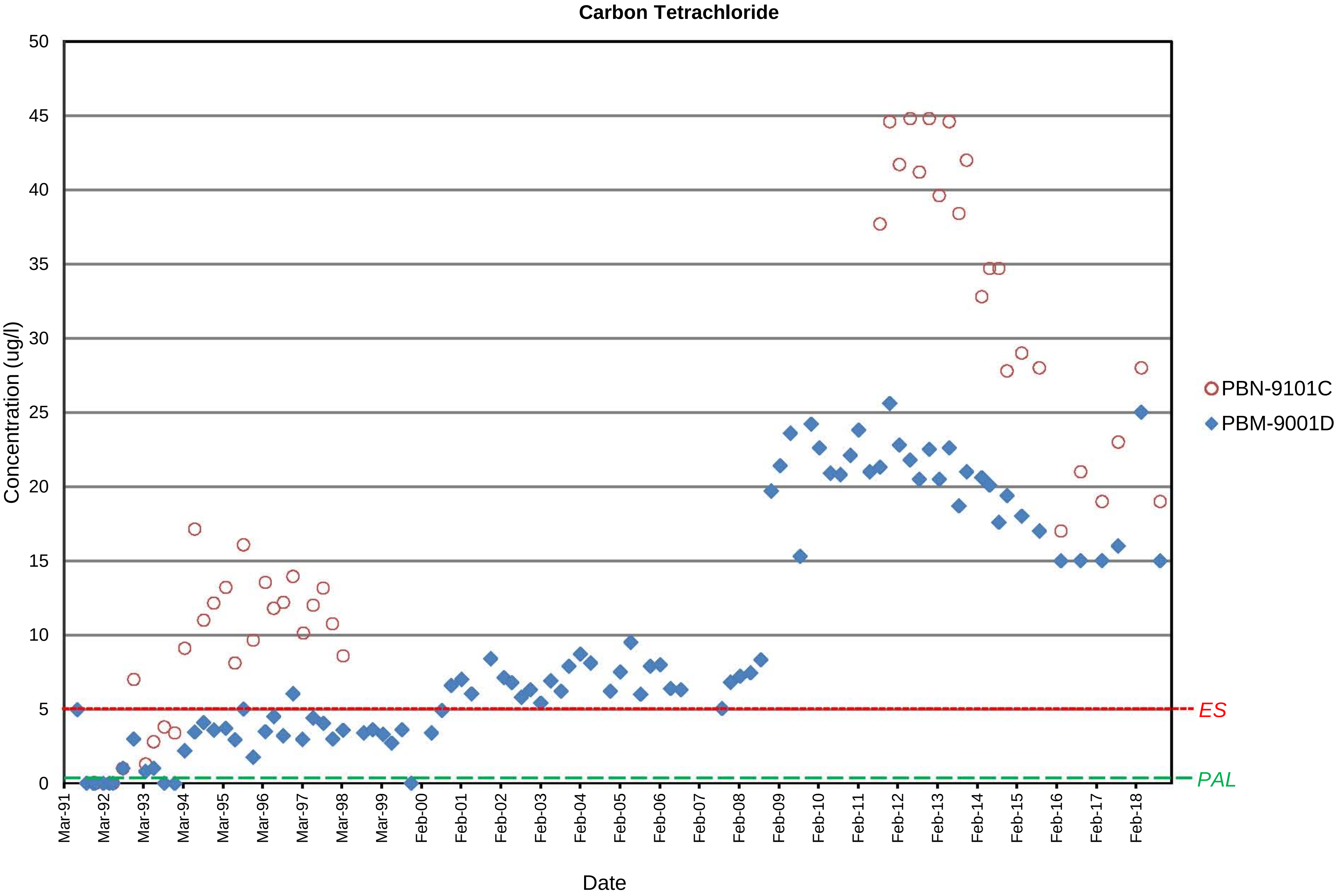
BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite



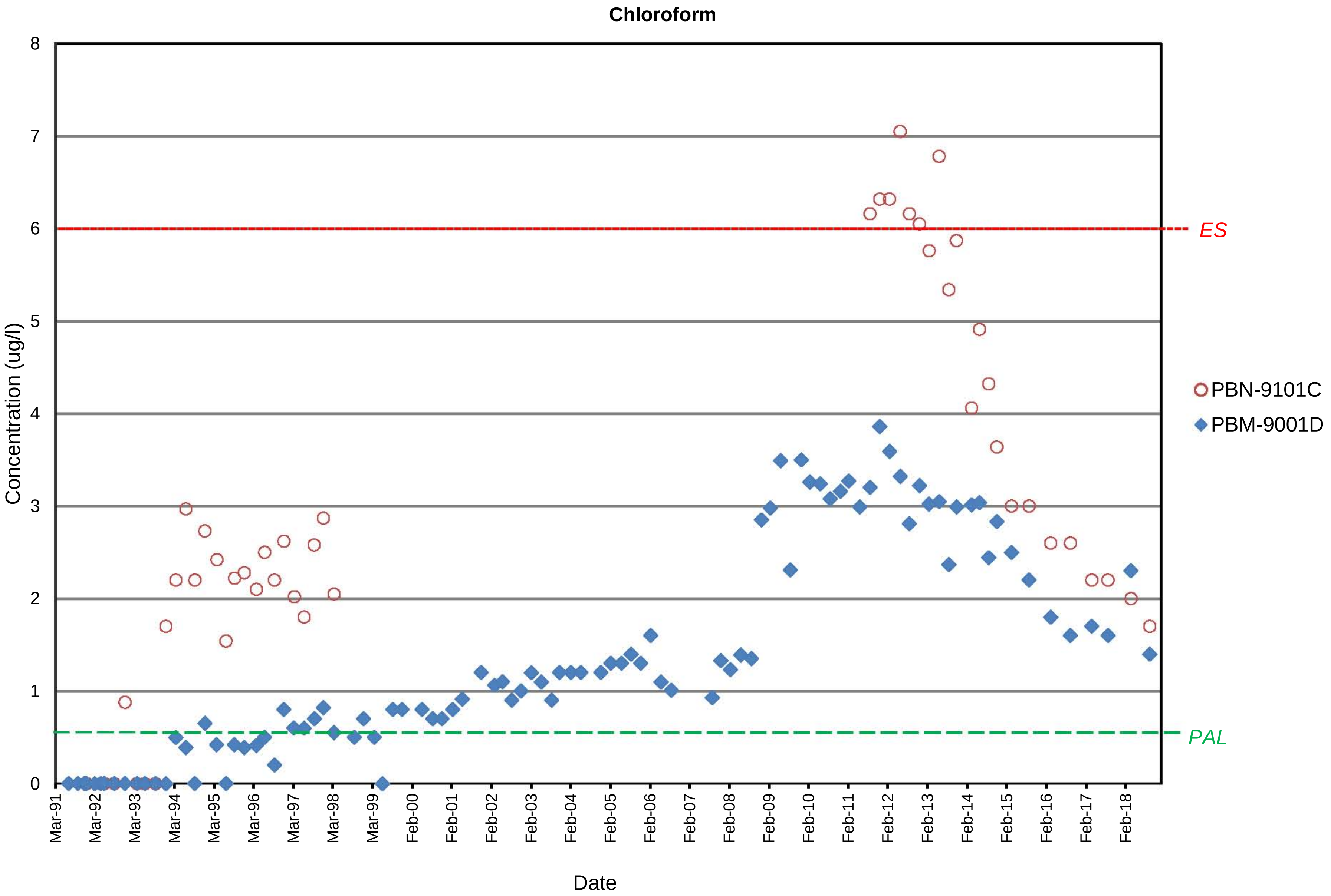
Total Dinitrotoluene



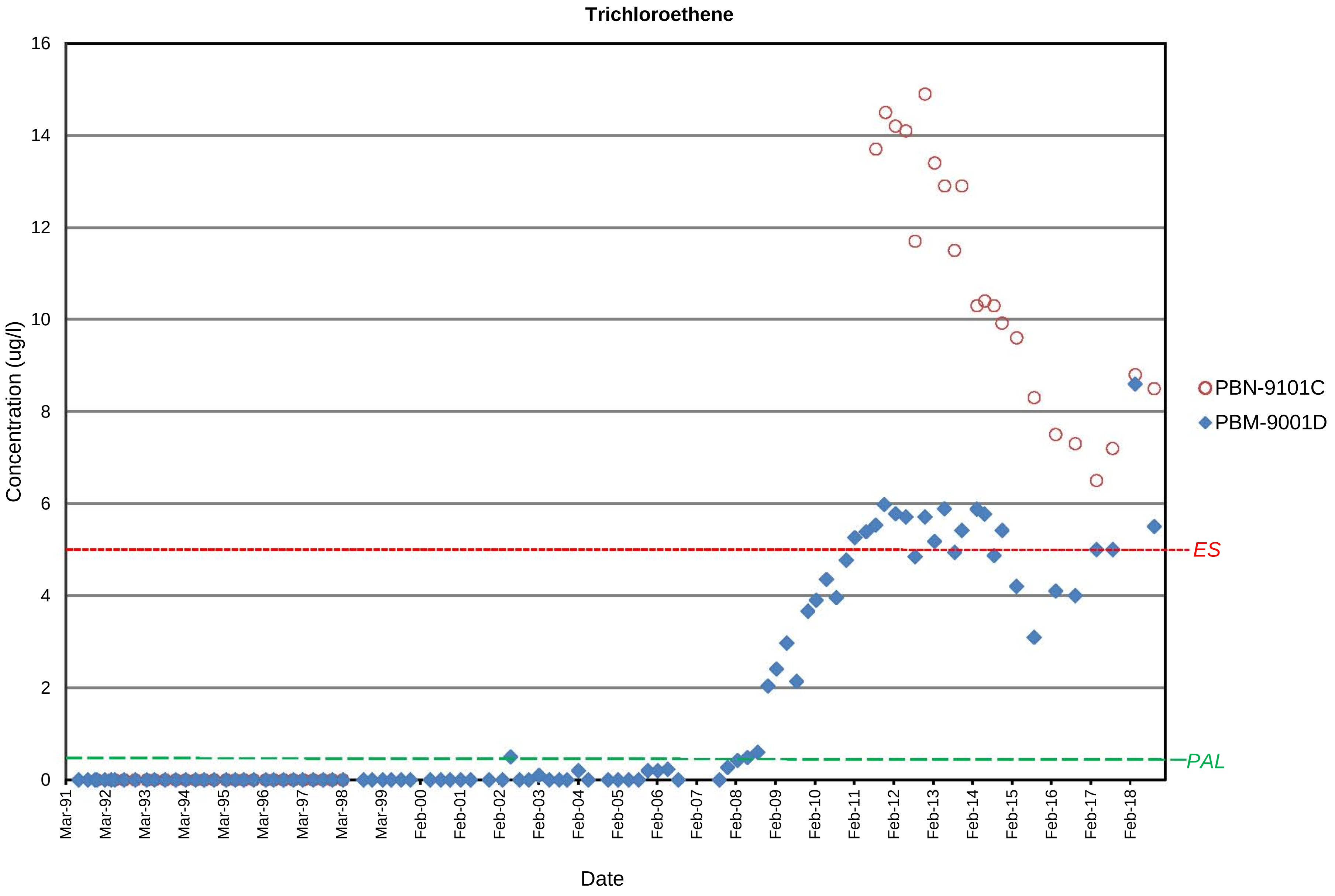
BAAP Groundwater Data | Propellant Burning Ground | Plume Leading Edge - Offsite



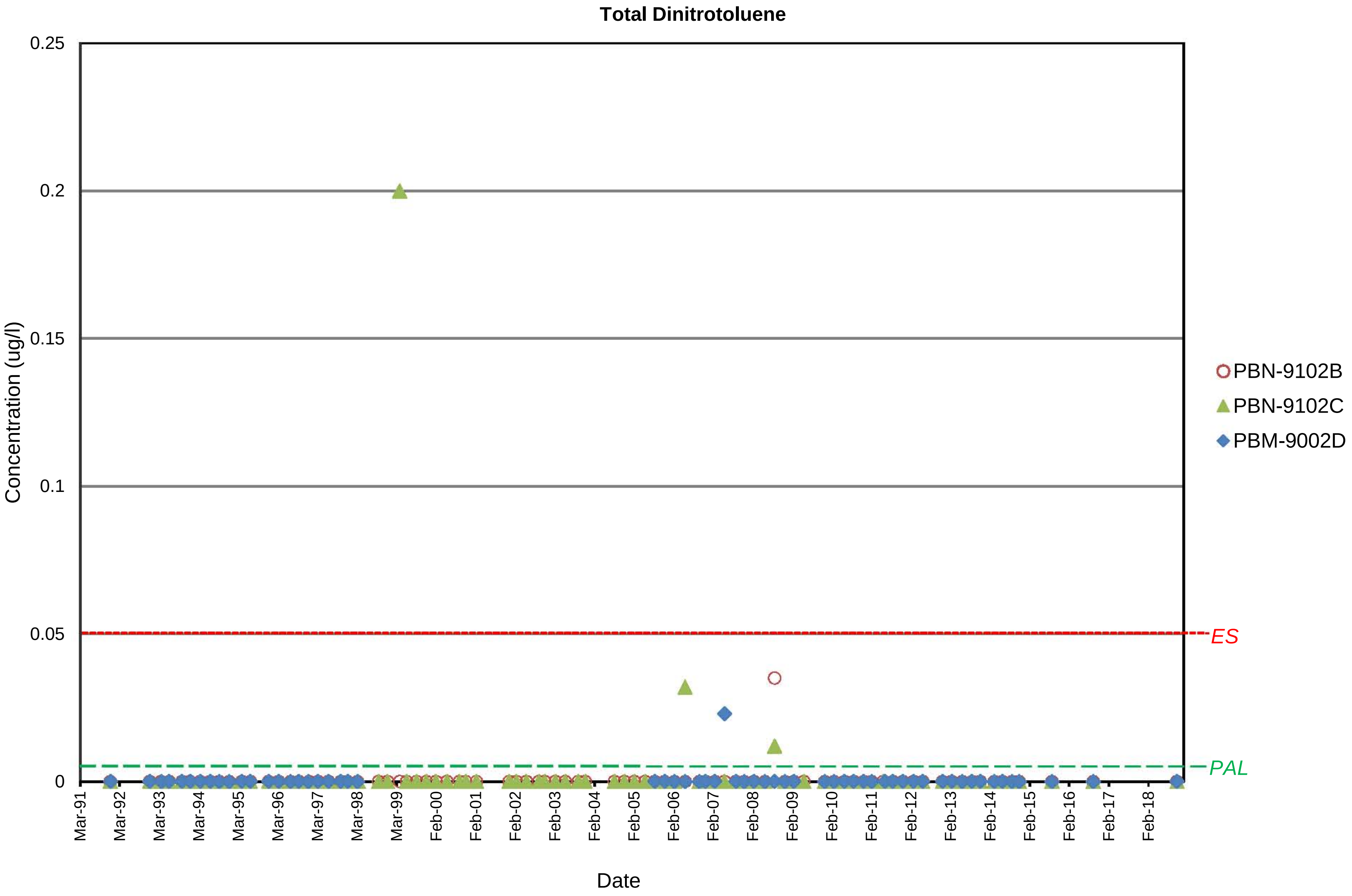
BAAP Groundwater Data Propellant Burning Ground Plume Leading Edge - Offsite

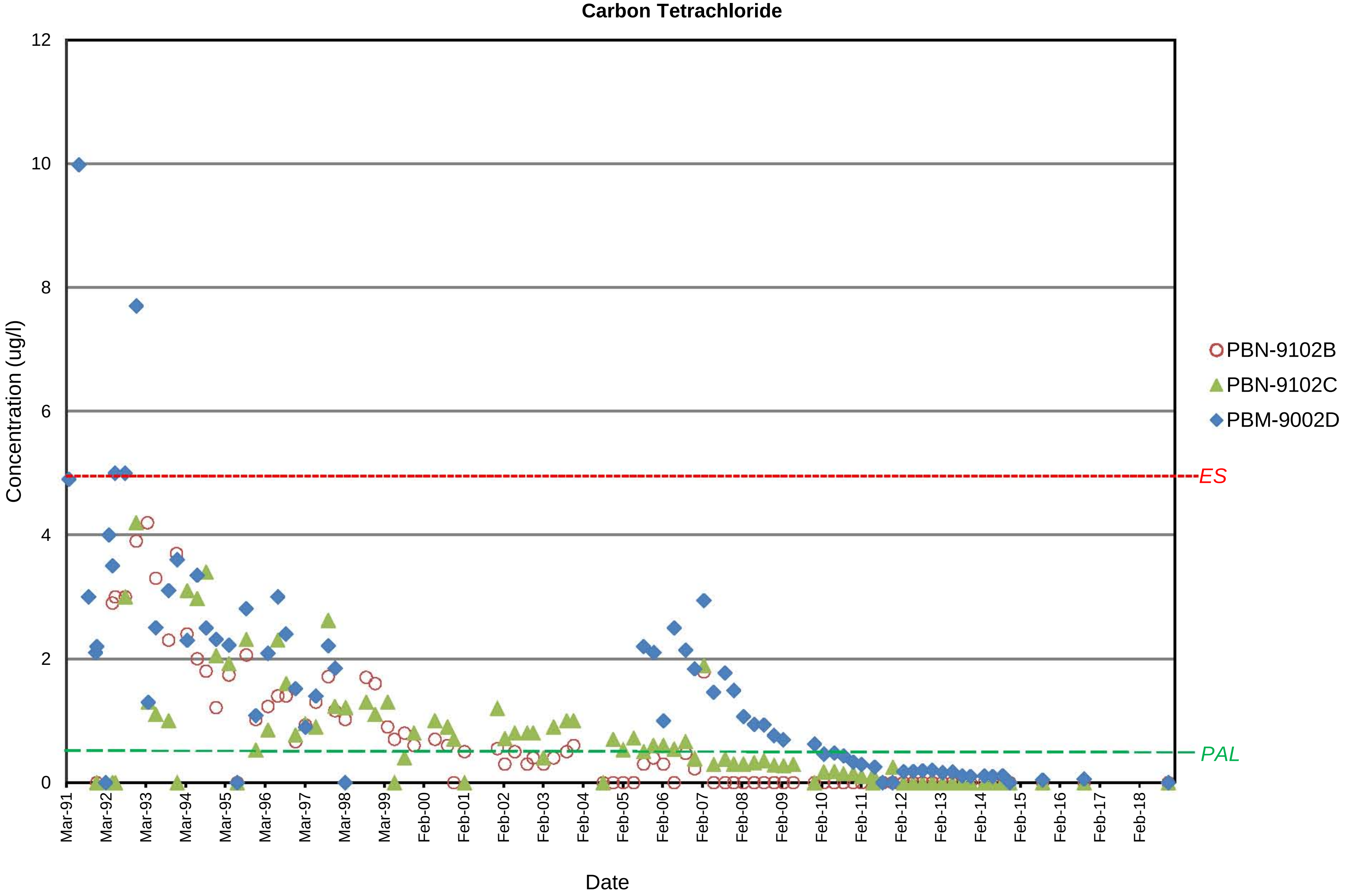


BAAP Groundwater Data | Propellant Burning Ground | Plume Leading Edge - Offsite

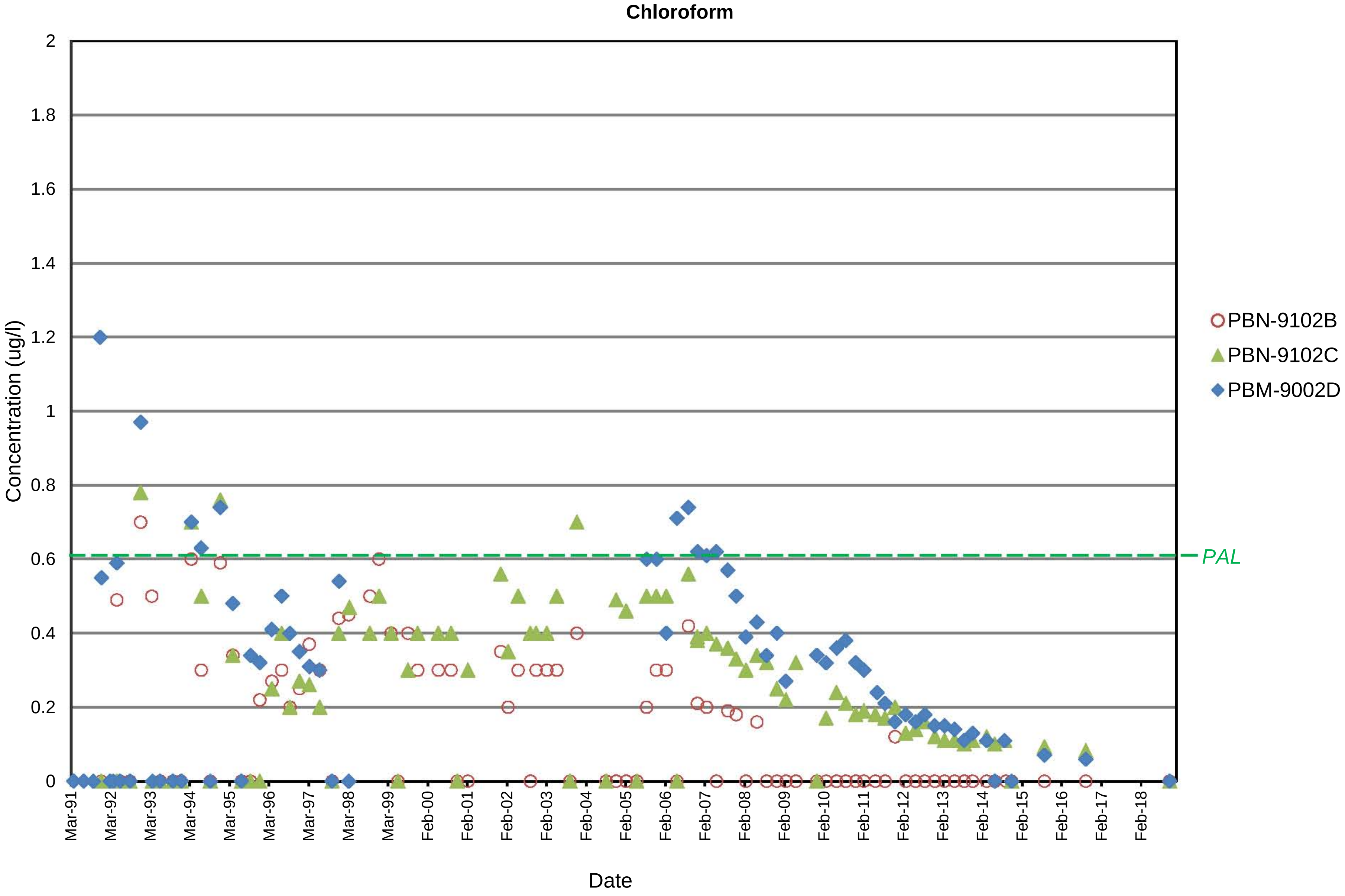


BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite

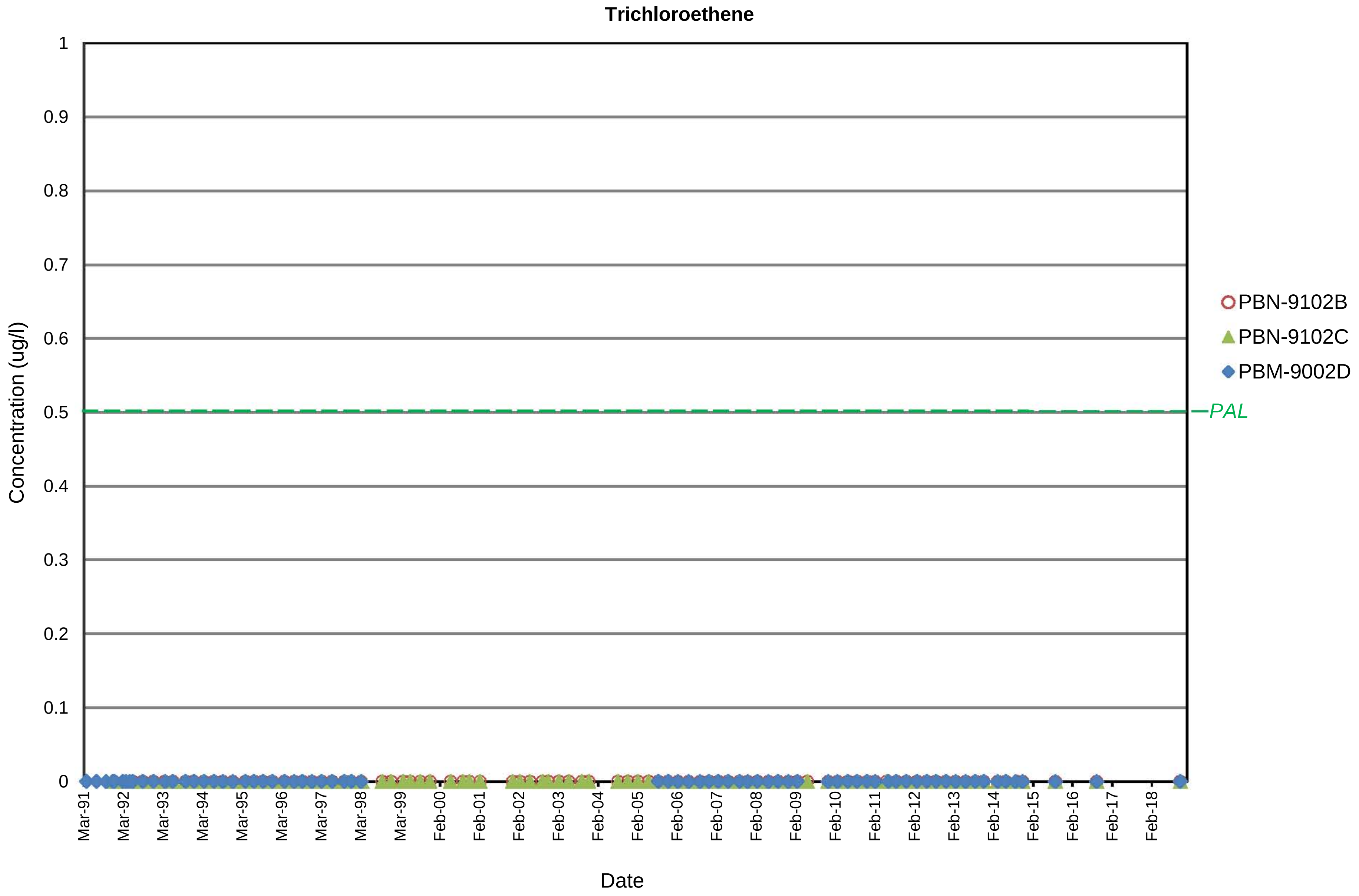



Carbon Tetrachloride
12
10
8
6
4
2
0
Concentration (ug/l)
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09
Feb-10
Feb-11
Feb-12
Feb-13
Feb-14
Feb-15
Feb-16
Feb-17
Feb-18
Date
ES
PAL
PBN-9102B
PBN-9102C
PBM-9002D

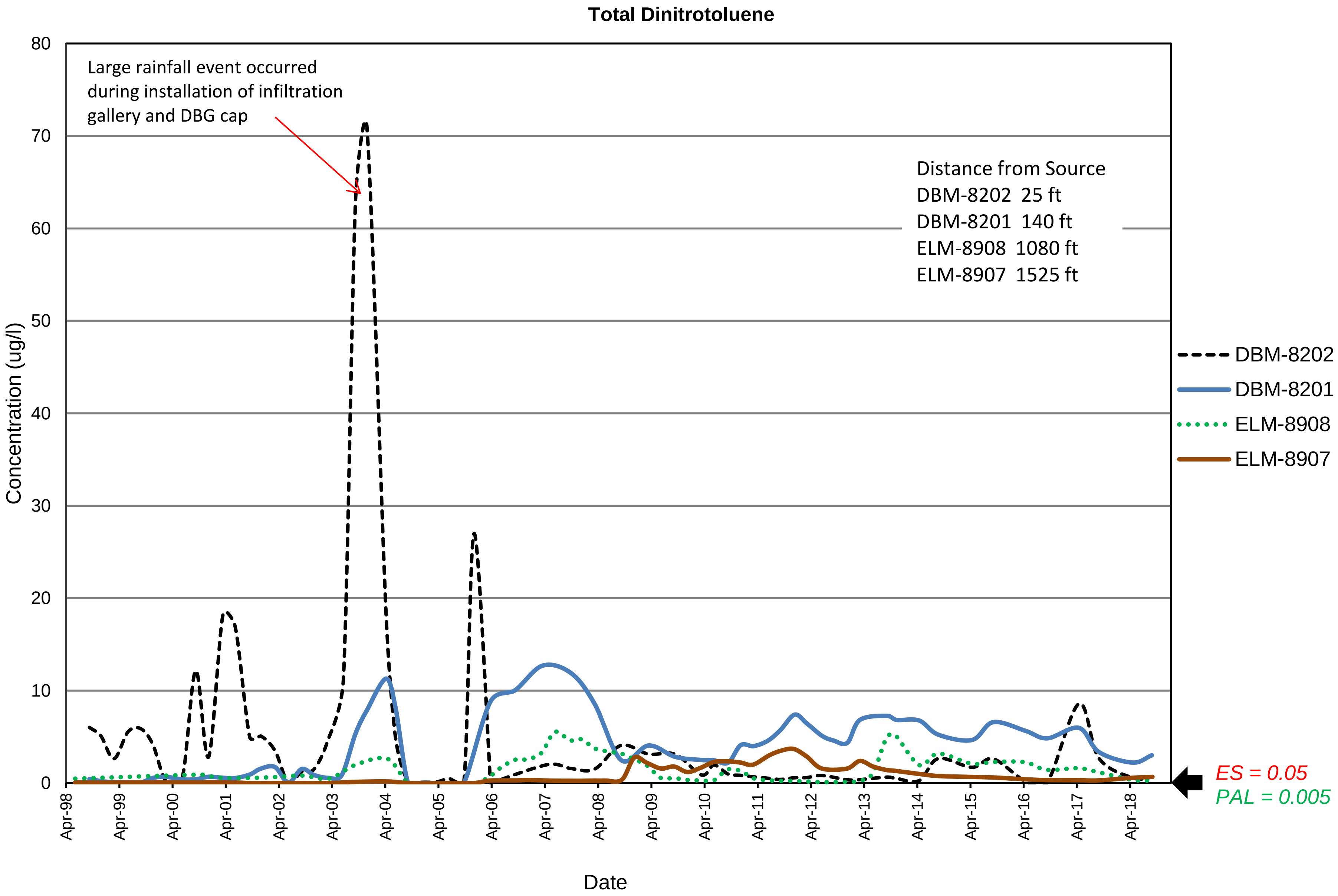
BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite

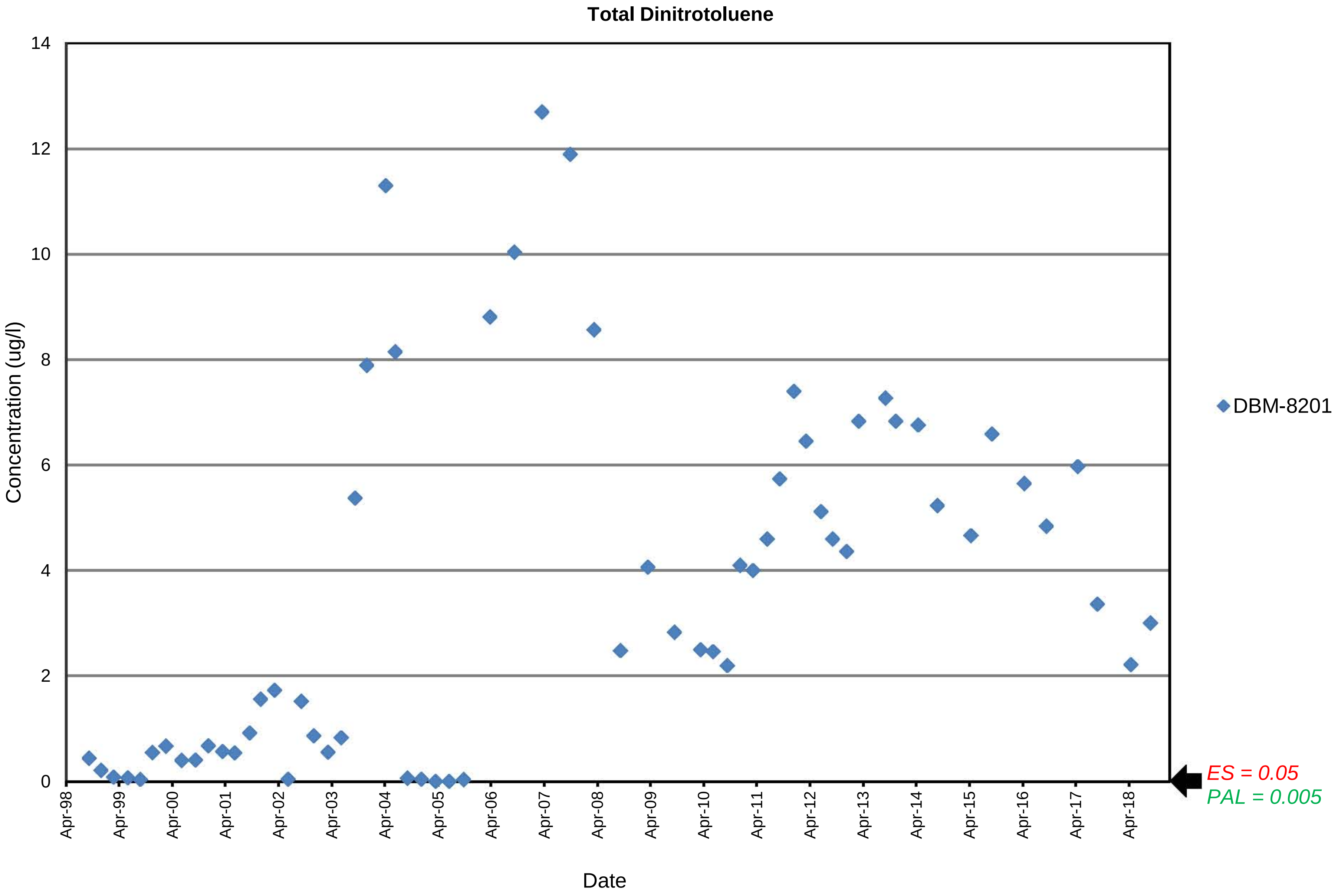


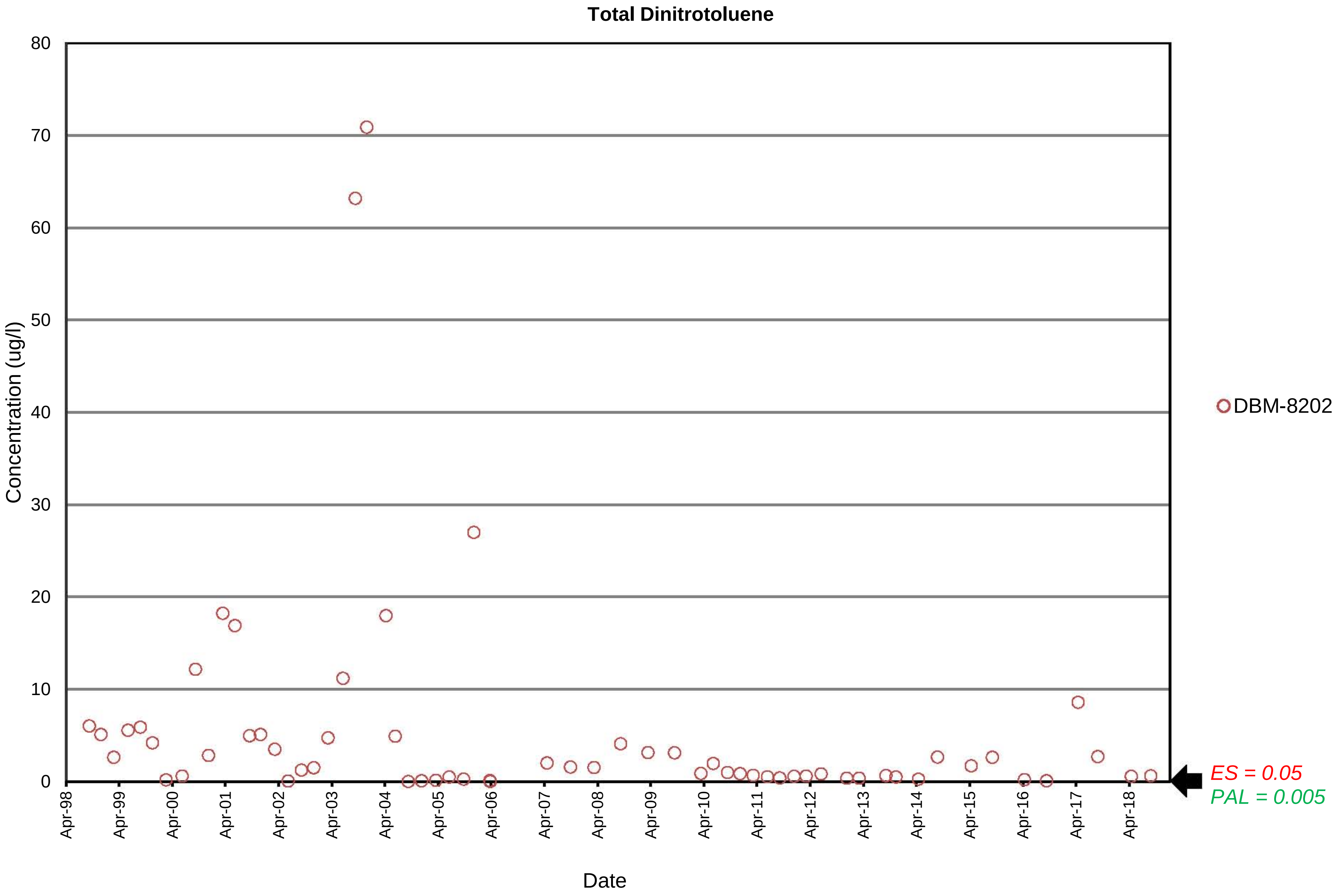
BAAP Groundwater Data | Propellant Burning Ground | Plume Edge - Offsite

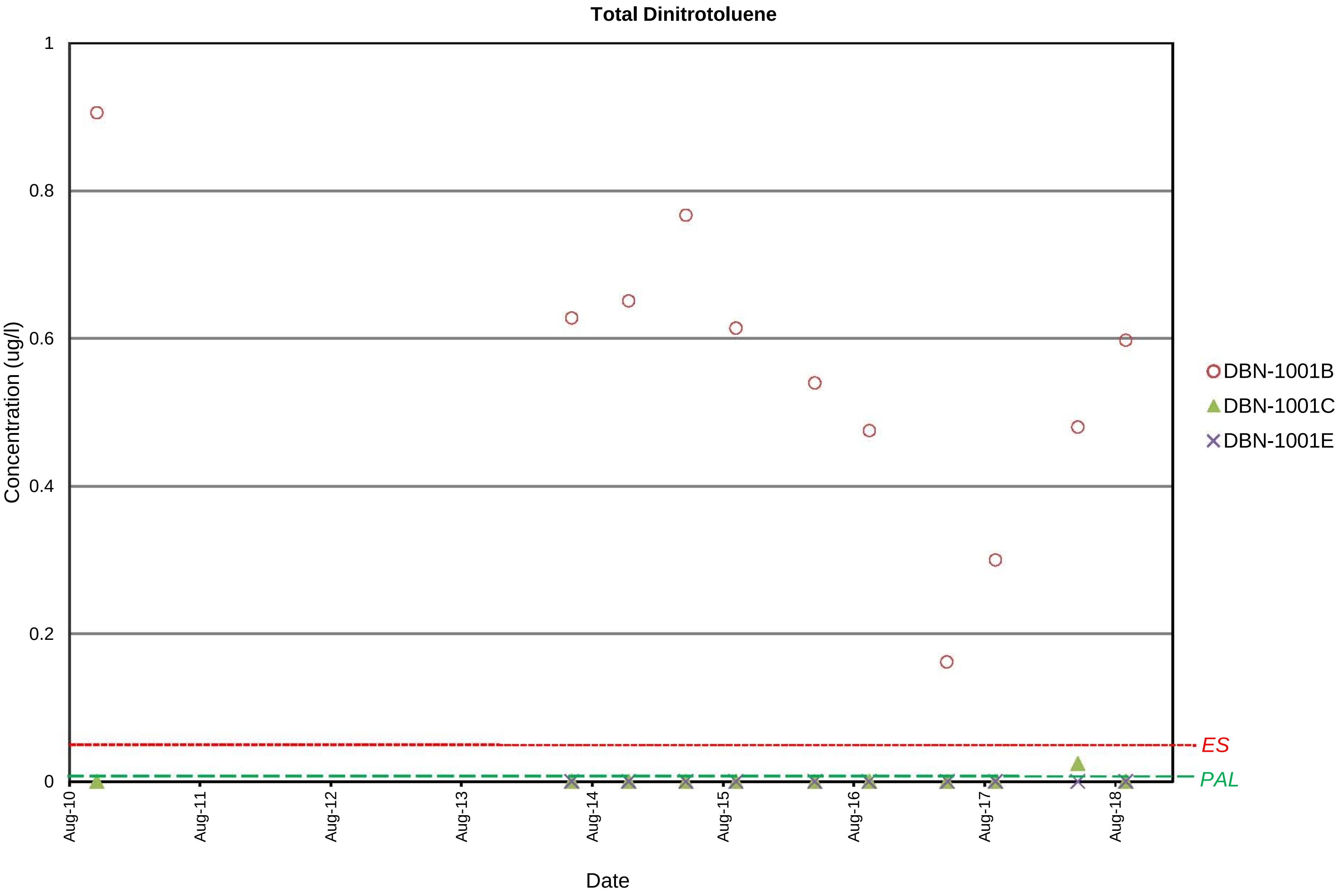


Concentration Graphs
Deterrent Burning Ground Plume

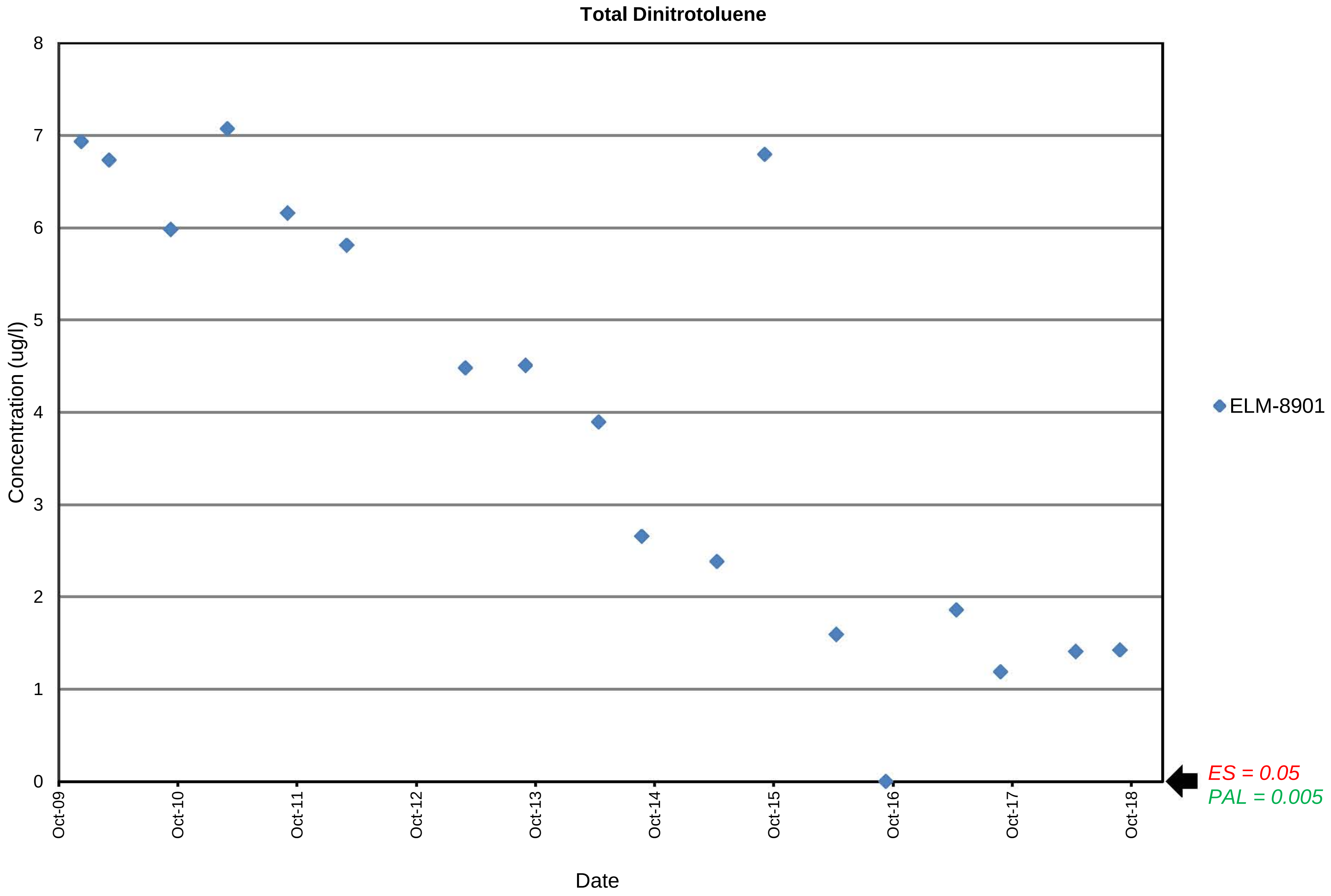

Total Dinitrotoluene
Large rainfall event occurred during installation of infiltration gallery and DBG cap
Distance from Source
DBM-8202 25 ft
DBM-8201 140 ft
ELM-8908 1080 ft
ELM-8907 1525 ft
Concentration (ug/l)
80
70
60
50
40
30
20
10
0
Apr-98
Apr-99
Apr-00
Apr-01
Apr-02
Apr-03
Apr-04
Apr-05
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
Date
DBM-8202
DBM-8201
ELM-8908
ELM-8907
ES = 0.05
PAL = 0.005


Total Dinitrotoluene
Concentration (ug/l)
14
12
10
8
6
4
2
0
Apr-98
Apr-99
Apr-00
Apr-01
Apr-02
Apr-03
Apr-04
Apr-05
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
Date
◆ DBM-8201
ES = 0.05
PAL = 0.005

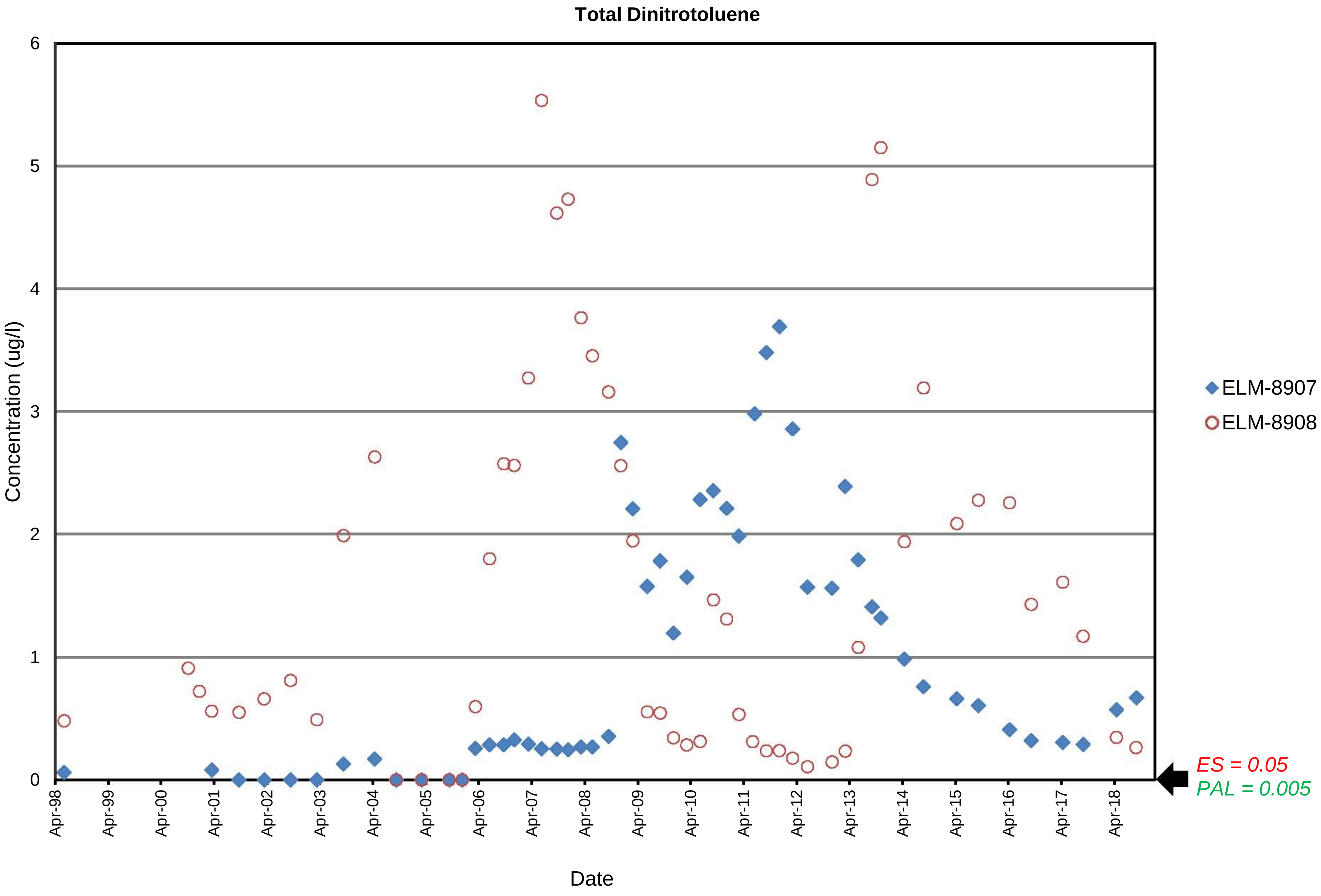

Total Dinitrotoluene
Concentration (ug/l)
0
10
20
30
40
50
60
70
80
Apr-98
Apr-99
Apr-00
Apr-01
Apr-02
Apr-03
Apr-04
Apr-05
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
Date
○ DBM-8202
ES = 0.05
PAL = 0.005

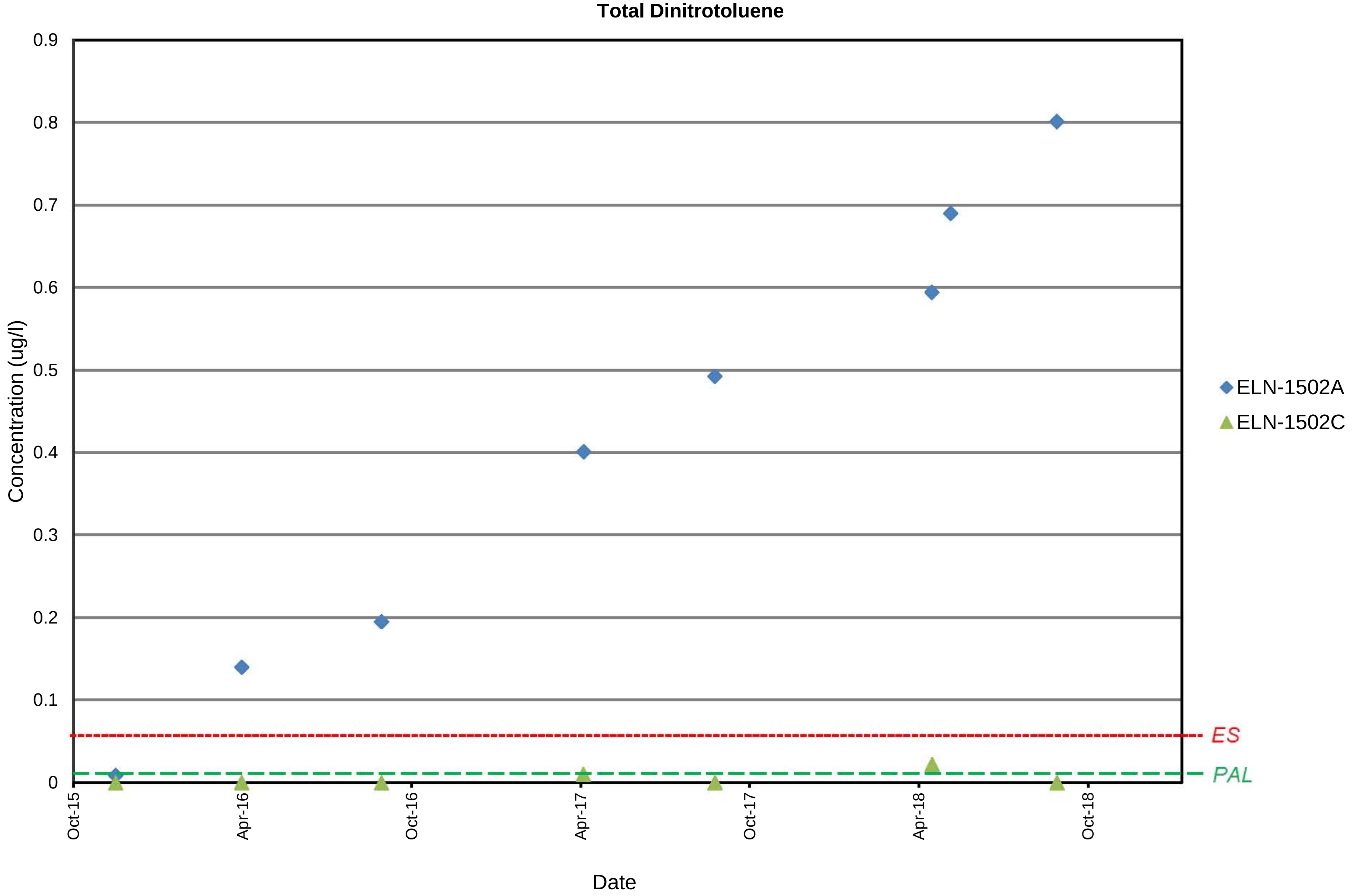

Total Dinitrotoluene
Concentration (ug/l)
1
0.8
0.6
0.4
0.2
0
Aug-10
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Date
DBN-1001B
DBN-1001C
DBN-1001E
ES
PAL

BAAP Groundwater Data Deterrent Burning Ground Plume Center

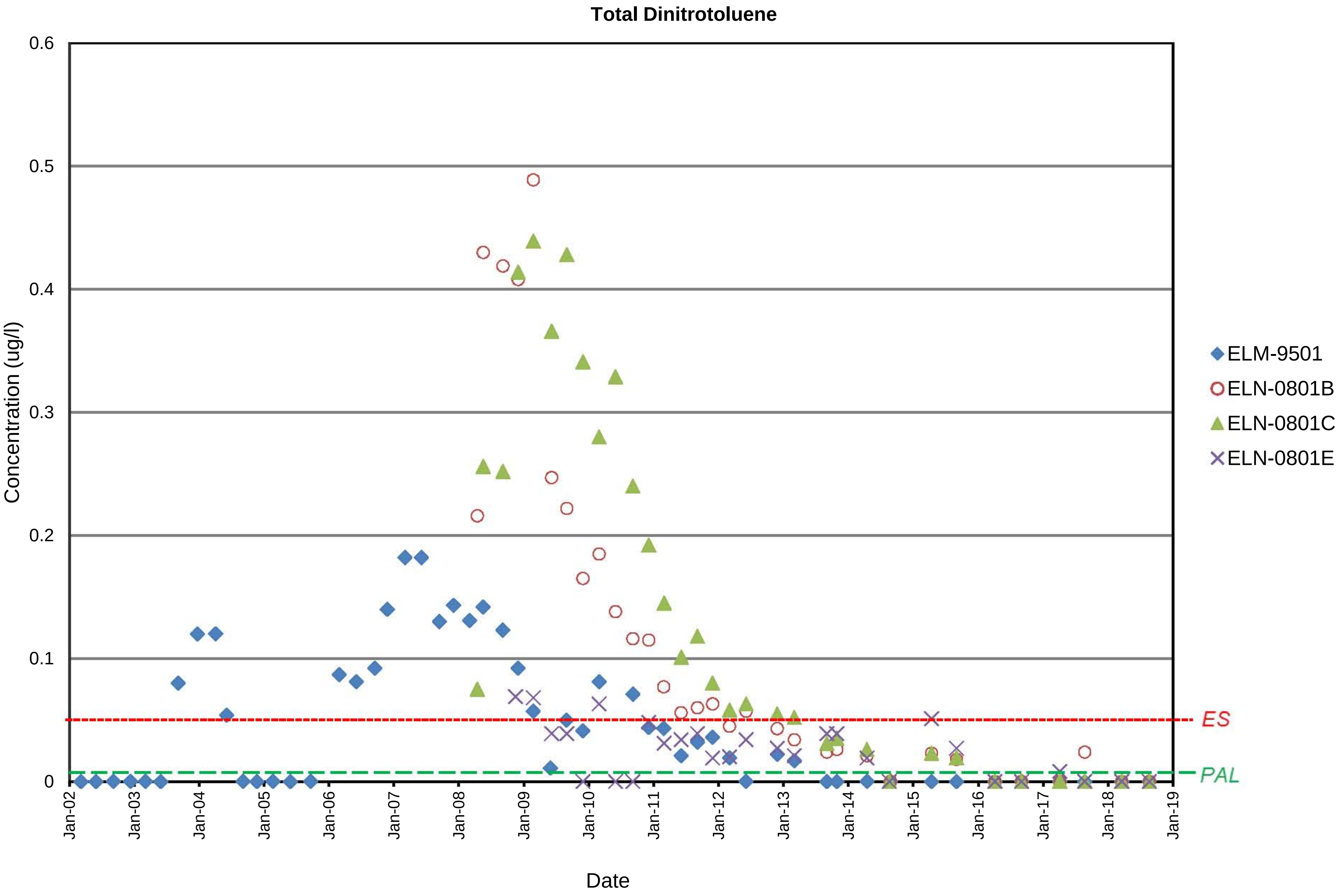


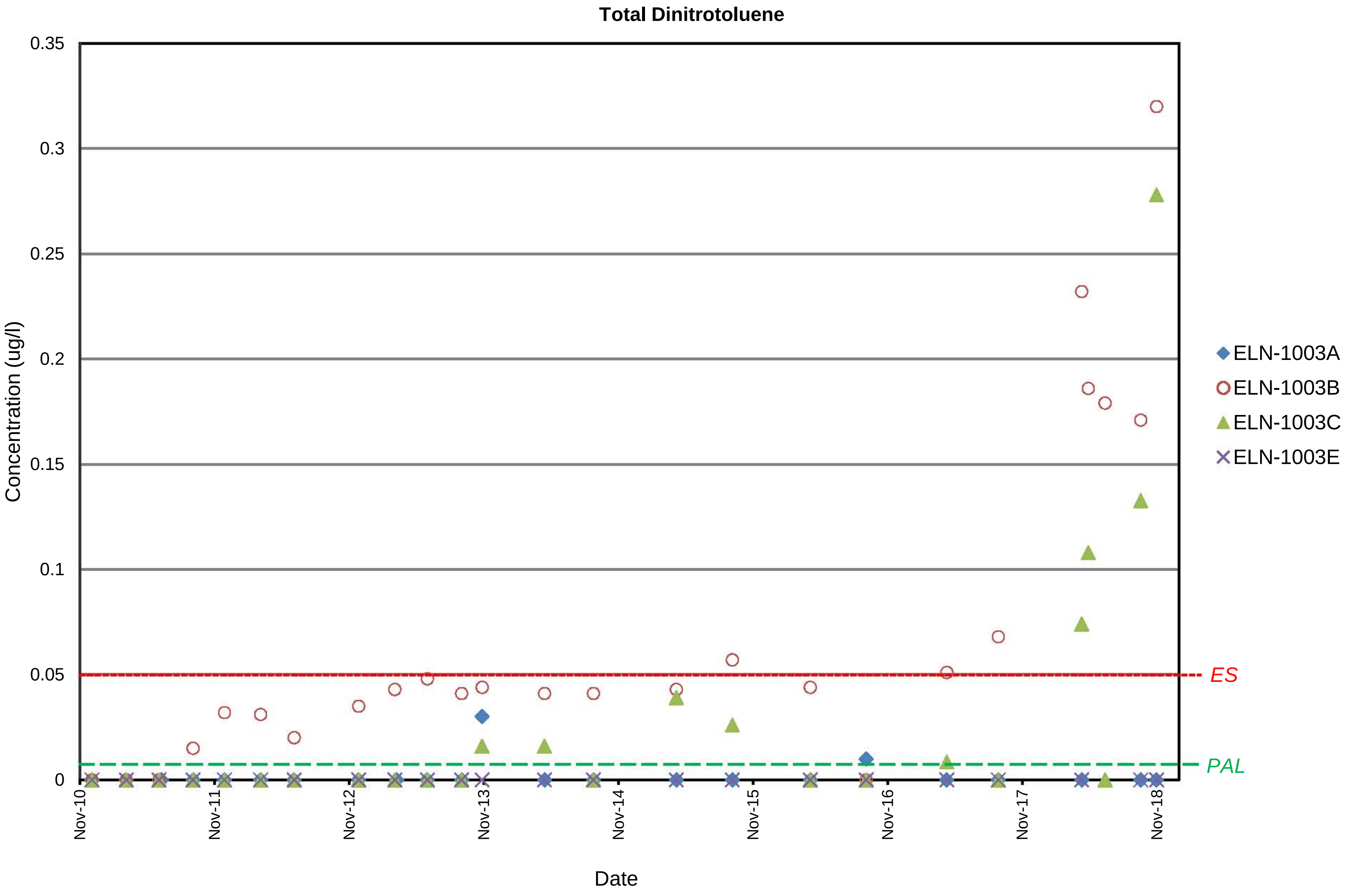
BAAP Groundwater Data Deterrent Burning Ground Plume Center




Total Dinitrotoluene
Concentration (ug/l)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Oct-15
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Date
ES
PAL
◆ ELN-1502A
▲ ELN-1502C

BAAP Groundwater Data | Deterrent Burning Ground | Plume Center - Downgradient



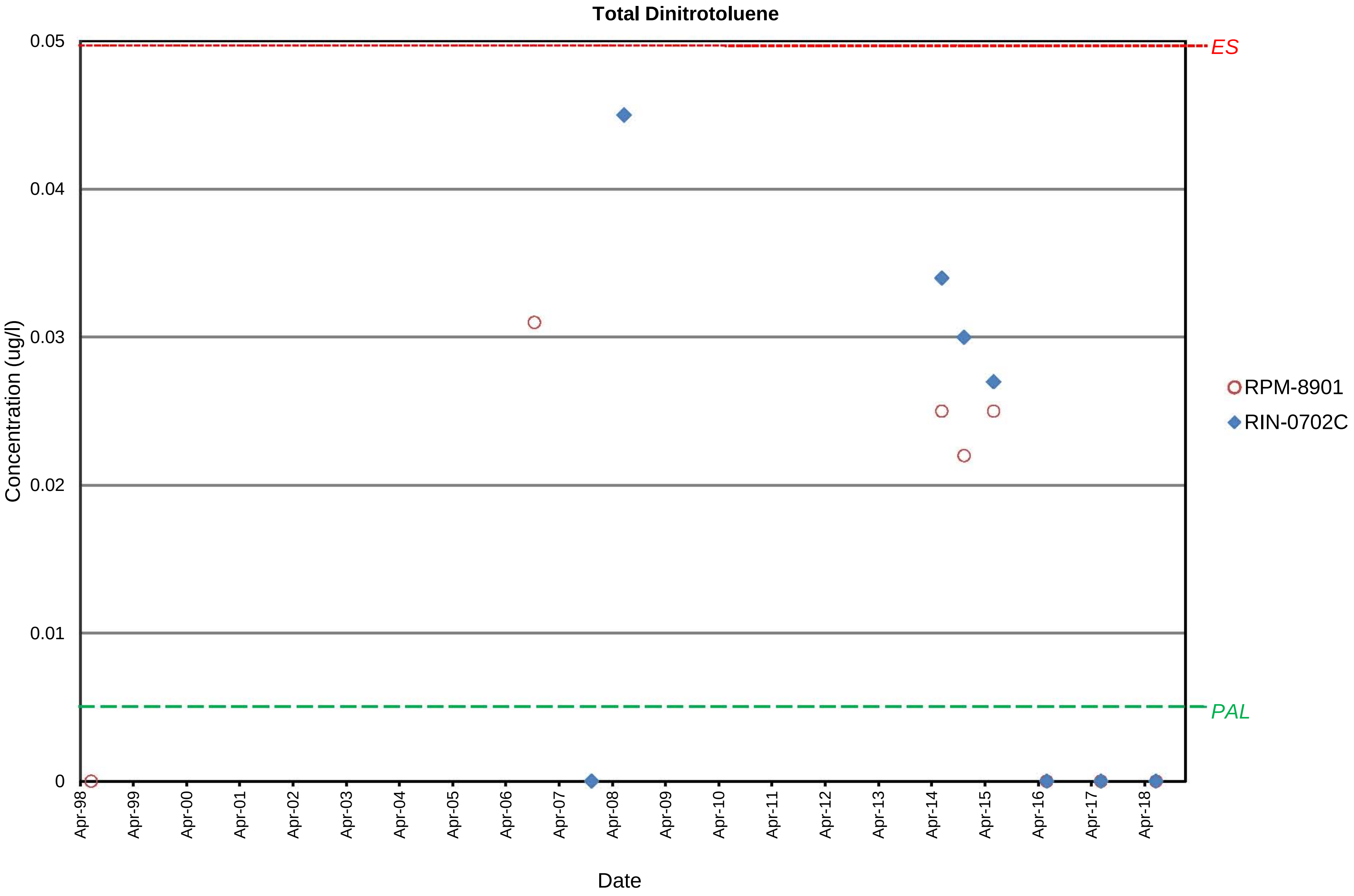

Total Dinitrotoluene
Concentration (ug/l)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Nov-10
Nov-11
Nov-12
Nov-13
Nov-14
Nov-15
Nov-16
Nov-17
Nov-18
Date
ES
PAL
◆ ELN-1003A
○ ELN-1003B
▲ ELN-1003C
× ELN-1003E

Concentration Graphs
Central Plume

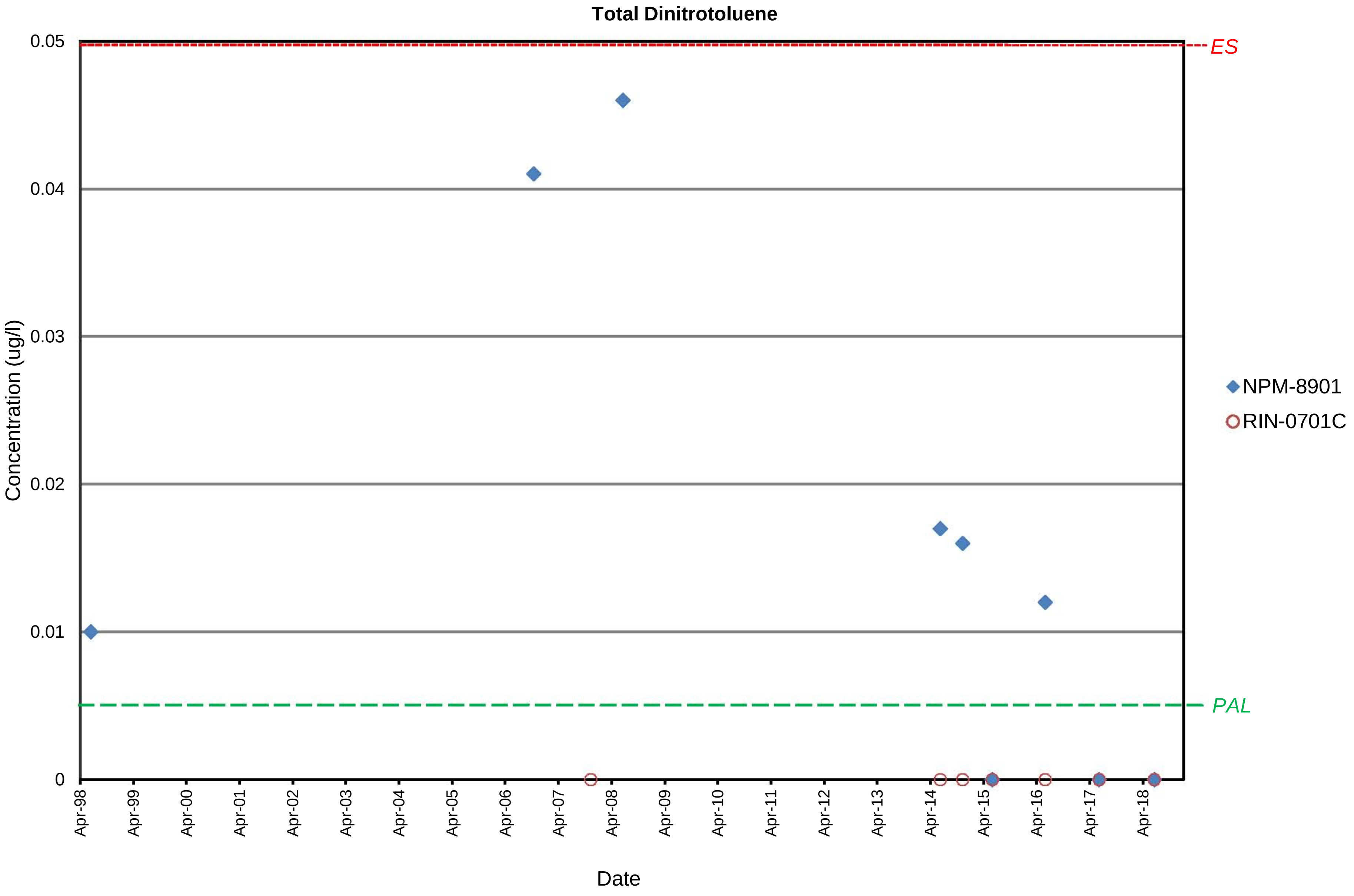
On-Site Downgradient Wells	Compound	Year Range	Page
RPM-8901, RIN-0702C	DNT	1998 - 2018	1
NPM-8901, RIN-0701C	DNT	1998 - 2018	2
NLN-1001A, C	DNT	2010 - 2018	3
RIN-1002A, C, RIN-1501D	DNT	2010 - 2018	4
RIN-1005A, C	DNT	2010 - 2018	5
USDA 6, RIN-1003A, RIN-0703C	DNT	2006 - 2018	6
RIN-1004B	DNT	2010 - 2018	7

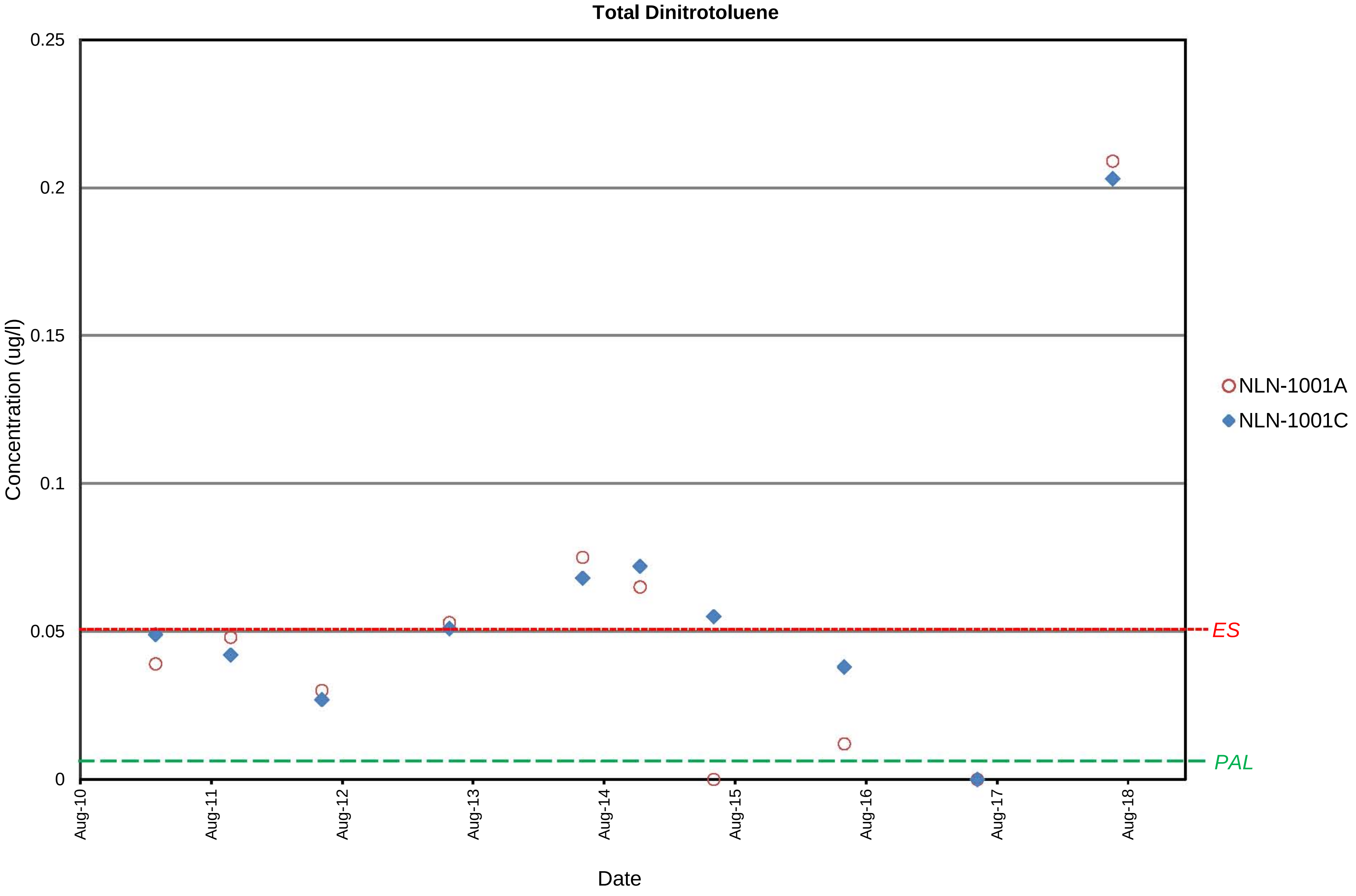
Off-Site Downgradient Wells	Compound	Year Range	Page
SEN-0501A, B, D	DNT	2005 - 2018	8
SEN-0502A, D	DNT	2005 - 2018	9
SEN-0503A, B, D	DNT	2005 - 2018	10

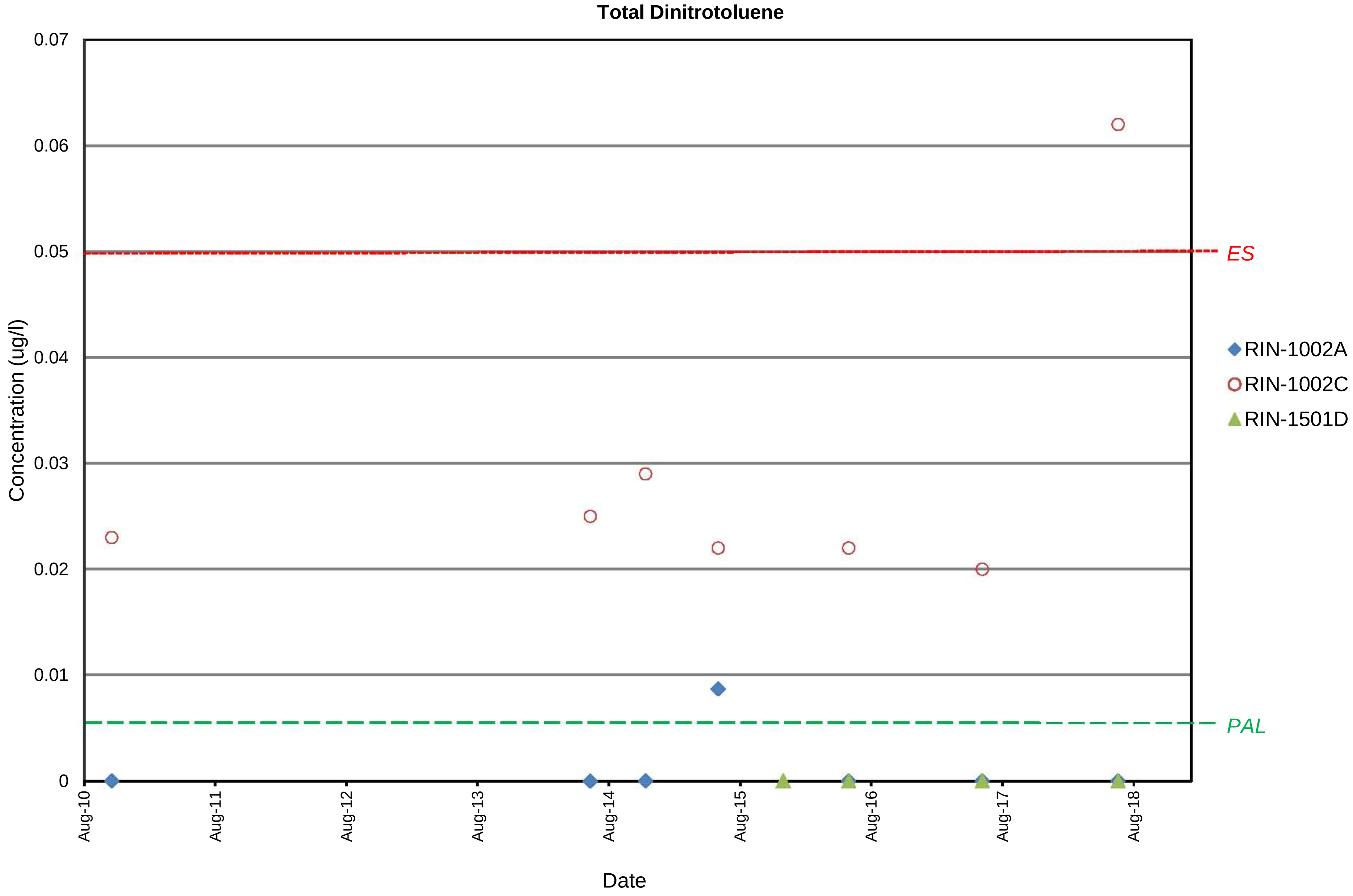
BAAP Groundwater Data Central Plume Plume Center



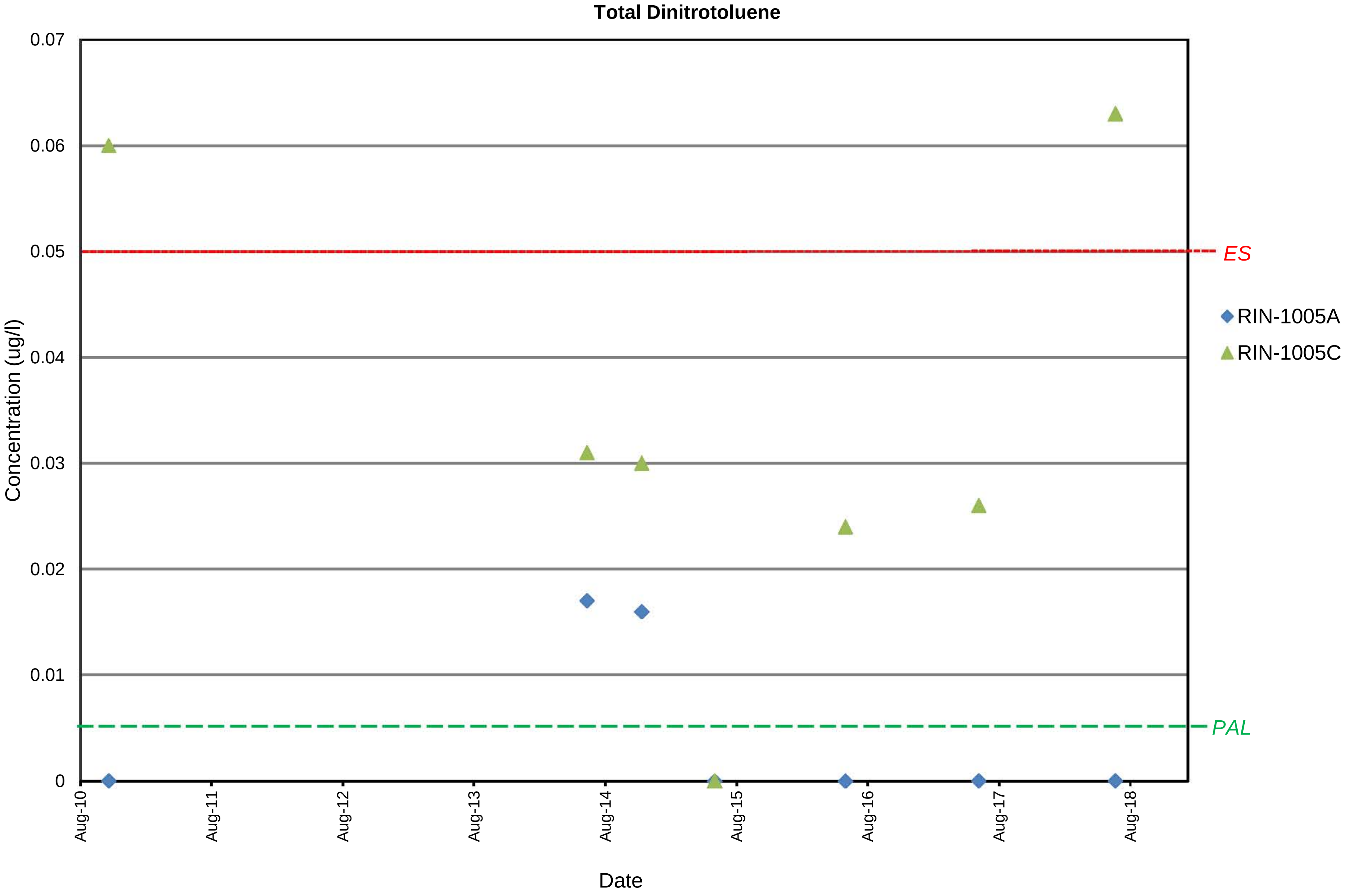
BAAP Groundwater Data | Central Plume | Plume Center

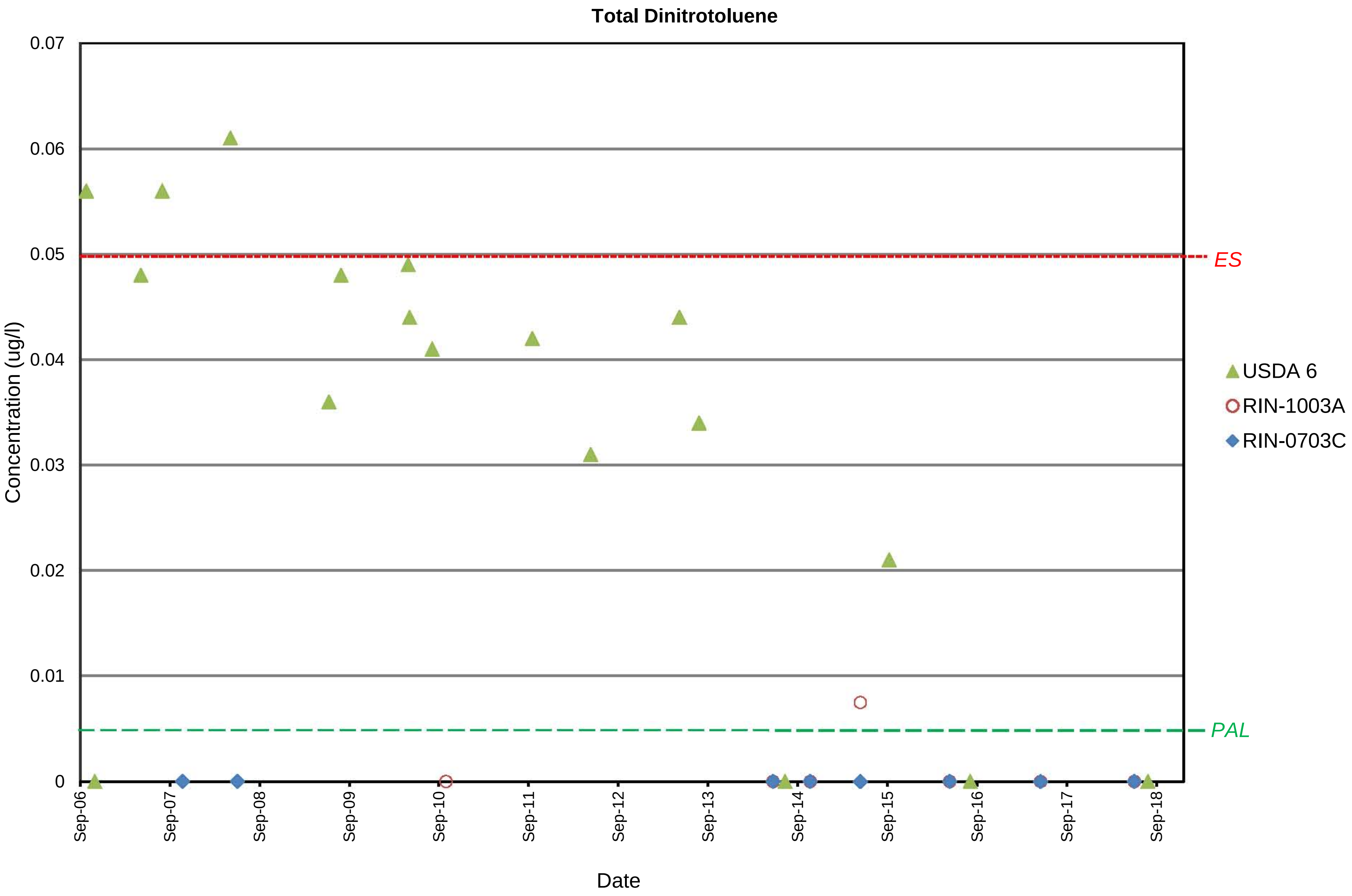



Total Dinitrotoluene
Concentration (ug/l)
0.25
0.2
0.15
0.1
0.05
0
Aug-10
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Date
ES
PAL
NLN-1001A
NLN-1001C

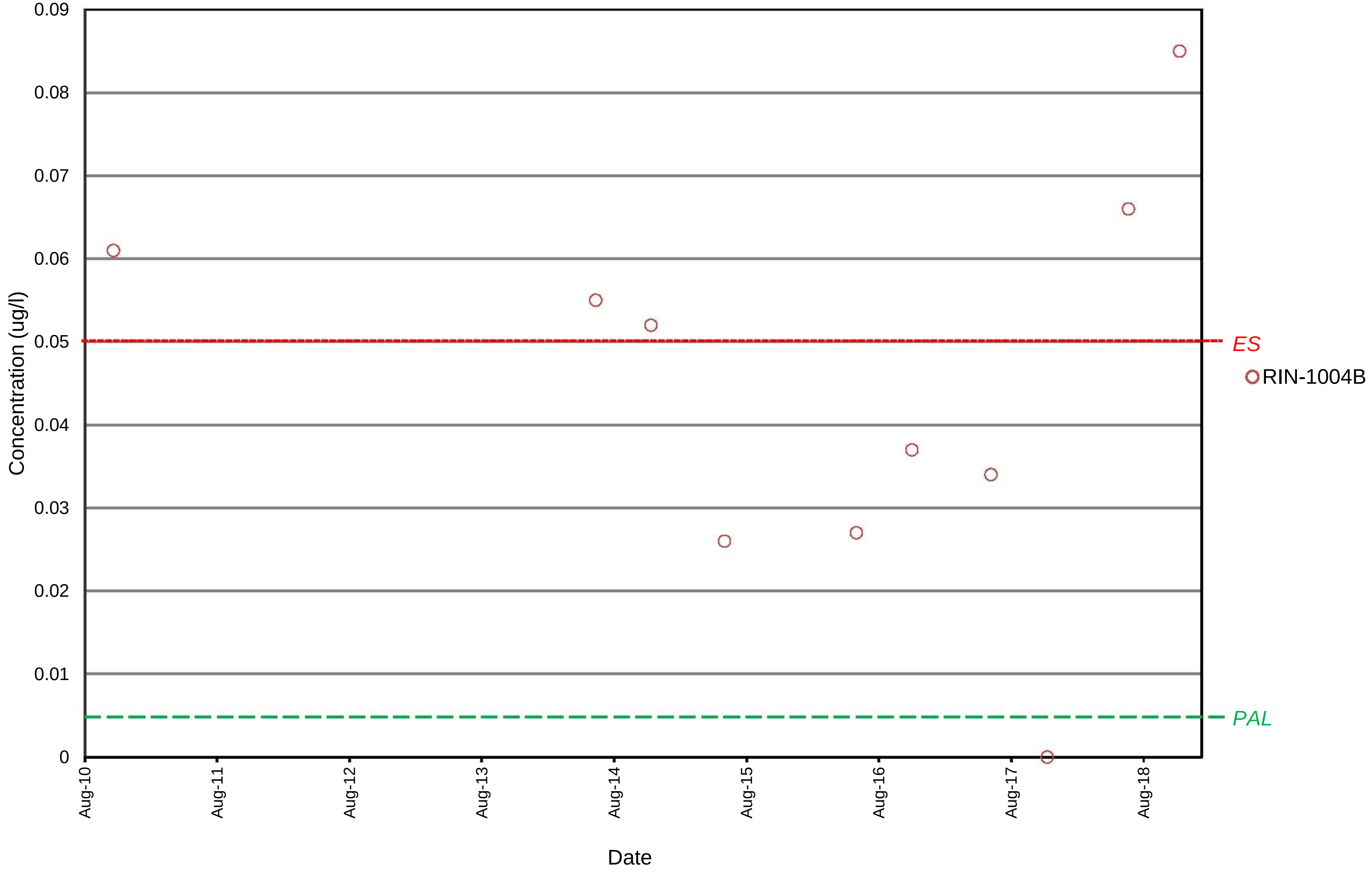

Total Dinitrotoluene
Concentration (ug/l)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Aug-10
Aug-11
Aug-12
Aug-13
Aug-14
Aug-15
Aug-16
Aug-17
Aug-18
Date
ES
PAL
RIN-1002A
RIN-1002C
RIN-1501D

BAAP Groundwater Data | Central Plume | Plume Edge

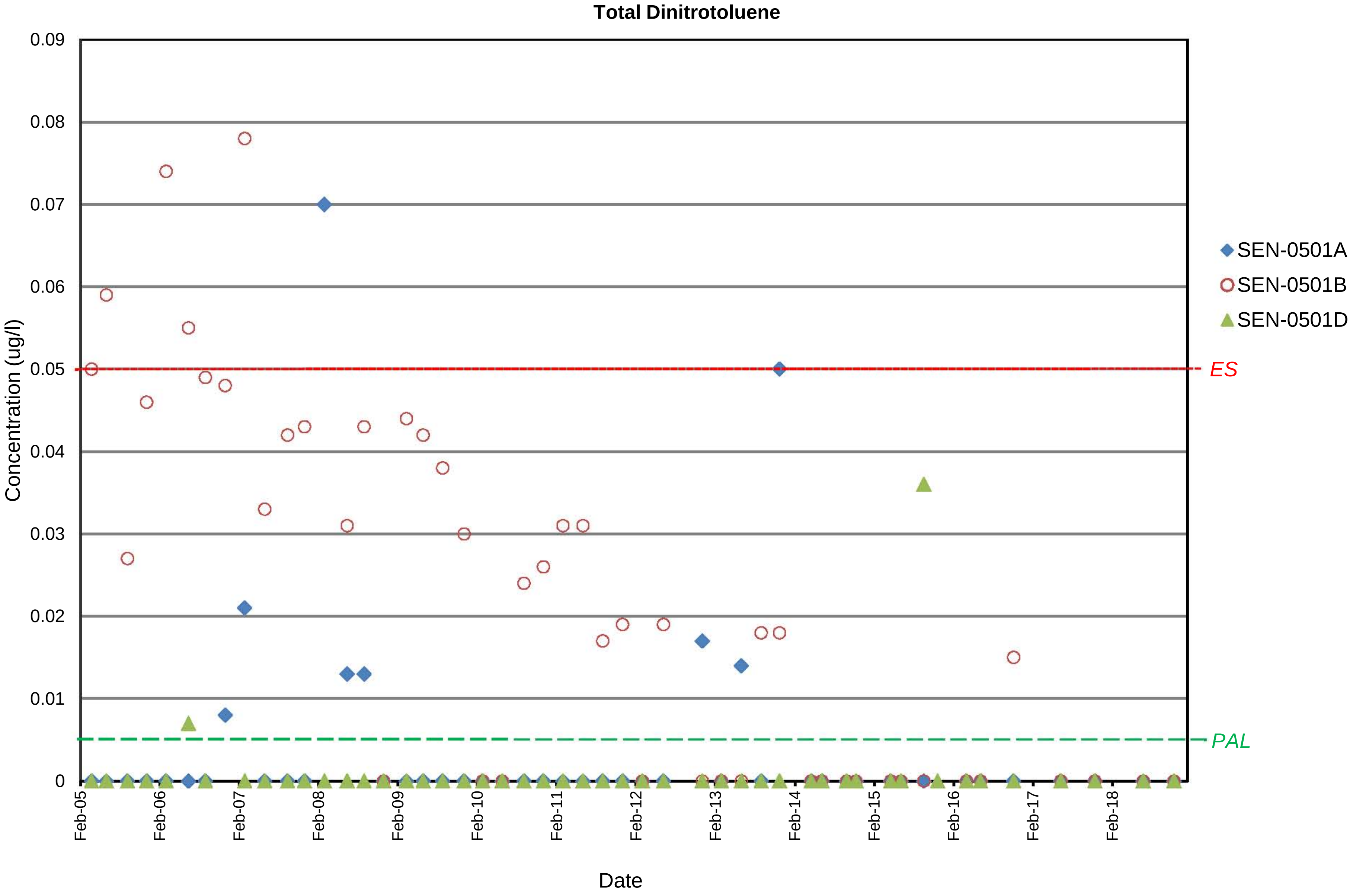



Total Dinitrotoluene
Concentration (ug/l)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
ES
PAL
Sep-06
Sep-07
Sep-08
Sep-09
Sep-10
Sep-11
Sep-12
Sep-13
Sep-14
Sep-15
Sep-16
Sep-17
Sep-18
Date
USDA 6
RIN-1003A
RIN-0703C

Total Dinitrotoluene

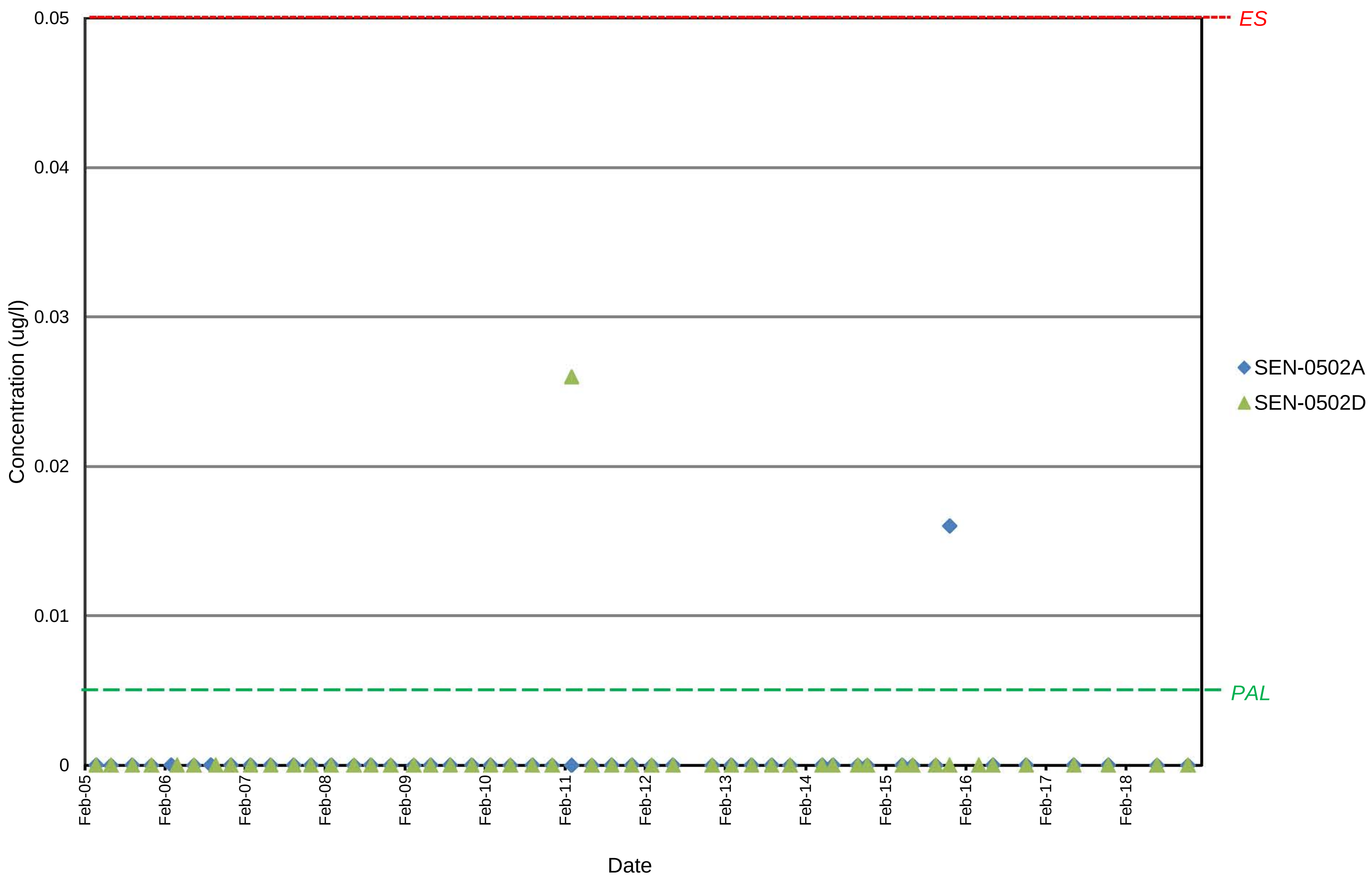


BAAP Groundwater Data | Central Plume | Plume Leading Edge

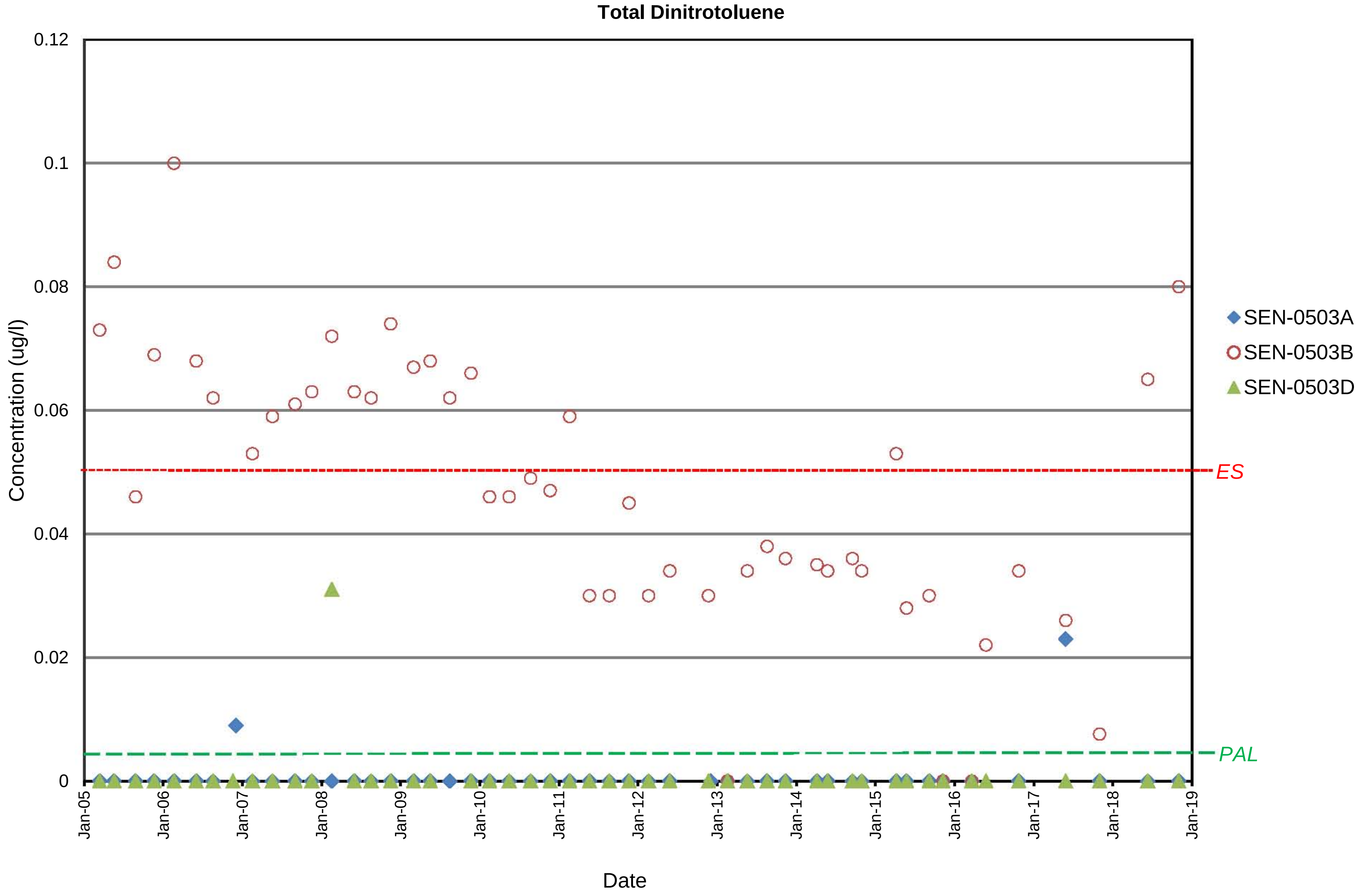


BAAP Groundwater Data Central Plume Plume Leading Edge

Total Dinitrotoluene



BAAP Groundwater Data	Central Plume	Plume Leading Edge

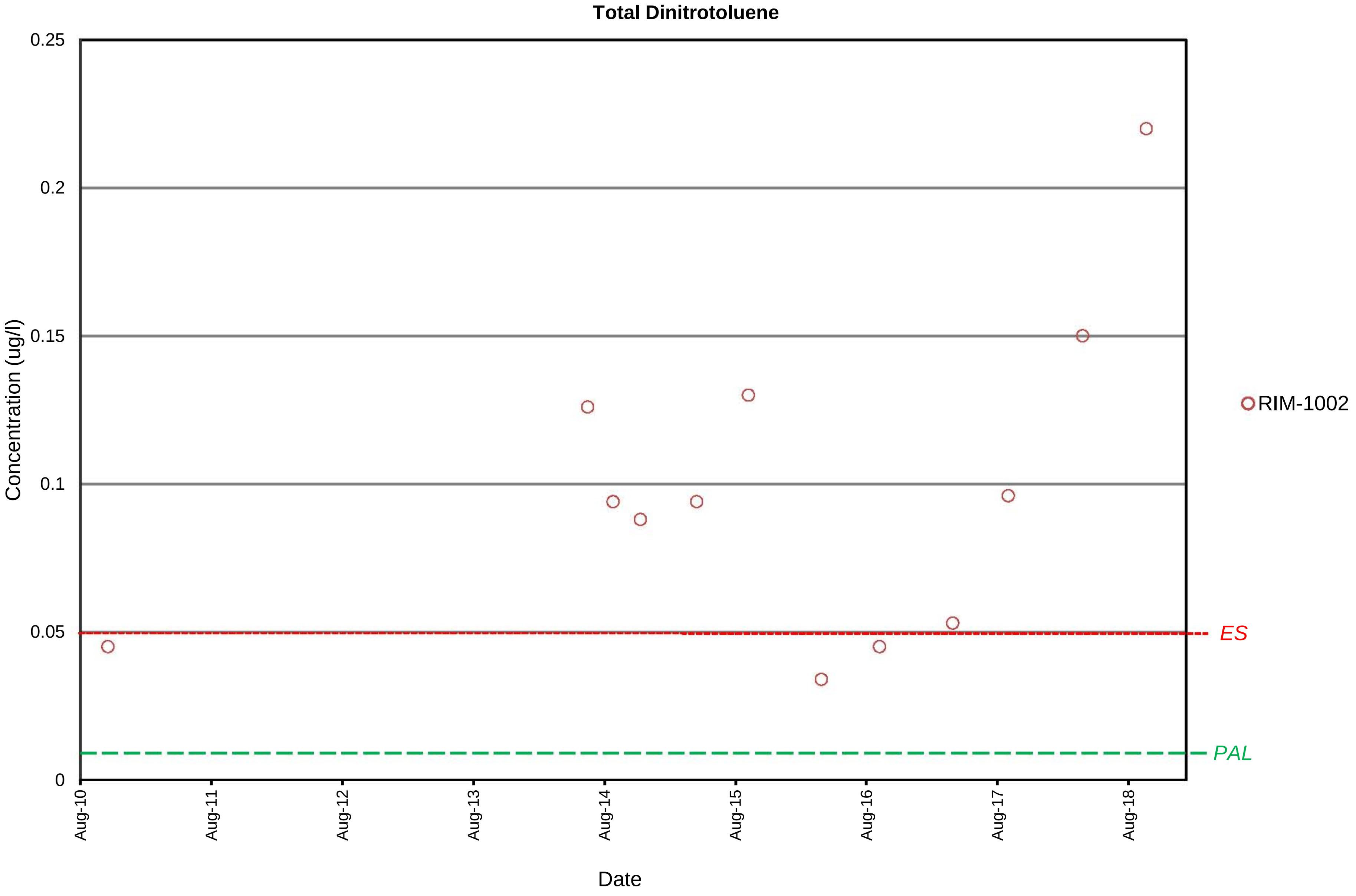


Concentration Graphs
Nitrocellulose Production Area Plume

Source Area Wells	Compound	Year Range	Page
RIM-1002	DNT	2010 - 2018	1
RIM-0705, RIN-1007C	DNT	2007 - 2018	2

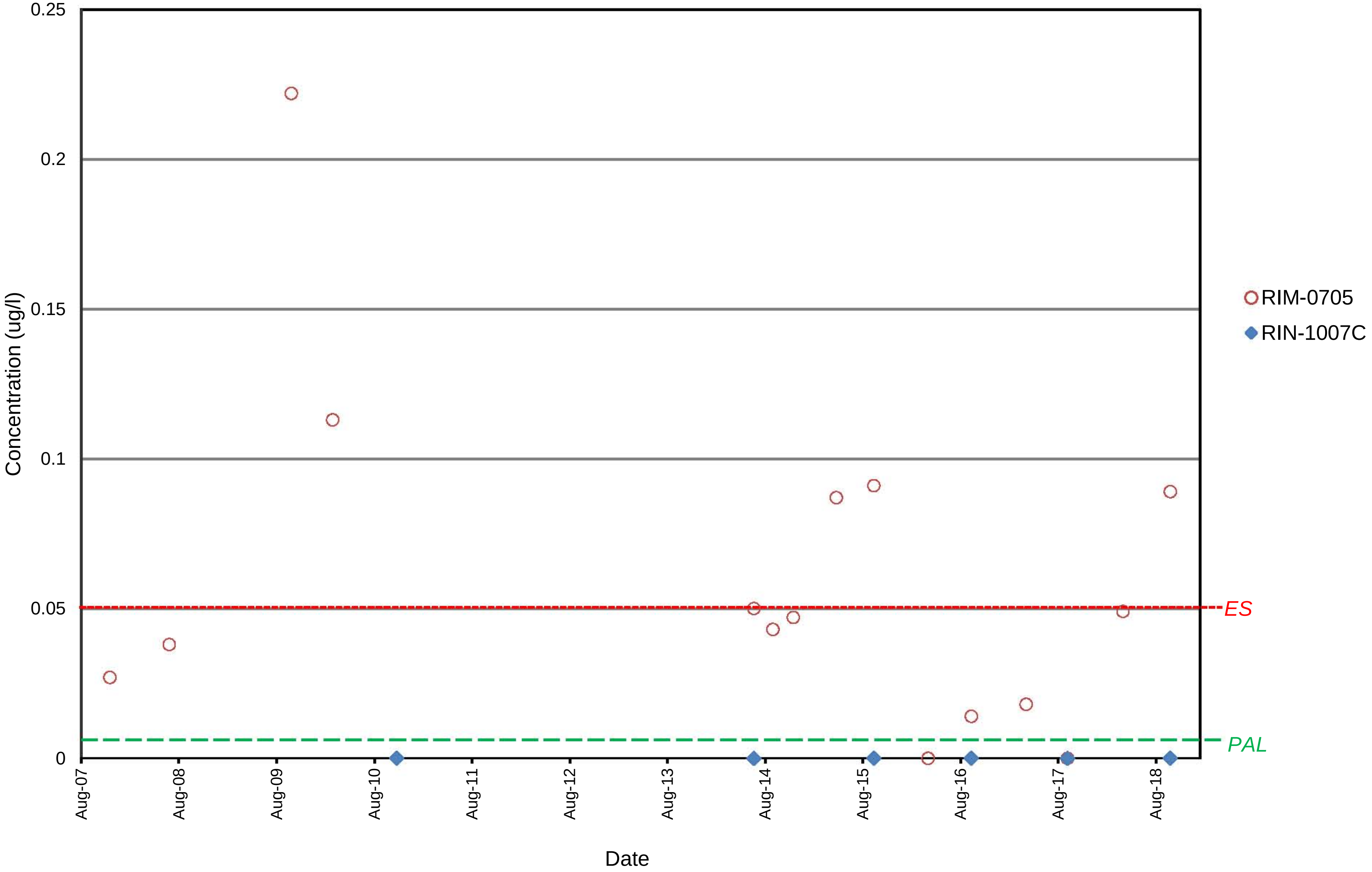
On-Site Downgradient Wells	Compound	Year Range	Page
RIN-1001A, C	DNT	2010 - 2018	3

BAAP Groundwater Data | Nitrocellulose Production Area Plume | Plume Center

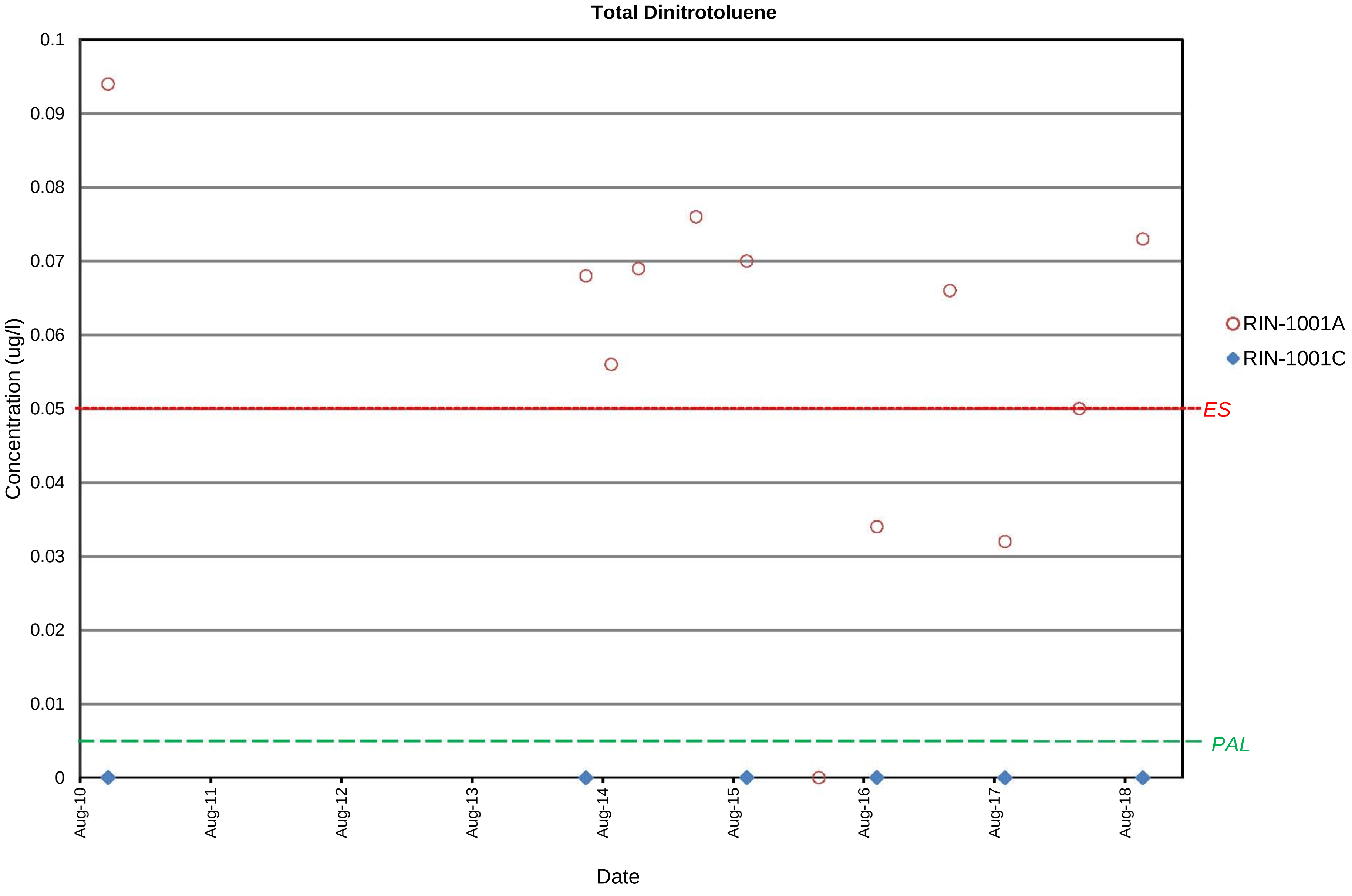


BAAP Groundwater Data | Nitrocellulose Production Area Plume | Plume Center

Total Dinitrotoluene



BAAP Groundwater Data | Nitrocellulose Production Area Plume | Plume Center



Appendix F

Vapor Intrusion Investigation Reports (2012)

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
BADGER ARMY AMMUNITION PLANT
2 BADGER ROAD
BARABOO, WISCONSIN 53913-5000

August 15, 2012

SUBJECT: Vapor Intrusion Pathway Analysis Reports
Badger Army Ammunition Plant

Mr. Will Myers
Hydrogeologist Program Coordinator
Wisconsin Department of Natural Resources
South Central Region
3911 Fish Hatchery Road
Fitchburg, WI 53711-5397

Dear Mr. Myers:

The Wisconsin Department of Natural Resources (WDNR) issued a letter dated September 9, 2011 reminding responsible parties that a vapor intrusion investigation should be conducted at all sites where volatile organic compounds (VOC) are present in the soil and groundwater. The Propellant Burning Ground (PBG) Plume contains the following VOCs: carbon tetrachloride, chloroform, and trichloroethylene. The Deterrent Burning Ground and Central Plumes contain primarily dinitrotoluene, which does not pose a vapor pathway risk.

Based on the WDNR letter and the Alternative Feasibility Study – Groundwater Remedial Strategy, Badger Technical Services, LLC (BTS) conducted a vapor intrusion pathway analysis for the PBG Plume.

In February 2012, BTS personnel conducted ten vapor intrusion pathway borings in accordance with WDNR vapor intrusion guidance, *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, PUB-RR-800, December 2010 using the post-run tubing vapor sampling technique. Due to inconclusive results for half the samples, due to ineffectively sealed fittings, BTS recommended conducting further investigation of this pathway at five locations.

On April 19, 2012, BTS submitted the *Vapor Intrusion Pathway Analysis Report* to the Department of the Army (Enclosure 1). A complete evaluation of the vapor pathway was not possible based on the initial information because several of the soil gas samples reported elevated levels of the leak detection tracer gas. Therefore, BTS conducted a supplemental investigation in June and July 2012, as reported in the BTS July 16, 2012, *Supplemental Vapor Intrusion Pathway Analysis Report* (Enclosure 2), at locations where the soil gas analytical data were deemed invalid be re-sampled using helium as the leak-detection tracer gas using an alternate leak detection methodology.

Based on the results of the activities presented within these reports, the data indicate the PBG Plume does not present a significant risk to human health via vapor intrusion off-site. Analytical results of soil gas samples collected off-site do not exceed the WDNR Vapor Risk Screening Levels for Deep Soil Gas.

Please do not hesitate to contact me at 608-643-3361 if you have any questions.

Sincerely,

Joan M. Kenney

Joan M. Kenney
Commander's Representative

Attachments
Enclosures
Copy furn: Hank Kuehling, WDNR SCR R&R Program LTE Hydrogeologist
Michelle Mullin, U.S. Environmental Protection Agency
Ryan Wozniak, Wisconsin Department of Health and Family Services
Ralph Jesse, U.S. Department of Agriculture
Badger Technical Services, LLC

Attachments

Soil Boring Log Information

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-1

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/27/12	Date Drilling Completed 2/27/12	Drilling Method Direct-Push

WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 540043 N, 319020 E NE of SW of Section 14 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Sumpter**

Sample										Soil Properties					
Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/Comments
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin	Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name: Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis
License/Permit/Monitoring Number:
Boring Number: VIP-2

Boring Drilled by: Name of crew chief (first, last) and Firm
First Name: Dave Last Name: Paulson
Firm: Soil Essentials LTD
Date Drilling Started: 2/27/12
Date Drilling Completed: 2/27/12
Drilling Method: Direct-Push

WI Unique Well No DNR Well ID No. Well Name
Final Static Water ____ Feet MSL
Surface Elevation ____ Feet MSL
Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location
State Plane 540372 N, 317498 E
SW of NE of Section 14 T 10 N R 6 E
Local Grid Location ______ Feet N S ______ Feet E W

Facility ID: **157053930**
County: **Sauk**
County Code: **57**
Civil Town/City/ or Village: **Town of Sumpter**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-25’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 25’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin
Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-3

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/27/12	Date Drilling Completed 2/27/12	Drilling Method Direct-Push
WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 540322 N, 315818 E SE of NW of Section 26 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID	County	County Code	Civil Town/City/ or Village
157053930	**Sauk**	**57**	**Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-4

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/27/12	Date Drilling Completed 2/27/12	Drilling Method Direct-Push

WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 540766 N, 315809 E SW of NE of Section 26 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45'	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 45' bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ _________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-5

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/27/12	Date Drilling Completed 2/27/12	Drilling Method Direct-Push

WI Unique Well No	DNR Well ID No.	Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541097 N, 315811 E SW of NE of Section 26 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-6

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/27/12	Date Drilling Completed 2/27/12	Drilling Method Direct-Push

WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541455 N, 315689 E NW of SW of Section 25 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID	County	County Code	Civil Town/City/ or Village
157053930	**Sauk**	**57**	**Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-7

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/28/12	Date Drilling Completed 2/28/12	Drilling Method Direct-Push
WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541541 N, 314767 E NW of NW of Section 36 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID	County	County Code	Civil Town/City/ or Village
157053930	**Sauk**	**57**	**Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-8	
Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/28/12	Date Drilling Completed 2/28/12	Drilling Method Direct-Push
WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches
Local Grid Origin (estimated:) or Boring Location State Plane 541463 N, 315099 E SW of SW of Section 25 T 10 N R 6 E	Local Grid Location ______ Feet N S	______ Feet E W	
Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

SOIL BORING LOG INFORMATION
Form 4400-122

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-9

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/28/12	Date Drilling Completed 2/28/12	Drilling Method Direct-Push

WI Unique Well No	DNR Well ID No.	Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541465 N, 315363 E SW of SW of Section 25 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45'	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 45' bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-10

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 2/28/12	Date Drilling Completed 2/28/12	Drilling Method Direct-Push
WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541565 N, 316021 E SW of NW of Section 26 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample									Soil Properties						
Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/Comments
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Jeff Larkin Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-1A

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dave Last Name: Paulson Firm: Soil Essentials LTD	Date Drilling Started 7/3/12	Date Drilling Completed 7/3/12	Drilling Method Direct-Push
WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 540043 N, 319020 E NE of SW of Section 14 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID	County	County Code	Civil Town/City/ or Village
157053930	**Sauk**	**57**	**Town of Sumpter**

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/Comments
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Brenda Boyce
Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-4A

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dan Last Name: Bendorf Firm: Probe Technologies, Inc.	Date Drilling Started 6/27/12	Date Drilling Completed 6/27/12	Drilling Method Direct-Push
WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches
Local Grid Origin (estimated:) or Boring Location State Plane 540766 N, 315809 E SW of NE of Section 26 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W		

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample									Soil Properties						
Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/Comments
			0-37’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 37’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Brenda Boyce

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-5A

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dan Last Name: Bendorf Firm: Probe Technologies, Inc.	Date Drilling Started 6/27/12	Date Drilling Completed 6/27/12	Drilling Method Direct-Push

WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541097 N, 315811 E SW of NE of Section 26 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID **157053930**	County **Sauk**	County Code **57**	Civil Town/City/ or Village **Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-40’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 40’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Brenda Boyce Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ _________________

Page 1 of 1

Facility/Project Name: Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis
License/Permit/Monitoring Number:
Boring Number: VIP-7A

Boring Drilled by: Name of crew chief (first, last) and Firm
First Name: Dan Last Name: Bendorf
Firm: Probe Technologies, Inc.
Date Drilling Started: 6/27/12
Date Drilling Completed: 6/27/12
Drilling Method: Direct-Push

WI Unique Well No DNR Well ID No. Well Name
Final Static Water ____ Feet MSL
Surface Elevation ____ Feet MSL
Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location
State Plane 541541 N, 314767 E
NW of NW of Section 36 T 10 N R 6 E
Local Grid Location
______ Feet N S ______ Feet E W

Facility ID: **157053930**
County: **Sauk**
County Code: **57**
Civil Town/City/ or Village: **Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-37’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 37’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Brenda Boyce
Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis	License/Permit/Monitoring Number	Boring Number VIP-9A

Boring Drilled by: Name of crew chief (first, last) and Firm First Name: Dan Last Name: Bendorf Firm: Probe Technologies	Date Drilling Started 6/27/12	Date Drilling Completed 6/27/12	Drilling Method Direct-Push

WI Unique Well No DNR Well ID No. Well Name	Final Static Water ____ Feet MSL	Surface Elevation ____ Feet MSL	Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location State Plane 541465 N, 315363 E SW of SW of Section 25 T 10 N R 6 E	Local Grid Location ______ Feet N S ______ Feet E W

Facility ID	County	County Code	Civil Town/City/ or Village
157053930	**Sauk**	**57**	**Town of Prairie du Sac**

Sample									Soil Properties					
Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/Comments
			0-39’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection. B.T. @ 39’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Brenda Boyce

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

SOIL BORING LOG INFORMATION
Form 4400-122

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☒ Other ☐ ________________

Page 1 of 1

Facility/Project Name: Badger Army Ammunition Plant / Vapor Intrusion Pathway Analysis

License/Permit/Monitoring Number:

Boring Number: VIP-10A

Boring Drilled by: Name of crew chief (first, last) and Firm
First Name: Dave Last Name: Paulson
Firm: Soil Essentials LTD

Date Drilling Started: 7/3/12

Date Drilling Completed: 7/3/12

Drilling Method: Direct-Push

WI Unique Well No DNR Well ID No. Well Name

Final Static Water ____ Feet MSL

Surface Elevation ____ Feet MSL

Borehole Diameter 2.125 inches

Local Grid Origin (estimated:) or Boring Location
State Plane 541565 N, 316021 E
SW of NW of Section 26 T 10 N R 6 E

Local Grid Location
______ Feet N S ______ Feet E W

Facility ID	County	County Code	Civil Town/City/ or Village
157053930	**Sauk**	**57**	**Town of Prairie du Sac**

Sample		Blow Counts	Depth in Feet (Below ground surface)	SOIL ROCK DESCRIPTION	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties					RQD/Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	
			0-45’	No soil samples were collected. Boring drilled to install HDPE tubing for soil vapor collection.										
				B.T. @ 45’ bgs.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Brenda Boyce

Firm: Badger Technical Services, LLC.

This form is authorized by Chapters 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats. Completion of this form is mandatory. Failure to file this form may result in forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. NOTE: See instructions for more information, including where the completed form should be sent.

Well / Drillhole / Borehole Abandonment Forms

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-1
Gov't Lot # (if applicable):
¼ / ¼: NE / SW
¼:
Section: 14
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ☐ ft. / ☐ M (Local Grid ☐)
540043 [✓ N] / S 319020 [✓ E] / W Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone: [✓ S] C N
Local Grid Origin ☐ ft. / ☐ M
______ N, ______ E / W Datum:
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone: S C N
Reason For Abandonment: Temporary Soil Boring
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/27/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only

Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ____

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-2
Gov't Lot # (if applicable):
¼ / ¼: SW / NE
¼:
Section: 14
Township: 10 N
Range: 6 ☑ E ☐ W

Well Location ☐ ft. / ☐ M (Local Grid ☐) Datum
540372 [✓ N] / S 317498 [✓ E] / W NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N

Local Grid Origin ☐ ft. / ☐ M Datum
______ N, ______ E / W ______
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N

Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 25
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	25	25 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/27/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only

Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ____

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-3
Gov't Lot # (if applicable):
¼ / ¼: SE / NW
¼:
Section: 26
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐)
540322 [✓ N] / S 315818 [✓ E] / W Datum NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N
Local Grid Origin ft. / M Datum
____ N, ____ E / W
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo State: WI ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 25
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	25	25 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/27/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus State: WI ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:
☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-4
Gov't Lot # (if applicable):
¼ / ¼: SW / NE
¼:
Section: 26
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐)
540766 [✓ N] / S 315809 [✓ E] / W
Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N
Local Grid Origin ft. / M
______ N, ______ E / W
Datum:
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 25
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	25	25 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/27/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-5
Gov't Lot # (if applicable):
¼ / ¼: SE / NE
¼:
Section: 26
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐)
541097 [✓ N] / S 315811 [✓ E] / W
Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone: [✓ S] C N
Local Grid Origin ft. / M
______ N, ______ E / W
Datum:
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone: S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 25
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet)

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	25	25 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/27/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:
☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ____

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-6
Gov't Lot # (if applicable):
¼ / ¼: NW / SW
¼:
Section: 25
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐)
541455 [✓ N] / S 315689 [✓ E] / W Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone: [✓ S] C N
Local Grid Origin ft. / M Datum
____ N, ____ E / W
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone: S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/27/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other:

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-7
Gov't Lot # (if applicable):
¼ / ¼: NW / NW
¼:
Section: 36
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐)
541541 [✓ N] / S 314767 [✓ E] / W Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N
Local Grid Origin ft. / M
_______ N, _______ E / W Datum:
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/28/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/28/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:
☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-8
Gov't Lot # (if applicable):
¼ / ¼: SW / SW
¼:
Section: 25
Township: 10 N
Range: 6 ☑ E ☐ W

Well Location ft. / M (Local Grid ☐)
541463 [✓ N] / S 315099 [✓ E] / W Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone: [✓ S] C N

Local Grid Origin ft. / M
______ N, ______ E / W Datum
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone: S C N

Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo State: WI ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/28/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet)

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/28/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus State: WI ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-9
Gov't Lot # (if applicable):
¼ / ¼: SW / SW
¼:
Section: 25
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ☐ ft. / ☐ M (Local Grid ☐)
541465 [✓ N] / S 315363 [✓ E] / W Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone: [✓ S] C N
Local Grid Origin ☐ ft. / ☐ M Datum
______ N, ______ E / W ______
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone: ☐ S ☐ C ☐ N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/28/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet)

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	45 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/28/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-10
Gov't Lot # (if applicable):
¼ / ¼: SW / NW
¼:
Section: 26
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐)
541565 [✓ N] / S 316021 [✓ E] / W Datum NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N
Local Grid Origin ft. / M Datum
______ N, ______ E / W
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 2/28/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 2/28/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 4/19/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:
☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ____

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-1A
Gov't Lot # (if applicable):
¼ / ¼: NE / SW
¼:
Section: 14
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ft. / M (Local Grid ☐) Datum
540043 [✓ N] / S 319020 [✓ E] / W NAD 83
Zone
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ [✓ S] C N
Local Grid Origin ft. / M Datum
____ N, ____ E / W
Zone
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ S C N
Reason For Abandonment: Temporary Soil Boring
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 7/3/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson
Date of Abandonment: 7/3/12
Street or Route: W6306 State Road 39
Telephone Number: (608) 527-2355
City: New Glarus
State: WI
ZIP Code: 53574
Signature of Person Doing Work:
Date Signed: 7/12/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk

Common Well Name: VIP-4A
Gov't Lot # (if applicable):

¼ / ¼: SW / NE
¼:
Section: 26
Township: 10 N
Range: 6 ☑ E ☐ W

Well Location ft. / M (Local Grid ☐)
540766 [✓ N] / S 315809 [✓ E] / W
Datum: NAD 83
WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N

Local Grid Origin ft. / M
______ N, ______ E / W
Datum:
WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N

Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant

Facility ID: 157053930
License/Permit/Monitoring No.:

Street Address of Well: 2 Badger Road

City, Village or Town: Baraboo

Present Well Owner: U.S. Army
Original Well Owner:

Street Address or Route of Present Owner: 2 Badger Road

City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 6/27/12

If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 37
Casing Diameter (in.):

Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):

Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown

If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	37	30 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dan Bendorf
Date of Abandonment: 6/27/12

Street or Route: W1225 South Shore Drive
Telephone Number: (262) 470-4768

City: Palmyra
State: WI
ZIP Code: 53156

Signature of Person Doing Work:
Date Signed: 7/12/12

DNR Use Only

Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ____

1. General Information

WI Unique Well No. ___ ___ ___ ___ ___	DNR Well ID No.	County Sauk
Common Well Name VIP-5A		Gov't Lot # (if applicable)

¼ / ¼ SE / NE	¼	Section 26	Township 10 N	Range 6 ☑ E ☐ W

Well Location ☐ ft. / ☐ M (Local Grid ☐) Datum

541097 [✓ N] / S 315811 [✓ E] / W NAD 83

WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone [✓ S] C N

Local Grid Origin ☐ ft. / ☐ M Datum

____ N, ____ E / W

WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone S C N

Reason For Abandonment Temp. Borehole-Vapor Collection	WI Unique Well No. of Replacement Well ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name
Badger Army Ammunition Plant

Facility ID 157053930	License/Permit/Monitoring No.

Street Address of Well
2 Badger Road

City, Village or Town
Baraboo

Present Well Owner U.S. Army	Original Well Owner

Street Address or Route of Present Owner
2 Badger Road

City Baraboo	State WI	ZIP Code 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date
6/27/12

If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.) 40	Casing Diameter (in.)
Lower Drillhole Diameter (in.) 2.125	Casing Depth (ft.)

Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown

If yes, to what depth (feet)?	Depth to Water (feet)

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	40	35 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work Dan Bendorf	Date of Abandonment 6/27/12
Street or Route W1225 South Shore Drive	Telephone Number (262) 470-4768

City Palmyra	State WI	ZIP Code 53156	Signature of Person Doing Work	Date Signed 7/12/12

DNR Use Only

Date Received	Noted By
Comments	

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04)

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.	DNR Well ID No.	County
___ ___ ___ ___ ___		Sauk

Common Well Name	Gov't Lot # (if applicable)
VIP-7A	

¼ / ¼	¼	Section	Township	Range	
NW / NW		36	10 N	6	☑ E ☐ W

Well Location ft. / M (Local Grid ☐) Datum

541541 [✓ N] / S 314767 [✓ E] / W NAD 83

Zone

WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ [✓ S] C N

Local Grid Origin ft. / M Datum

______ N, ______ E / W ______

Zone

WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ S C N

Reason For Abandonment	WI Unique Well No. of Replacement Well
Temp. Borehole-Vapor Collection	___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name
Badger Army Ammunition Plant

Facility ID	License/Permit/Monitoring No.
157053930	

Street Address of Well
2 Badger Road

City, Village or Town
Baraboo

Present Well Owner	Original Well Owner
U.S. Army	

Street Address or Route of Present Owner
2 Badger Road

City	State	ZIP Code
Baraboo	WI	53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date
6/27/12

If a Well Construction Report is available, please attach.

Construction Type:

☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:

☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.)	Casing Diameter (in.)
37	

Lower Drillhole Diameter (in.)	Casing Depth (ft.)
2.125	

Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown

If yes, to what depth (feet)?	Depth to Water (feet)

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material

☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials

☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:

☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	37	30 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work	Date of Abandonment
Dan Bendorf	6/27/12

Street or Route	Telephone Number
W1225 South Shore Drive	(262) 470-4768

City	State	ZIP Code	Signature of Person Doing Work	Date Signed
Palmyra	WI	53156		7/12/12

DNR Use Only

Date Received	Noted By

Comments

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04) Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:
☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___
DNR Well ID No.:
County: Sauk
Common Well Name: VIP-9A
Gov't Lot # (if applicable):
¼ / ¼: SW / SW
¼:
Section: 25
Township: 10 N
Range: 6 ☑ E ☐ W
Well Location ☐ ft. / ☐ M (Local Grid ☐) Datum
541465 [✓ N] / S 315363 [✓ E] / W NAD 83
Zone
WTM–☑ UTM–☐ Latitude/Longitude–☐ State Plane–☑ [✓ S] C N
Local Grid Origin ☐ ft. / ☐ M Datum
______ N, ______ E / W ______
Zone
WTM–☐ UTM–☐ Latitude/Longitude–☐ State Plane–☐ S C N
Reason For Abandonment: Temp. Borehole-Vapor Collection
WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant
Facility ID: 157053930
License/Permit/Monitoring No.:
Street Address of Well: 2 Badger Road
City, Village or Town: Baraboo
Present Well Owner: U.S. Army
Original Well Owner:
Street Address or Route of Present Owner: 2 Badger Road
City: Baraboo
State: WI
ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 6/27/12
If a Well Construction Report is available, please attach.

Construction Type:
☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 39
Casing Diameter (in.):
Lower Drillhole Diameter (in.): 2.125
Casing Depth (ft.):
Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown
If yes, to what depth (feet)?
Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials
☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:
☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	39	35 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dan Bendorf
Date of Abandonment: 6/27/12
Street or Route: W1225 South Shore Drive
Telephone Number: (262) 470-4768
City: Palmyra
State: WI
ZIP Code: 53156
Signature of Person Doing Work:
Date Signed: 7/12/12

DNR Use Only
Date Received:
Noted By:
Comments:

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Well / Drillhole / Borehole Abandonment

Form 3300-005 (R 12/04)

Page 1 of 2

Notice: Completion of this report is required by chs. 160, 281, 283, 289, 291-293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291-293, 295, and 299, Wis. Stats., failure to file this form may result in a forfeiture of between $10-25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on this form is not intended to be used for any other purpose. Return form to the appropriate DNR office and bureau. See instructions on reverse for more information.

Route to:

☐ Drinking Water ☐ Watershed/Wastewater ☐ Waste Management ☑ Remediation/Redevelopment ☐ Other: ______

1. General Information

WI Unique Well No.: ___ ___ ___ ___ ___

DNR Well ID No.:

County: Sauk

Common Well Name: VIP-10A

Gov't Lot # (if applicable):

¼ / ¼: SW / NW

¼:

Section: 26

Township: 10 N

Range: 6 ☑ E ☐ W

Well Location ☐ ft. / ☐ M (Local Grid ☐)

541565 [✓ N] / S 316021 [✓ E] / W Datum: NAD 83

WTM– ☑ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☑ Zone: [✓ S] C N

Local Grid Origin ☐ ft. / ☐ M

______ N, ______ E / W Datum: ______

WTM– ☐ UTM– ☐ Latitude/Longitude– ☐ State Plane– ☐ Zone: S C N

Reason For Abandonment: Temp. Borehole-Vapor Collection

WI Unique Well No. of Replacement Well: ___ ___ ___ ___ ___

2. Facility / Owner Information

Facility Name: Badger Army Ammunition Plant

Facility ID: 157053930

License/Permit/Monitoring No.:

Street Address of Well: 2 Badger Road

City, Village or Town: Baraboo

Present Well Owner: U.S. Army

Original Well Owner:

Street Address or Route of Present Owner: 2 Badger Road

City: Baraboo State: WI ZIP Code: 53913

3. Well / Drillhole / Borehole Information

☐ Monitoring Well
☐ Water Well
☑ Borehole / Drillhole

Original Construction Date: 7/3/12

If a Well Construction Report is available, please attach.

Construction Type:

☐ Drilled ☐ Driven (Sandpoint) ☐ Dug
☑ Other (specify): Geoprobe

Formation Type:

☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth From Groundsurface (ft.): 45

Casing Diameter (in.):

Lower Drillhole Diameter (in.): 2.125

Casing Depth (ft.):

Was well annular space grouted? ☐ Yes ☑ No ☐ Unknown

If yes, to what depth (feet)?

Depth to Water (feet):

4. Pump, Liner, Screen, Casing & Sealing Material

Pump and piping removed?	☐ Yes	☐ No	☑ N/A
Liner(s) removed?	☐ Yes	☐ No	☑ N/A
Screen removed?	☐ Yes	☐ No	☑ N/A
Casing left in place?	☐ Yes	☐ No	☑ N/A
Was casing cut off below surface?	☐ Yes	☐ No	☑ N/A
Did sealing material rise to surface?	☑ Yes	☐ No	☐ N/A
Did material settle after 24 hours?	☐ Yes	☑ No	☐ N/A
If yes, was hole retopped?	☐ Yes	☐ No	☑ N/A
If bentonite chips were used, were they hydrated with water from a known safe source?	☐ Yes	☐ No	☑ N/A

Required Method of Placing Sealing Material

☐ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Screened & Poured (Bentonite Chips) ☑ Other (Explain): Poured / chipped bentonite

Sealing Materials

☐ Neat Cement Grout ☐ Clay-Sand Slurry (11 lb./gal. wt.)
☐ Sand-Cement (Concrete) Grout ☐ Bentonite-Sand Slurry " "
☐ Concrete ☑ Bentonite Chips

For Monitoring Wells and Monitoring Well Boreholes Only:

☐ Bentonite Chips ☐ Bentonite - Cement Grout
☐ Granular Bentonite ☐ Bentonite - Sand Slurry

5. Material Used To Fill Well / Drillhole

5. Material Used To Fill Well / Drillhole	From (ft.)	To (ft.)	No. Yards, Sacks Sealant or Volume (circle one)	Mix Ratio or Mud Weight
Chipped Bentonite	Surface	45	40 lbs	

6. Comments

7. Supervision of Work

Name of Person or Firm Doing Sealing Work: Dave Paulson

Date of Abandonment: 7/3/12

Street or Route: W6306 State Road 39

Telephone Number: (608) 527-2355

City: New Glarus State: WI ZIP Code: 53574

Signature of Person Doing Work:

Date Signed: 7/12/12

DNR Use Only

Date Received: Noted By:

Comments:

19 April 2012

Contracting Officer's Representative
Badger Army Ammunition Plant
2 Badger Road
Baraboo, WI 53913-5000

Subject: Vapor Intrusion Pathway Analysis Report

Dear Sir:

The Wisconsin Department of Natural Resources (WDNR) issued a letter dated September 9, 2011 reminding responsible parties that a vapor intrusion investigation should be conducted at all sites where volatile organic compounds (VOC) are present in the soil and groundwater. The Propellant Burning Ground (PBG) Plume contains the following VOCs: carbon tetrachloride, chloroform and trichloroethylene (TCE). The Deterrent Burning Ground and Central Plumes contain primarily dinitrotoluene (DNT), which does not pose a vapor pathway risk.

The *Alternative Feasibility Study – Groundwater Remedial Strategy* (Alt FS) document states that a vapor intrusion pathway analysis would be conducted along the PBG Plume to determine the level of risk to down-gradient receptors. Based on the WDNR letter and the Alt FS, Badger Technical Services, LLC (BTS) conducted a vapor intrusion pathway analysis for the PBG Plume. BTS performed this work under Performance Work Statement (PWS) #0050.

The PBG Plume extends along the southwest portion of Badger Army Ammunition Plant (BAAAP) and off-site toward the Wisconsin River in the direction of groundwater flow. Figure 1 shows the PBG Plume area in relation to BAAAP. On February 27 and 28, 2012, BTS personnel conducted ten vapor intrusion pathway (VIP) Geoprobe® borings to a depth of 25 or 45 feet approximately half-way to the groundwater table (per WDNR vapor intrusion guidance, *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, PUB-RR-800, December 2010) using post-run tubing vapor sampling technique. VIP borings were placed at well nest locations to compare groundwater contaminant concentrations to the soil vapor results. VIP boring locations are depicted on Figure 2.

After drilling the VIP boring to the desired depth, new high-density polyethylene 3/8-inch or 1/4-inch OD tubing was placed down to the bottom of the borehole. The tubing was connected to a flow controller/sampler attached to a 6-liter summa canister. Under negative pressure, the canister was allowed to draw vapor from the bottom of the borehole until filled, approximately 30 to 50 minutes. To ensure sample integrity, quality control leak detection tracer techniques were used during sample collection at borings VIP-1 through VIP-9. Isopropyl alcohol wetted rags were placed around fitting connections to determine whether any leaking or short-circuiting of air through the fittings had occurred. Boring VIP-10 was inadvertently omitted from the leak detection methodology. Soil borings were abandoned following sample collection.

Soil vapor samples were submitted to the Wisconsin State Laboratory of Hygiene (certification #113133790) for chloroform, carbon tetrachloride and TCE Method TO-15 laboratory analysis. Chloroform was detected within sample VIP-10 at a concentration of 22.3 parts per billion vapor (ppbV) exceeding the WDNR Vapor Risk Screening Level (RSL) for Deep Soil Gas (see *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, PUB-RR-800, December 2010). However, because this sample was collected beyond the extent of the PBG Plume, and based on its proximity to the Windings subdivision, the chloroform is likely the result of well chlorination activities. Analytical results also detected chloroform, carbon tetrachloride and/or TCE at concentrations below WDNR Vapor RSLs at borings VIP-1, VIP-5, VIP-8, and VIP-9. A summary of the analytical results is presented on Table 1. Laboratory reports and chain of custody records are attached.

Please note that due to the presence of isopropanol, analytical results for samples VIP-1, VIP-4, VIP-5, VIP-7, and VIP-9 are considered questionable. The presence of the isopropanol is due to the short-circuiting of air through the hardware/fitting connections. Sample results for VIP-6 and VIP-8 were also flagged due to isopropanol related issues. However, according to Wisconsin State Laboratory of Hygiene personnel, the flag is the result of a failed quality control check and had no bearing on the results for the targeted compounds.

Other than the carbon tetrachloride concentrations identified in monitoring well PBN-9101C and borings VIP-8 and VIP-9, there does not appear to be a definitive groundwater to soil vapor contaminant correlation. Due to the short-circuiting of soil vapor in the five above-referenced borings, it is difficult to provide a reasonable correlative assessment between the soil vapor and most recent groundwater monitoring results shown in Table 2.

Based on the investigation results, which were inconclusive for half the samples due to ineffectively sealed fittings, BTS recommends that the Army conduct further investigation of this pathway at five locations. BTS suggests that soil gas samples be collected again, utilizing a refined sample collection procedure, at VIP-1, VIP-4, VIP-5, VIP-7 and VIP-9. VIP-10 will be added to confirm the level of chloroform at that location. Helium will be used as a leak detection tracer due to the ability of the laboratory to quantify this element. Additional steps will be taken to ensure that fittings are adequately sealed.

Please contact Clair Ruenger or myself if you have any questions.

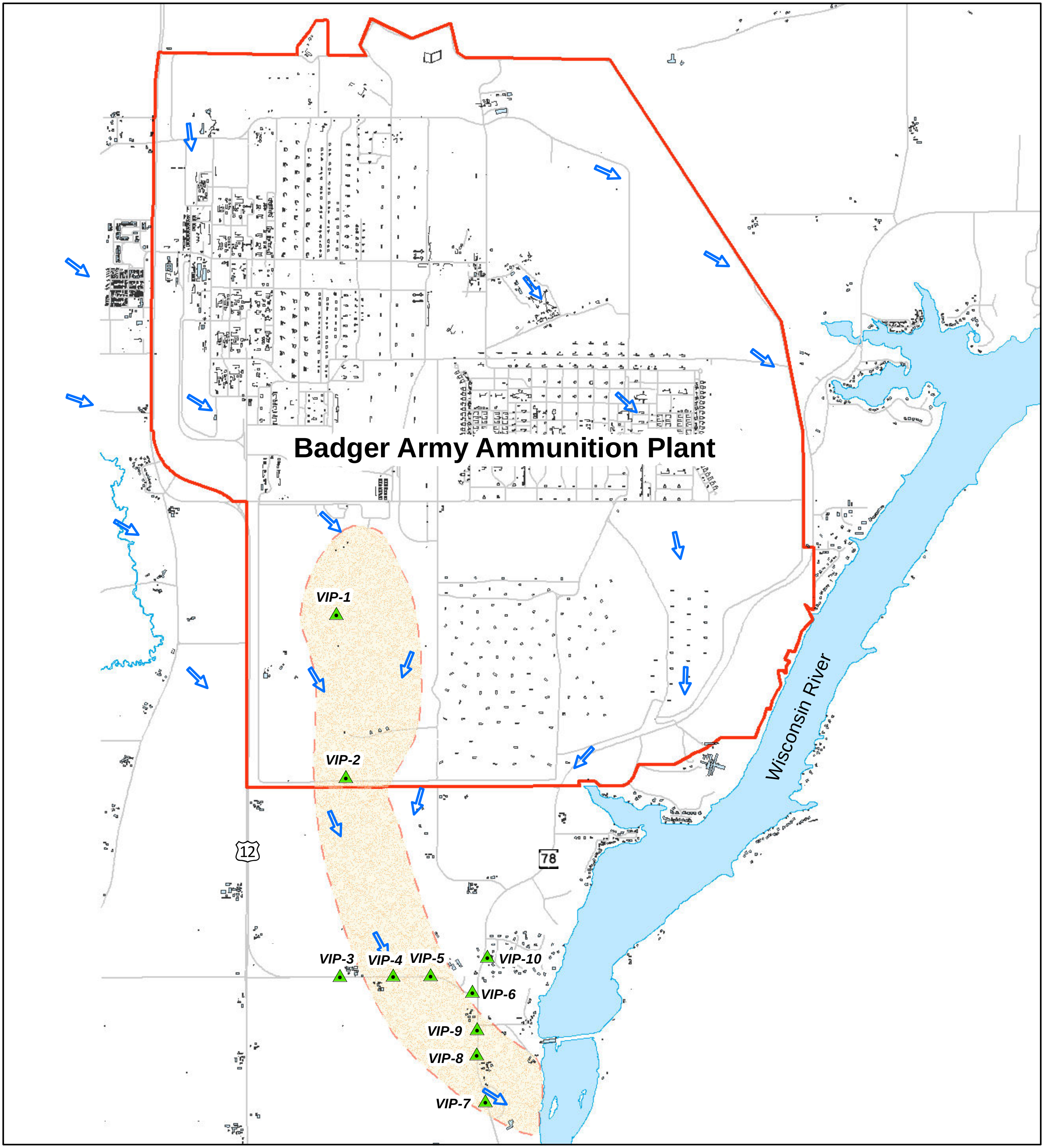
Respectfully,

F. A. Anstett
Sr. Program Manager

BHB:dkf
Att. a/s

let_sitton_041912_Vapor Intrusion Investigation Report

Figures



Legend

Badger Army Ammunition Plant Boundary

▲ Vapor Intrusion Pathway Boring

Groundwater Flow

Groundwater Plume

Paved Road

Existing Building

Former Building Footprint

Figure 1

Site Location Map
Vapor Intrusion Pathway Analysis Report
Badger Army Ammunition Plant

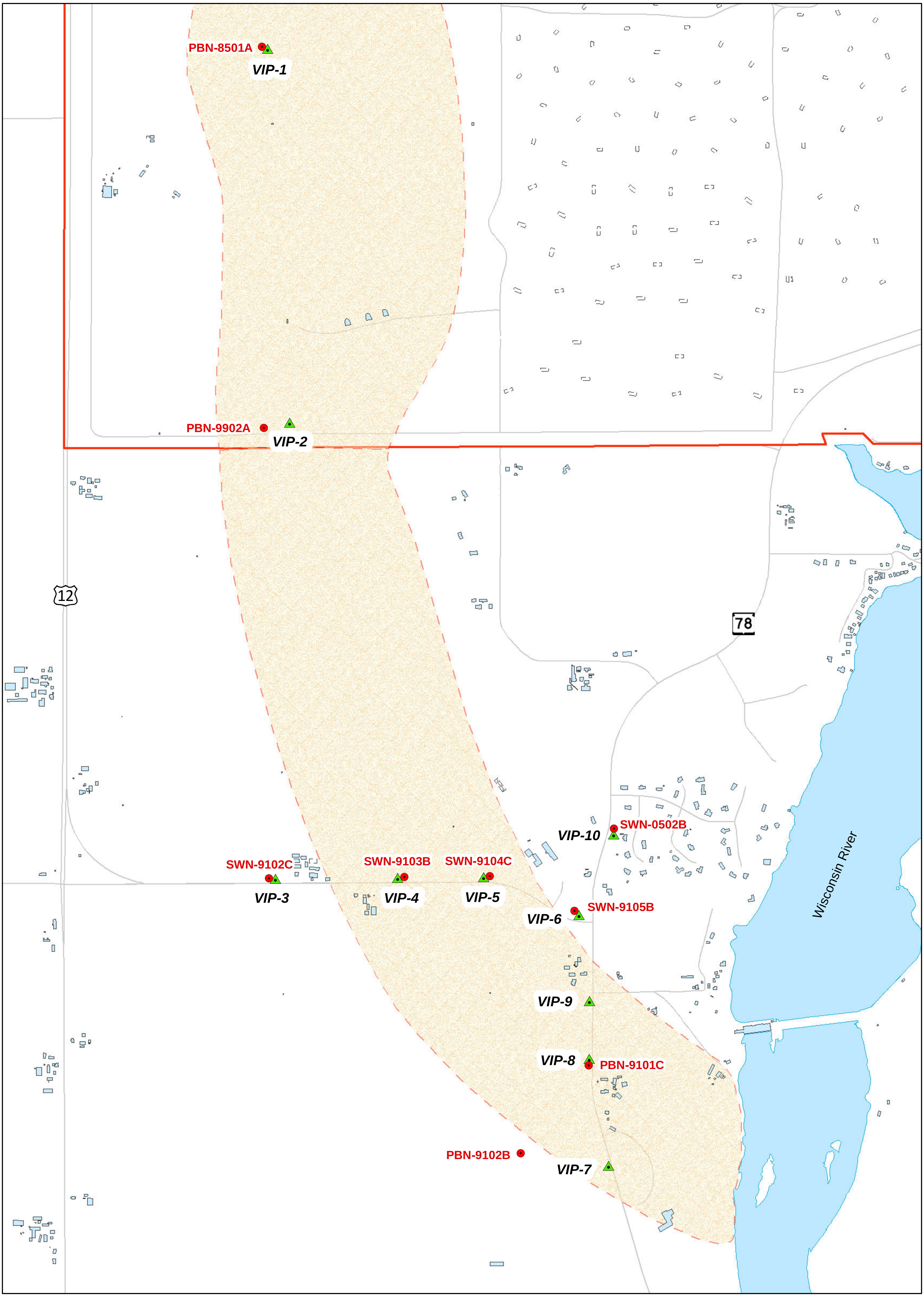
1 inch = 3,500 feet

0 5,000 10,000 Feet

BTS
BADGER TECHNICAL SERVICES

N

D:\GIS_Projects\BTS Projects\
Vapor Instrusion\MXDs\Fig_1_Site Loc



Legend

- ━ Badger Army Ammunition Plant Boundary
- ▲ Vapor Intrusion Pathway Boring
- ● Monitoring Well
- ▨ Groundwater Plume
- ━ Paved Road
- ▭ Existing Building
- ⌐ ⌐ Former Building Footprint

Figure 2

Boring Location Map
Vapor Intrusion Pathway Analysis Report
Badger Army Ammunition Plant

1 inch = 1,042 feet

0 1,400 2,800 Feet

BTS
BADGER TECHNICAL SERVICES

N

D:\GIS_Projects\BTS Projects\
Vapor Instrusion\MXDs\Fig_1_Vapor_Inv

Tables

Table 1

Soil Vapor Sample Analytical Results

Vapor Intrusion Pathway Analysis Report

Badger Army Ammunition Plant

Boring/Soil Vapor Sample ID	Location Description	Date Sampled	Sample Depth (feet bgs)	Chloroform	Carbon Tetrachloride	Trichloroethylene
VIP-1	Badger Army Ammuniton Plant	2/27/12	45.0	<0.085* (IS)	0.296* (IS)	<0.085* (IS)
VIP-2	Badger Army Ammuniton Plant	2/27/12	25.0	<0.085 (IS)	<0.085 (IS)	<0.085 (IS)
VIP-3	County Road Z Right of Way	2/27/12	45.0	<0.085 (IS)	<0.085 (IS)	<0.085 (IS)
VIP-4	County Road Z Right of Way	2/27/12	45.0	<0.085* (IS)	<0.085* (IS)	<0.085* (IS)
VIP-5	County Road Z Right of Way	2/27/12	45.0	0.441*^	<0.085*^	<0.085*^
VIP-6	State Highway 78 Right-of-Way	2/27/12	45.0	<0.085^	<0.085^	<0.085^
VIP-7	State Highway 78 Right-of-Way	2/28/12	45.0	<0.085*^	<0.085*^	<0.085*^
VIP-8	State Highway 78 Right-of-Way	2/28/12	45.0	0.159^ (J)	29.2^ (U)	0.316^
VIP-9	State Highway 78 Right-of-Way	2/28/12	45.0	<0.085*^	0.814*^	<0.085*^
VIP-10	State Highway 78 Right-of-Way	2/28/12	45.0	**22.3^ (U)**	<0.085^	<0.085^
Wisconsin Department of Natural Resources - Vapor Risk Screening Levels for Deep Soil Gas				22	64	38

Results expressed in parts per billion vapor (ppbV)

Bold text identifies a vapor risk screening level exceedance.

bgs - Below ground surface

* Due to the high amount of isopropanol in this sample (there was a leak in the probe setup), the results are questionable.

^ Because of residual isopropanol (IPA) in the instrumentation, the 4-bromofluorobenzene (BFB) tune check did not pass, so the results are approximate.

IS - The internal standard QC limit is exceeded.

J - Analytical result is between limit of detection (LOD) and limit of quantitation (LOQ).

U - Results are approximate, above upper calibration range.

Table 2

Groundwater Analytical Results

Vapor Intrusion Pathway Analysis Report

Badger Army Ammunition Plant

Boring/Soil Vapor Sample ID	Monitoring Well ID (nearest soil vapor sample)	Groundwater Depth (feet bgs)	Groundwater Monitoring Well Screen Interval (feet bgs)	Chloroform	Carbon Tetrachloride	Trichloroethylene
VIP-1	PBN-8501A	98.0	112.9-121.9	0.42 J	3.91	1.02
VIP-2	PBN-9902A	43.5	45.0-60.0	<0.10	<0.10	<0.10
VIP-3	SWN-9102C	76.7	142.5-152.5	<0.10	<0.10	<0.10
VIP-4	SWN-9103B	79.1	103.4-113.4	1.58	14	1.13
VIP-5	SWN-9104C	79.3	154.0-164.0	0.47 J	1.28	<0.10
VIP-6	SWN-9105B	80.7	102.5-112.5	0.51	<0.10	<0.10
VIP-7	PBN-9102B	76.7	105.0-115.0	0.12 J	<0.10	<0.10
VIP-8	PBN-9101C	85.0	142.5-152.5	6.32	44.6	14.5
VIP-9	PBN-9101C	85.0	142.5-152.5	6.32	44.6	14.5
VIP-10	SWN-0502B	103.5	145.8-155.8	1.11	0.15 J	<0.10

Results expressed in micrograms per liter (ug/l)

bgs - Below ground surface

J - Analytical result is between limit of detection (LOD) and limit of quantitation (LOQ).

Note - Groundwater monitoring activities were not conducted during the Vapor Intrusion Pathway Analysis project. The groundwater results presented in this table are associated with September and December 2011 quarterly groundwater monitoring at the Badger Army Ammunition Plant.

Laboratory Reports and Chain of Custody Records

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003671

BADGER TECHNICAL SERVICES
1 BADGER ROAD
BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/27/2012 09:11:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-1 @ BADGER ARMY AMMUNITION PLANT
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date 03/07/2012
Lab Comment SEE OW003671.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	*IS ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	*IS 0.296	PPB V	0.085	0.280	
TRICHLOROETHYLENE	*IS ND	PPB V	0.085	0.280	

OW003671.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003671 CONTAINS THE FOLLOWING FLAGS.

THE INTERNAL STANDARD QC LIMIT IS EXCEEDED - *IS.

DUE TO THE HIGH AMOUNT OF ISOPROPANOL IN THIS SAMPLE, THERE WAS A LEAK IN THE PROBE SETUP, THEREFORE THE RESULTS ARE QUESTIONABLE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003671

Analysis Date	Lab Comment
03/07/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003672

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/27/2012 10:25:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-2 @ BADGER ARMY AMMUNITION PLANT
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date: 03/07/2012
Lab Comment: THE INTERNAL STANDARD QC LIMIT IS EXCEEDED - *IS.

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	*IS ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	*IS ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	*IS ND	PPB V	0.085	0.280	

Analysis Date: 03/07/2012
Lab Comment:

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003672

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Organic Chemistry

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: OW003673

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/27/2012 12:02:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-3-CTY Z ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date: 03/07/2012
Lab Comment: THE INTERNAL STANDARD QC LIMIT IS EXCEEDED - *IS.

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	*IS ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	*IS ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	*IS ND	PPB V	0.085	0.280	

Analysis Date: 03/07/2012
Lab Comment:

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003673

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003674

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/27/2012 13:59:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-4-CTY Z ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date: 03/07/2012
Lab Comment: SEE OW003674.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	*IS ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	*IS ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	*IS ND	PPB V	0.085	0.280	

```
OW003674.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003674 CONTAINS THE
FOLLOWING FLAGS.

THE INTERNAL STANDARD QC LIMIT IS EXCEEDED - *IS.

DUE TO THE HIGH AMOUNT OF ISOPROPANOL IN THIS SAMPLE, THERE
WAS A LEAK IN THE PROBE SETUP, THEREFORE THE RESULTS ARE
QUESTIONABLE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.
```

Environmental Health Division — Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003674

Analysis Date	Lab Comment
03/07/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Laboratory Report

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003675

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/27/2012 15:10:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-5-CTY Z ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date: 03/14/2012
Lab Comment: SEE OW003675.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	0.441	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

OW003675.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003675 CONTAINS THE FOLLOWING FLAGS.

DUE TO THE HIGH AMOUNT OF ISOPROPANOL IN THIS SAMPLE, THERE WAS A LEAK IN THE PROBE SETUP, THEREFORE THE RESULTS ARE QUESTIONABLE.

BECAUSE OF THE IPA LEAK, THE BFB TUNE CHECK DID NOT PASS SO THE RESULTS ARE APPROXIMATE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

WSLH Sample: OW003675

Analysis Date	Lab Comment
03/14/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9500948

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003676

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/27/2012 16:25:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-6-HWY 78 ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date	Lab Comment
03/14/2012	SEE OW003676.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

OW003676.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003676 CONTAINS THE
FOLLOWING FLAGS.

BECAUSE OF THE IPA LEAK, THE BFB TUNE CHECK DID NOT PASS
SO THE RESULTS ARE APPROXIMATE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

WSLH Sample: OW003676

Analysis Date	Lab Comment
03/14/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division　　Organic Chemistry

WDNR LAB ID: 113133790　NELAP LAB ID: E37658　EPA LAB　WI00007　WI DATCP ID: 105-415

WSLH Sample: OW003677

BADGER TECHNICAL SERVICES
1 BADGER ROAD
BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/28/2012 08:20:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-7-HWY 78 ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)

Analyses and Results:

Analysis Date: 03/14/2012
Lab Comment: SEE OW003677.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

OW003677.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003677 CONTAINS THE FOLLOWING FLAGS.

DUE TO THE HIGH AMOUNT OF ISOPROPANOL IN THIS SAMPLE, THERE WAS A LEAK IN THE PROBE SETUP, THEREFORE THE RESULTS ARE QUESTIONABLE.

BECAUSE OF THE IPA LEAK, THE BFB TUNE CHECK DID NOT PASS SO THE RESULTS ARE APPROXIMATE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

WSLH

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Organic Chemistry

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: OW003677

Analysis Date	Lab Comment
03/14/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003678

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/28/2012 10:00:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-8 HWY 78 RPW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date: 03/14/2012
Lab Comment: SEE OW003678.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	0.159	PPB V	0.085	0.280	
Note: The reported value above is equal to or greater than the LOD and less than the LOQ.					
CARBON TETRACHLORIDE	*U 29.2	PPB V	0.085	0.280	
TRICHLOROETHYLENE	0.316	PPB V	0.085	0.280	

Environmental Health Division — Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003678

OW003678.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003678 CONTAINS THE FOLLOWING FLAGS.

RESULTS ARE APPROXIMATE, ABOVE UPPER CALIBRATION RANGE - *U.

BECAUSE OF THE IPA LEAK, THE BFB TUNE CHECK DID NOT PASS SO THE RESULTS ARE APPROXIMATE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

Analysis Date	Lab Comment
03/14/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003679

BADGER TECHNICAL SERVICES

1 BADGER ROAD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/28/2012 11:32:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-9-HWY 78 ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date	Lab Comment
03/14/2012	SEE OW003679.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	0.814	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003679

OW003679.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003679 CONTAINS THE FOLLOWING FLAGS.

DUE TO THE HIGH AMOUNT OF ISOPROPANOL IN THIS SAMPLE, THERE WAS A LEAK IN THE PROBE SETUP, THEREFORE THE RESULTS ARE QUESTIONABLE.

BECAUSE OF THE IPA LEAK, THE BFB TUNE CHECK DID NOT PASS SO THE RESULTS ARE APPROXIMATE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

Analysis Date	Lab Comment
03/14/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

WSLH

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003680

BADGER TECHNICAL SERVICES
1 BADGER ROAD
BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 03/02/2012 09:20:00
Date Reported: 03/20/2012
Sample Reason:

Field #:
Collection Start: 02/28/2012 13:27:00
Collection End:
Collected By: JML-BADGER TECHNICAL
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-10-HWY 78 ROW
Sample Description: 6 L CANISTER / PASSIVE CANISTER SAMPLER (CS1200E)
Analyses and Results:

Analysis Date: 03/14/2012
Lab Comment: SEE OW003680.MM1

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	*U 22.3	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

OW003680.MM1:

WISCONSIN STATE LABORATORY OF HYGIENE SAMPLE OW003680 CONTAINS THE FOLLOWING FLAGS.

RESULTS ARE APPROXIMATE, ABOVE UPPER CALIBRATION RANGE - *U.

BECAUSE OF THE IPA LEAK, THE BFB TUNE CHECK DID NOT PASS SO THE RESULTS ARE APPROXIMATE.

IF YOU HAVE ANY QUESTIONS, CONTACT STEVE GEIS AT (608) 224-6269.

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW003680

Analysis Date	Lab Comment
03/14/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR T015 - PREP	COMPLETE				1

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9500953

Page 1 of 2

State of Wisconsin
Department of Natural Resources

PO# BTS0001344

Chain of Custody Record

Form 4100-145 (R 3/09)

Sample Collector(s) Name JEFF LARKIN	**Return Report As:** (select one) ☒ Email ☐ Hard Copy	**Email or Postal Address** jeffrey.larkin@specpro-inc.com	**Phone Number (include area code)** 608-434-5571
Property Owner Department of the Army		**Property Address** Badger Army Ammunition Plant Baraboo, WI 53913-5000	**Phone Number (include area code)**

Split Samples: Offered? ☐ Yes ☐ No
Accepted? ☐ Yes ☐ No Accepted By (Signature): ____________

Field ID No.	Date	Time	No. of Containers	Station Location Sample Description	Lab ID Number	Lab Use Only: Cracked / Broken	Improperly Sealed	Good Condition	Other Comments
VIP-1	2/27/12	0911-0942	1	Badger Army Ammunition Plant For: carbon tetrachloride, chloroform + TCE Analysis TO-15					
VIP-2	2/27/12	1025-1056	1	Badger Army Ammunition Plant For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					
VIP-3	2/27/12	1202-1232	1	Cty Z ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					
VIP-4	2/27/12	1359-1429	1	Cty Z ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					
VIP-5	2/27/12	1510-1540	1	Cty Z ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					
VIP-6	2/27/12	1625-1706	1	Hwy 78 ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					

Was the sample shipping container sealed on receipt? ☐ Yes ☐ No

Method of Shipment:

- ☐ Staff
- ☐ U.S. Postal Service
- ☐ UPS
- ☒ FedEx
- ☐ Other–specify: ____________

Reason for Sample Collection:

- ☐ Anhydrous Ammonia Spill
- ☐ Animal Waste
- ☐ Open Burning
- ☐ Dairy Product Spill
- ☐ Construction/Storm Water Runoff
- ☐ Pesticide Spill * – Specify Pesticide: ____________
- ☐ Hazardous Waste Release *
- ☐ Petroleum Product Release * – Specify Product: ____________
- ☐ Industrial Spill/Runoff * – Specify Industry Type: ____________
- ☐ Other – Specify: ____________

* Contact the laboratory with product information and for consultation. Also, include sample of suspected spilled product.

I hereby certify that I received and properly handled these samples as noted below:

Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time
	~~2/29/12~~ 3/1/12 / 1125		3-1-12
Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time
Relinquished By (Signature)	Date / Time	Received for Laboratory By (Signature)	Date / Time

Disposition of Unused Portion Sample:

- ☐ Dispose
- ☐ Return
- ☐ Retain until further notice
- ☐ Other ____________

If you need additional room for notes, use the back of this form.

Page 2 of 2

State of Wisconsin
Department of Natural Resources

PO# BTS0001344

Chain of Custody Record

Form 4100-145 (R 3/09)

Sample Collector(s) Name: JEFF LARKIN

Return Report As: (select one) ☒ Email ☐ Hard Copy

Email or Postal Address: jeffrey.larkin@specpro-inc.com

Phone Number (include area code): 608-434-5571

Property Owner: Department of the Army

Property Address: Badger Army Ammunition Plant
Baraboo, WI 53913-5000

Phone Number (include area code):

Split Samples: Offered? ☐ Yes ☐ No
Accepted? ☐ Yes ☐ No Accepted By (Signature):

Field ID No.	Date	Time	No. of Containers	Station Location Sample Description	Lab ID Number	Lab Use Only Cracked / Broken	Improperly Sealed	Good Condition	Other Comments
VIP-7	2/28/12	0820-0915	1	Hwy 78 ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					
VIP-8	2/28/12	1000-1032	1	Hwy 78 ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					
VIP-9	2/28/12	1132-1206	1	Hwy 78 ROW For: carbon tetrachloride chloroform + TCE analyses (TO-15)					
VIP-10	2/28/12	1327-1359	1	Hwy 78 ROW For: carbon tetrachloride, chloroform + TCE analyses (TO-15)					

Was the sample shipping container sealed on receipt? ☐ Yes ☐ No

Method of Shipment:
- ☐ Staff
- ☐ U.S. Postal Service
- ☐ UPS
- ☒ FedEx
- ☐ Other–specify:

Reason for Sample Collection:
- ☐ Anhydrous Ammonia Spill
- ☐ Animal Waste
- ☐ Open Burning
- ☐ Dairy Product Spill
- ☐ Construction/Storm Water Runoff
- ☐ Pesticide Spill * – Specify Pesticide:
- ☐ Hazardous Waste Release *
- ☐ Petroleum Product Release * – Specify Product:
- ☐ Industrial Spill/Runoff * – Specify Industry Type:
- ☐ Other – Specify:

* Contact the laboratory with product information and for consultation. Also, include sample of suspected spilled product.

I hereby certify that I received and properly handled these samples as noted below:

Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time
3/1/12 1250	~~2/29/12~~		

Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time

Relinquished By (Signature)	Date / Time	Received for Laboratory By (Signature)	Date / Time

Disposition of Unused Portion Sample:
- ☐ Dispose
- ☐ Return
- ☐ Retain until further notice
- ☐ Other

If you need additional room for notes, use the back of this form.

BADGER TECHNICAL SERVICES

16 July 2012

Contracting Officer's Representative
Badger Army Ammunition Plant
2 Badger Road
Baraboo, WI 53913-5000

Subject: Supplemental Vapor Intrusion Pathway Analysis Report

Dear Sir:

On April 19, 2012, Badger Technical Services, LLC (BTS) submitted the *Vapor Intrusion Pathway Analysis Report* to the Department of the Army. The investigation included conducting ten Geoprobe® borings to a depth half way to the water table depth and collecting a soil gas sample at that depth. The purpose of the investigation was to determine the risk to human receptors should vapors from the Propellant Burning Ground (PBG) Plume partition from the groundwater to the soil. The PBG plume is the one of three plumes migrating from the Badger Army Ammunition Plant and is the only one plume associated with contaminants (volatile organic compounds) with the potential for vapor pathway concerns.

A complete evaluation of the vapor pathway was not possible based on the initial information because several of the soil gas samples reported elevated levels of the leak detection tracer gas. Therefore, BTS proposed the locations where the soil gas analytical data were deemed invalid be re-sampled using helium as the leak-detection tracer gas using an alternate leak detection methodology. BTS performed this work under Performance Work Statement (PWS) #0067.

The previous vapor intrusion pathway analysis resulted in five soil gas sample locations (VIP-1, VIP-4, VIP-5, VIP-7, and VIP-9) considered to have questionable analytical results due to the presence of isopropyl alcohol, the leak detection tracer gas, in the samples. In addition, vapor intrusion probe boring VIP-10 was inadvertently omitted from the leak detection methodology and the sample also reported an elevated level of chloroform. These six locations were selected to be re-sampled to either obtain reliable analytical data and/or to confirm the previous analytical result. Figure 1 shows the PBG Plume in relation to the Badger Army Ammunition Plant (BAAAP) and the locations of the initial ten probe borings with corresponding well locations.

On June 27, 2012, Probe Technologies of Palmyra, Wisconsin advanced four Geoprobe® borings to a depth of approximately 40 feet below grade (bg). These probe boring locations were VIP-4A, VIP-5A, VIP-7A, and VIP-9A. The Geoprobe® encountered refusal at approximately 15 to 20 feet bg preventing the advancement and sample collection of VIP-1A and VIP-10A. Several attempts were made in the general area to penetrate a denser layer, but were not successful. On July 3, 2012, Soil Essentials of New Glarus, Wisconsin advanced the probe borings VIP-1A and VIP-10A to 45 feet bg with a more powerful Geoprobe®.

After drilling the probe boring to the desired depth, new high-density polyethylene 3/8-inch or 1/4-inch OD tubing was placed down to the bottom of the borehole (post-run tubing vapor sampling technique) and threaded onto the tip of the hollow steel drill rods. The down-hole tubing connects to a laboratory-supplied flow controller/sampler attached to a laboratory-supplied 6-liter summa canister. To ensure sample integrity, the following quality control leak detection tracer technique was used prior to sample collection. The flow controller/sampler with vinyl tubing connected to each end was placed inside an airtight container. Helium gas was injected into the airtight container. A helium gas detector (RadioDetection MGD-2002) was inserted into the tubing connected to the flow controller/sampler and the other end of the tubing was left open to the ambient air. BTS personnel monitored the helium detector to see whether any leaking or short-circuiting of air through the fittings was occurring. None of the tracer tests indicated leaks in the fittings. The flow controller/sampler was then connected to the summa canister, and the tubing was connected to the down-hole tubing with hose clamps. The valve on the summa canister was opened and under negative pressure, the canister was allowed to draw vapor from the bottom of the borehole until filled, approximately 30 minutes. The valve was then closed on the summa canister and the flow controller removed. Soil borings were abandoned with bentonite chips following sample collection.

Soil vapor samples were submitted to the Wisconsin State Laboratory of Hygiene (certification #113133790) for chloroform, carbon tetrachloride, and trichloroethylene (TCE) Method TO-15 laboratory analysis. Carbon tetrachloride was detected within sample VIP-1A at a concentration of 68.3 parts per billion vapor (ppbV) exceeding the WDNR Vapor Risk Screening Level (RSL) for Deep Soil Gas of 64 ppbV (see *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, PUB-RR-800, December 2010). Analytical results also reported concentrations below WDNR Vapor RSLs at VIP-9A and VIP-10A. Carbon tetrachloride was reported at 0.563 ppbV at VIP-9A, and at VIP-10A, carbon tetrachloride and TCE were reported at concentrations of 25.5 ppbV and 1.08 ppbV, respectively. Chloroform was not detected at VIP-10A. It should be noted that the property closest to this data point has an in-ground swimming pool which, along with potential of private well chlorination impacts could be source(s) of the chloroform previously detected. Table 1 provides a summary of the analytical results. Laboratory reports and chain of custody records are attached.

There does not appear to be a strong correlation between groundwater concentrations and soil gas for the selected volatile organic compounds. Table 2 provides the groundwater analytical data for the three contaminants of concern and groundwater depth information for the shallow monitoring wells nearest to the probe boring locations. The well location with the highest groundwater contamination is PBN-9101C with carbon tetrachloride at 44.6 micrograms per liter (µg/l), which is in proximity to VIP-8 and VIP-9A. Carbon tetrachloride in soil gas was reported at 29.2 ppbV at VIP-8 and only 0.563 ppbV at VIP-9A. The soil gas sample with the highest reported concentration of carbon tetrachloride was VIP-1A with 68.3 ppbV; however, the carbon tetrachloride groundwater concentration at that location (PBN-8501A) is only 3.91 µg/l. VIP-10A is located outside the PBG Plume; however, carbon tetrachloride was reported at 25.5 ppbV at that location.

There seems to be more of a correlation between density of lithology and soil gas concentrations. Probe borings that encountered difficulty in penetrating at shallow depth (15 to 20 feet bg) were the locations where the soil gas concentrations were highest. As stated previously, VIP-1A and VIP-10A required a more powerful Geoprobe® to penetrate to total depth. The more dense lithologic layer could be acting as a confining layer, concentrating the low-level vapors below the dense layer and preventing the soil gas from diffusing to the surface. It should be noted, valid concentrations reported off-site are still below any WDNR Vapor RSLs.

The supplemental vapor intrusion pathway analysis filled the data gaps and provided reliable data to adequately evaluate the vapor pathway from the PBG Plume. Based on the findings of this analysis and the previous investigation, the data indicate that the PBG Plume does not present a significant risk to human health via vapor intrusion off-site. Analytical results of soil gas samples collected off-site do not exceed the WDNR Vapor RSLs for Deep Soil Gas.

Please contact Clair Ruenger or myself if you have any questions.

Respectfully,

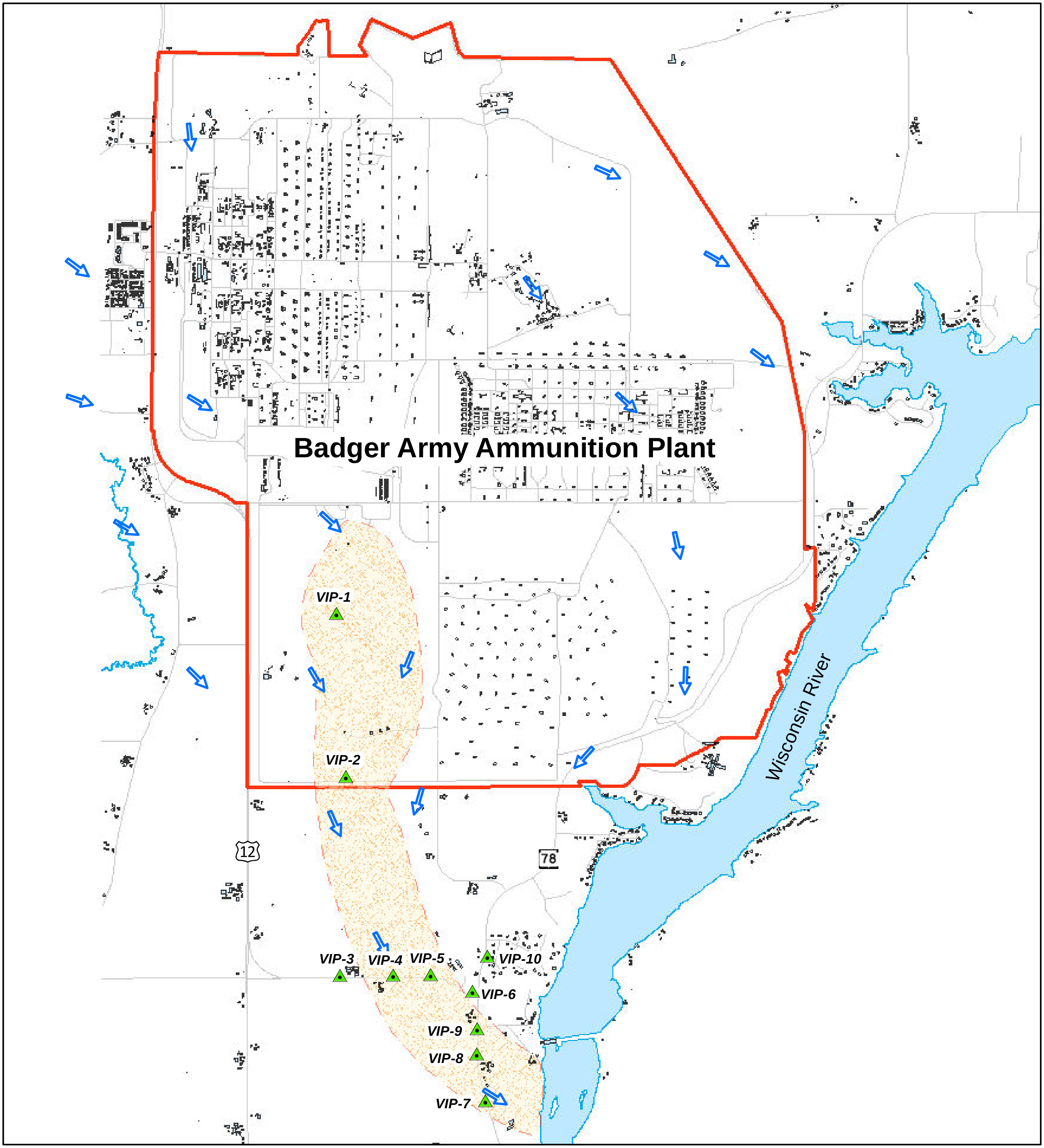
F. A. Anstett

F. A. Anstett
Sr. Program Manager

BHB:dkf
Att. a/s

let_sitton_071612_Supplemental VIPA Report.doc

Figures



Legend

- — Badger Army Ammunition Plant Boundary
- ▲ Vapor Intrusion Pathway Boring
- ↘ Groundwater Flow
- ▨ Groundwater Plume
- — Paved Road
- 🟦 Existing Building
- ⌐ Former Building Footprint

Figure 1

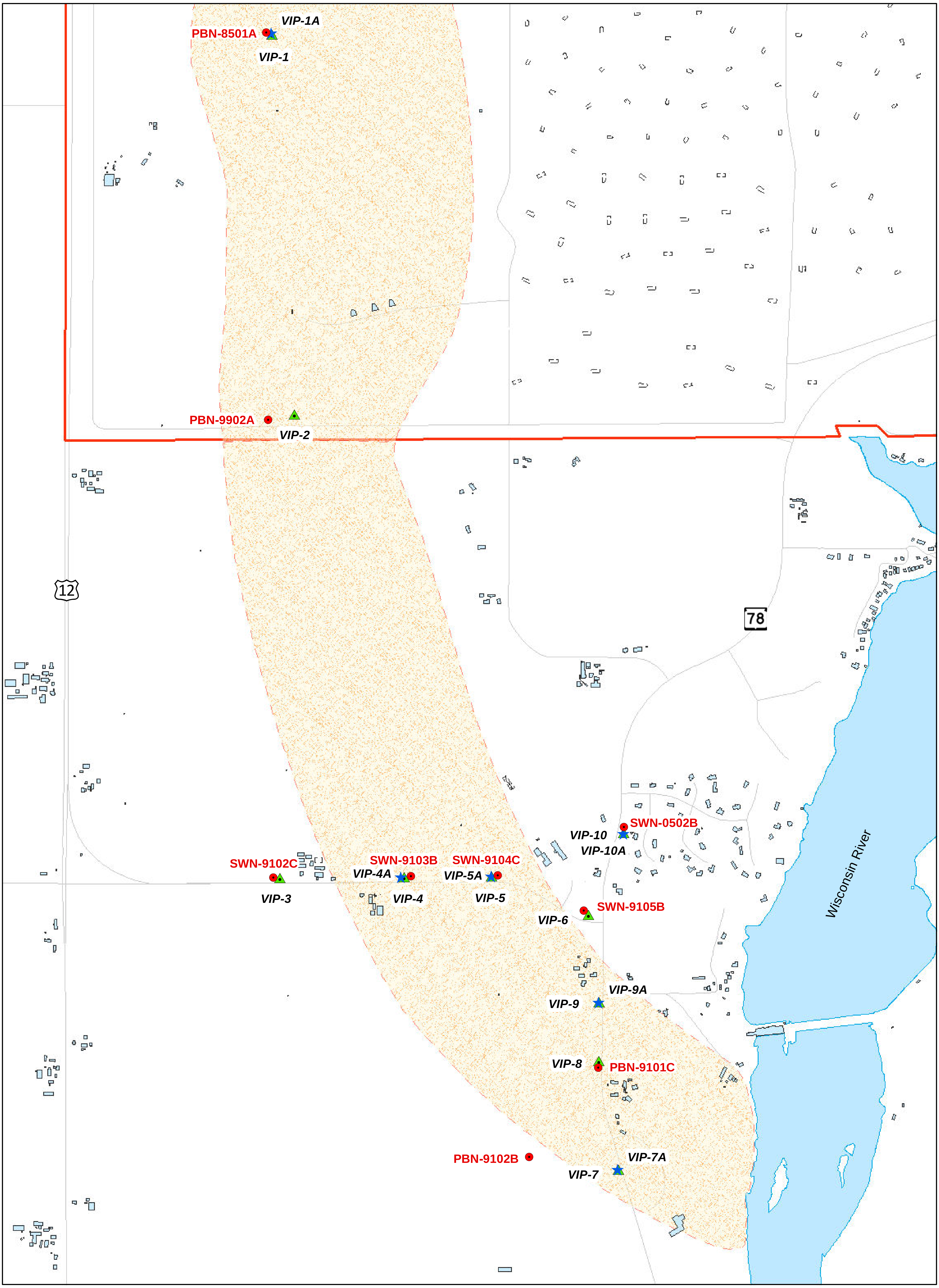
Site Location Map
Supplemental Vapor Intrusion Pathway Analysis Report
Badger Army Ammunition Plant

1 inch = 3,500 feet

0 5,000 10,000 Feet

BTS
BADGER TECHNICAL SERVICES

D:\GIS_Projects\BTS Projects\
Vapor Instrusion\Supplemental VIPA\Fig_1_Site Loc



Legend

▬	Badger Army Ammunition Plant Boundary
★	Supplemental Vapor Intrusion Probe (VIP-1A)
▲	Vapor Intrusion Probe (VIP-1)
●	Monitoring Well
▨	Groundwater Plume
▬	Paved Road
▭	Existing Building
⌐ ⌐	Former Building Footprint

Figure 2

Boring Location Map
Supplemental Vapor Intrusion Pathway Analysis Report
Badger Army Ammunition Plant

1 inch = 1,042 feet

0 1,400 2,800 Feet

D:\GIS_Projects\BTS Projects\
Vapor Instrusion\Supplemental VIPA\Fig_2_Vapor_Investigation

Tables

Table 1

Soil Vapor Sample Analytical Results

Supplemental Vapor Intrusion Pathway Analysis Report

Badger Army Ammunition Plant

Boring/Soil Vapor Sample ID	Location Description	Date Sampled	Sample Depth (feet bgs)	Chloroform	Carbon Tetrachloride	Trichloroethylene
VIP-1	_Badger Army Ammuniton Plant_	_2/27/12_	_45.0_	_<0.085* (IS)_	_0.296* (IS)_	_<0.085* (IS)_
VIP-1A	Badger Army Ammuniton Plant	7/3/12	45.0	<0.085	**68.3**	<0.694 (I)
VIP-2	_Badger Army Ammuniton Plant_	_2/27/12_	_25.0_	_<0.085 (IS)_	_<0.085 (IS)_	_<0.085 (IS)_
VIP-3	_County Road Z Right-of-Way_	_2/27/12_	_45.0_	_<0.085 (IS)_	_<0.085 (IS)_	_<0.085 (IS)_
VIP-4	_County Road Z Right-of-Way_	_2/27/12_	_45.0_	_<0.085* (IS)_	_<0.085* (IS)_	_<0.085* (IS)_
VIP-4A	County Road Z Right-of-Way	6/27/12	37.0	<0.085	<0.085	<0.085
VIP-5	_County Road Z Right-of-Way_	_2/27/12_	_45.0_	_0.441*^_	_<0.085*^_	_<0.085*^_
VIP-5A	County Road Z Right-of-Way	6/27/12	40.0	<0.085	<0.085	<0.085
VIP-6	_State Highway 78 Right-of-Way_	_2/27/12_	_45.0_	_<0.085^_	_<0.085^_	_<0.085^_
VIP-7	_State Highway 78 Right-of-Way_	_2/28/12_	_45.0_	_<0.085*^_	_<0.085*^_	_<0.085*^_
VIP-7A	State Highway 78 Right-of-Way	6/27/12	37.0	<0.085	<0.085	<0.085
VIP-8	_State Highway 78 Right-of-Way_	_2/28/12_	_45.0_	_0.159^ (J)_	_29.2^ (U)_	_0.316^_
VIP-9	_State Highway 78 Right-of-Way_	_2/28/12_	_45.0_	_<0.085*^_	_0.814*^_	_<0.085*^_
VIP-9A	State Highway 78 Right-of-Way	6/27/12	39.0	<0.085	0.563	<0.085
VIP-10	_State Highway 78 Right-of-Way_	_2/28/12_	_45.0_	**_22.3^ (U)_**	_<0.085^_	_<0.085^_
VIP-10A	State Highway 78 Right-of-Way	7/3/12	45.0	<0.085	25.5	1.08
Wisconsin Department of Natural Resources - Vapor Risk Screening Levels for Deep Soil Gas				22	64	38

Results expressed in parts per billion vapor (ppbV)

Bold text identifies a vapor risk screening level exceedance.

bgs - Below ground surface

* Due to the high amount of isopropanol in this sample (there was a leak in the probe setup), the results are questionable.

^ Because of residual isopropanol (IPA) in the instrumentation, the 4-bromofluorobenzene (BFB) tune check did not pass, so the results are approximate.

IS - The internal standard QC limit is exceeded.

J - Analytical result is between limit of detection (LOD) and limit of quantitation (LOQ).

U - Results are approximate, above upper calibration range.

Italics indicate previously reported data.

I - elevated detection limit due to matrix interference

Table 2

Groundwater Analytical Results

Supplemental Vapor Intrusion Pathway Analysis Report

Badger Army Ammunition Plant

Boring/Soil Vapor Sample ID	Monitoring Well ID (nearest soil vapor sample)	Groundwater Depth (feet bgs)	Groundwater Monitoring Well Screen Interval (feet bgs)	Chloroform	Carbon Tetrachloride	Trichloroethylene
VIP-1, VIP-1A	PBN-8501A	98.0	112.9-121.9	0.42 J	3.91	1.02
VIP-2	PBN-9902A	43.5	45.0-60.0	<0.10	<0.10	<0.10
VIP-3	SWN-9102C	76.7	142.5-152.5	<0.10	<0.10	<0.10
VIP-4, VIP-4A	SWN-9103B	79.1	103.4-113.4	1.58	14	1.13
VIP-5, VIP-5A	SWN-9104C	79.3	154.0-164.0	0.47 J	1.28	<0.10
VIP-6	SWN-9105B	80.7	102.5-112.5	0.51	<0.10	<0.10
VIP-7, VIP-7A	PBN-9102B	76.7	105.0-115.0	0.12 J	<0.10	<0.10
VIP-8	PBN-9101C	85.0	142.5-152.5	6.32	44.6	14.5
VIP-9, VIP-9A	PBN-9101C	85.0	142.5-152.5	6.32	44.6	14.5
VIP-10, VIP-10A	SWN-0502B	103.5	145.8-155.8	1.11	0.15 J	<0.10

Results expressed in micrograms per liter (ug/l)

bgs - Below ground surface

J - Analytical result is between limit of detection (LOD) and limit of quantitation (LOQ).

Note - Groundwater monitoring activities were not conducted during the Vapor Intrusion Pathway Analysis project. The groundwater results presented in this table are associated with September and December 2011 quarterly groundwater monitoring at the Badger Army Ammunition Plant.

Laboratory Reports and Chain of Custody Records

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OX000053

BADGER TECHNICAL SERVICES

1 BADGER RD.

BARABOO WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 07/05/2012
Date Reported: 07/10/2012
Sample Reason:

Field #:
Collection Start: 07/03/2012 08:26:00
Collection End: 07/03/2012 08:56:00
Collected By: BHB-BADGER TECH. SVC
County:
Sample Source: AIR
Sample Depth: 45'
Sample Information: SAMPLER 5473
Sample Location: VIP-1A BADGER ARMY AMMUNITION PLANT
Sample Description: 6L CANISTER/PASSIVE SAMPLER

Analyses and Results:

Analysis Date	Lab Comment
07/09/2012 10:48:45	INTERFERENCE INDICATED BY *I.

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	68.3	PPB V	0.085	0.280	
TRICHLOROETHYLENE	*I< 0.694	PPB V	0.085	0.280	

WSLH Sample: OX000053

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004797

BADGER TECHNICAL SERVICES

1 BADGER RD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 06/29/2012 11:12:00
Date Reported: 07/09/2012
Sample Reason:

Field #:
Collection Start: 06/27/2012 08:20:00
Collection End: 06/27/2012 08:45:00
Collected By: BHB
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-4A BADGER ARMY AMMUNITION PLANT
Sample Description: 6 L CANISTER / PASSIVE SAMPLER
Analyses and Results:

Analysis Date	Lab Comment
07/06/2012	

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004797

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004800

BADGER TECHNICAL SERVICES

1 BADGER RD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 06/29/2012 11:12:00
Date Reported: 07/09/2012
Sample Reason:

Field #:
Collection Start: 06/27/2012 09:50:00
Collection End: 06/27/2012 10:17:00
Collected By: BHB
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-5A BADGER ARMY AMMUNITION PLANT
Sample Description: 6 L CANISTER / PASSIVE SAMPLER
Analyses and Results:

Analysis Date
07/06/2012

Lab Comment

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004800

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004799

BADGER TECHNICAL SERVICES

1 BADGER RD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 06/29/2012 11:12:00
Date Reported: 07/09/2012
Sample Reason:

Field #:
Collection Start: 06/27/2012 14:40:00
Collection End: 06/27/2012 15:10:00
Collected By: BHB
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-7A BADGER ARMY AMMUNITION PLANT
Sample Description: 6 L CANISTER / PASSIVE SAMPLER

Analyses and Results:

Analysis Date 07/06/2012
Lab Comment

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	ND	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004799

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Organic Chemistry

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: OW004798

BADGER TECHNICAL SERVICES

1 BADGER RD

BARABOO, WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 06/29/2012 11:12:00
Date Reported: 07/09/2012
Sample Reason:

Field #:
Collection Start: 06/27/2012 13:30:00
Collection End: 06/27/2012 13:57:00
Collected By: BHB
County:
Sample Source: AIR
Sample Depth:
Sample Information:
Sample Location: VIP-9A BADGER ARMY AMMUNITION PLANT
Sample Description: 6 L CANISTER / PASSIVE SAMPLER
Analyses and Results:

Analysis Date: 07/06/2012
Lab Comment:

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	0.563	PPB V	0.085	0.280	
TRICHLOROETHYLENE	ND	PPB V	0.085	0.280	

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OW004798

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OX000054

BADGER TECHNICAL SERVICES

1 BADGER RD.

BARABOO WI 53913

Bill To
Billing ID: 7305879
Customer ID: 320225
TRACKING 4920
2601 AGRICULTURAL DRIVE
MADISON WI 53718

ID#:
Waterbody/Outfall ID:
Point/Well:
Account #: LH034
Project No:
Date Received: 07/05/2012
Date Reported: 07/10/2012
Sample Reason:

Field #:
Collection Start: 07/03/2012 09:58:00
Collection End: 07/03/2012 10:28:00
Collected By: BHB-BADGER TECH. SVC
County:
Sample Source: AIR
Sample Depth: 45'
Sample Information: SAMPLER 2432
Sample Location: VIP-10A BADGER ARMY AMMUNITION PLANT
Sample Description: 6L CANISTER/PASSIVE SAMPLER

Analyses and Results:

Analysis Date
07/09/2012 12:35:21

Lab Comment

Analysis Method	Result	Units	LOD	LOQ	Report Limit
CHLOROFORM	ND	PPB V	0.085	0.280	
CARBON TETRACHLORIDE	25.5	PPB V	0.085	0.280	
TRICHLOROETHYLENE	1.08	PPB V	0.085	0.280	

Environmental Health Division Organic Chemistry

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: OX000054

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Steve Geis at 608-224-6269.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

State of Wisconsin
Department of Natural Resources

PO# BTS 0001832

Chain of Custody Record

Form 4100-145 (R 3/09)

Sample Collector(s) Name: Brenda Boyce

Return Report As: (select one) ☑ Email ☐ Hard Copy

Email or Postal Address: brenda.boyce@specpro-inc.com

Phone Number (include area code): 608-434-5722

Property Owner: Department of the Army

Property Address: Badger Army Ammunition Plant

Phone Number (include area code):

Split Samples: Offered? ☐ Yes ☐ No

Accepted? ☐ Yes ☐ No Accepted By (Signature):

Field ID No.	Date	Time	No. of Containers	Station Location Sample Description		Lab Use Only			
						Cracked / Broken	Improperly Sealed	Good Condition	Other Comments
VIP-4A	6-27-12	8:20 8:45	1	Vapor sample for chloroform, TCE and carbon tetrachloride	06/29/12 11:12 OW004797				
VIP-5A	6-27-12	9:50 10:17	1	↓	OW004800				
VIP-7A	6-27-12	2:40 3:10	1	↓	OW004799				
VIP-9A	6-27-12	1:30 1:57	1	↓	OW004798				

Method of Shipment:

☐ Staff
☐ U.S. Postal Service
☐ UPS
☐ FedEx
☐ Other–specify:

Reason for Sample Collection:

☐ Anhydrous Ammonia Spill
☐ Animal Waste
☐ Open Burning
☐ Dairy Product Spill
☐ Construction/Storm Water Runoff
☐ Pesticide Spill * – Specify Pesticide:
☐ Hazardous Waste Release *
☐ Petroleum Product Release * – Specify Product:
☐ Industrial Spill/Runoff * – Specify Industry Type:
☐ Other – Specify:

*** Contact the laboratory with product information and for consultation. Also, include sample of suspected spilled product.**

Was the sample shipping container sealed on receipt? ☐ Yes ☐ No

I hereby certify that I received and properly handled these samples as noted below:

Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time
Brenda Boyce	6-28-12/1441		

Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time

Relinquished By (Signature)	Date / Time	Received for Laboratory By (Signature)	Date / Time

Disposition of Unused Portion Sample:

☐ Dispose
☐ Return
☐ Retain until further notice
☐ Other

If you need additional room for notes, use the back of this form.

State of Wisconsin
Department of Natural Resources

PO# BTS 0001832

Chain of Custody Record
Form 4100-145 (R 3/09)

Sample Collector(s) Name: Brenda Boyce

Return Report As: (select one) ☑ Email ☐ Hard Copy

Email or Postal Address: brenda.boyce@specpro-inc.com

Phone Number (include area code): 608-434-5722

Property Owner: Dept. of Army

Property Address: Badger Army Ammunition Plant

Phone Number (include area code):

Split Samples: Offered? ☐ Yes ☐ No

Accepted? ☐ Yes ☐ No Accepted By (Signature):

Field ID No.	Date	Time	No. of Containers	Station Location Sample Description	Lab ID Number	Lab Use Only			
						Cracked / Broken	Improperly Sealed	Good Condition	Other Comments
VIP-1A	7-3-12	8:26 8:56	1	Vapor sample for chloroform, TCE and carbon tetrachloride	0X000053			✓	
VIP-10A	7-3-12	9:58 10:28	1	analysis ↓	0X000054			✓	

Method of Shipment:

- ☐ Staff
- ☐ U.S. Postal Service
- ☐ UPS
- ☑ FedEx
- ☐ Other–specify:

Reason for Sample Collection:

- ☐ Anhydrous Ammonia Spill
- ☐ Animal Waste
- ☐ Open Burning
- ☐ Dairy Product Spill
- ☐ Construction/Storm Water Runoff
- ☐ Pesticide Spill * – Specify Pesticide:
- ☐ Hazardous Waste Release *
- ☐ Petroleum Product Release * – Specify Product:
- ☐ Industrial Spill/Runoff * – Specify Industry Type:
- ☐ Other – Specify:

*** Contact the laboratory with product information and for consultation. Also, include sample of suspected spilled product.**

Was the sample shipping container sealed on receipt? ☒ Yes ☐ No

I hereby certify that I received and properly handled these samples as noted below:

Relinquished By (Signature)	Date / Time	Received By (Signature)	Date / Time
Brenda Boyce	7-3-12/1345		
		Received for Laboratory By (Signature)	7/5/12 9:52

Disposition of Unused Portion Sample:

- ☐ Dispose
- ☐ Return
- ☐ Retain until further notice
- ☐ Other

If you need additional room for notes, use the back of this form.

Indoor Air Vapor Action Levels for Various VOCs
Quick Look-Up Table[1]
Based on **November 2011** Regional Screening Level Summary Table

Chemical	Non-Residential (1-in-100,000 risk for carcinogens)		Residential (1-in-100,000 risk for carcinogens)		Molecular Weight (MW)	Basis of RSL[2]
	ppbV*	μg/m³	ppbV*	μg/m³	g/mole	
Benzene	4.9	16.0	0.95	3.1	78.11	c
Carbon Tetrachloride	3.1	20	0.64	4.1	153.82	c
Chloroform	1.1	5.3	0.22	1.1	119.38	c
Chloromethane	190	390	45	94	50.49	n
Dichlorodifluoromethane	88	440	20	100	120.91	n
1,1 – Dichloroethane (1,1-DCA)	19	77	3.6	15	98.96	c
1,2-Dichloroethane (1,2-DCA)	1.1	4.7	0.23	0.94	98.96	c
1,1 -Dichloroethylene (1,1-DCE)	220	880	52	210	96.94	n
1,2-Dichloroethene (cis and mixed)	NA	NA	NA	NA	96.94	n
1,2-Dichloroethene (trans)	65	260	16	63	96.94	n
Ethylbenzene	11	49	2.2	9.7	106.17	c
Methyl-tert-Butyl Ether (MTBE)	130	470	26	94	88.15	c
Methylene Chloride	74	260	15	52	84.93	c
Naphthalene	0.68	3.6	0.14	0.72	128.18	c
Tetrachloroethylene	3.0	21	0.60	4.1	165.83	c
Toluene	5700	22,000	1400	5200	92.14	n
1,1,1 - Trichloroethane	4000	22,000	940	5200	133.41	n
Trichloroethylene	**1.6**	**8.8**	**0.38**	**2.1**	**131.39**	**n**
Trichloroflurometh ane	540	3100	130	730	137.37	n
Trimethylbenzene (1,2,4)	6.2	31	1.5	7.3	120.2	n
Trimethylbenzene (1,3,5)	NA	NA	NA	NA	120.2	n
Vinyl Chloride	11	28	0.62	1.6	62.5	c
Xylene (mix)	100	440	23	100	106.17	n
Xylene (n,m,o separately)	100	440	23	100	106.17	n

[1] Regional Screening Tables: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

[2] Basis for Regional Screening Level – n = non-carcinogen; c = carcinogen. Non-carcinogen RSL table values are based on a HI = 1; therefore, no multiple should be applied to the table values. Carcinogen RSL (cRSL) table values are listed as 1-in-1,000,000; in Wisconsin indoor air, 1-in-100,000 excess lifetime cancer risk is acceptable. This table of Vapor Action Levels was developed by multiplying the cRSL values by 10. Screening levels in this table are rounded to 2 significant digits.

* Conversions from μg/m³ to ppbV in this table based on T = 20ºC or 68 ºF; P = 1 atm or 101.325 kPA (see next page)

Update: December 6, 2011

Convert μg/m^3 to ppbV

On-line calculator: Indoor Air Unit Conversion
http://www.epa.gov/athens/learn2model/part-two/onsite/ia_unit_conversion.html
At 20ºC and 1 atm:

$$ppbV = \frac{\mu g \big/ m^3}{MW} \times 8.3144 \left[\frac{L \cdot kPa}{mol \cdot °K}\right] \times \left[T_{°C} \; + 273.15\right]°K \times \frac{1}{101.325\, kPa}$$

OR ppbV = (μg/m^3 x **24.05**)/molecular weight

Using indoor vapor action levels (VAL) to determine vapor risk screening levels (VRSL)

Vapor risk screening levels are used to estimate indoor air concentrations from sub-slab vapor, soil gas or groundwater concentrations. Standard attenuation factors are applied to each media. This table lists the attenuation factor (AF = C_{IA}/C_{source}) and the dilution factor (inverse of the AF). The VAL is divided by the AF or multiplied by the dilution factor to calculate the vapor risk screening level.

Media Screened	**Residential / Small Commercial Buildings**		**Large Commercial / Industrial Buildings**	
	Attenuation Factor	*Dilution Factor*	*Attenuation Factor*	*Dilution Factor*
Sub-slab vapor	0.1	10	0.01	100
Deep soil gas	0.01	100	0.001	1000
Groundwater	0.001	1000	0.0001	10,000

Determining the Vapor Risk Screening Level for Groundwater

(at what concentration would groundwater potentially cause an indoor air exceedance)

$$C_{gw} = \frac{C_{IA}}{\left(H \times AF_{gw} \times 1000 \, L \big/ m^3\right)}$$

Where: C_{gw} = groundwater concentration (**μg/L**)
C_{IA} = indoor air concentration (from Quick look-up table, **μg/m^3)**
H = Henry's Law constant (dimensionless) from Chemical Specific Parameter Table:
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
AF_{gw} = attenuation factor between groundwater and indoor air

Note: The default attenuation factor for groundwater to indoor air is 0.001. However, if the contaminated groundwater is located at the building foundation, the attenuation factor should be increased to 0.1 (i.e., treated as a sub-slab concentration). If contaminated groundwater is located close to the foundation (but not in contact with the foundation), the default attenuation factor of 0.001 may not be predictive of indoor air concentration. In that case, sub-slab sampling should be conducted.

Update: December 6, 2011

Appendix G

Screening Level Groundwater Risk Evaluation (Draft) - Exponent

EXTERNAL MEMORANDUM

TO: Joel Janssen, P.G., SpecPro Professional Services, LLC
FROM: Michael Kierski, Ph.D., and Michael Garry, Ph.D.
DATE: December 17, 2018
PROJECT: Badger Army Ammunition Plant, Risk Assessment Consulting Support
SUBJECT: Screening Level Groundwater Risk Evaluation (Draft)

Introduction

SpecPro Professional Services, LLC (SpecPro) requested Exponent evaluate the potential risk associated with exposure to groundwater at the Badger Army Ammunition Plant (BAAP) on behalf of the Department of the Army (Army). Risks associated with groundwater contamination can arise from domestic use of groundwater (e.g., drinking, bathing, and washing) from private residential wells. In addition, exposure to the contamination in groundwater can occur through chemical vapors emanating from groundwater due to transport of chemicals from the water table through soil resulting in release of the vapors into homes, which is referred to as vapor intrusion. We were asked to calculate potential risks associated with domestic use of groundwater from existing residential wells, offsite monitoring wells that are within areas not restricted with respect to the use of the groundwater, as well as hypothetical risks associated with onsite monitoring wells in the event that groundwater onsite is used as source of domestic water in the future.[1] The vapor intrusion exposure pathway will be separately evaluated by SpecPro.

A groundwater risk evaluation was conducted to estimate the cumulative risk associated with both current and hypothetical future exposure to groundwater by residents. Current risks were estimated by evaluating groundwater data collected from both monitoring wells and residential wells located offsite and associated with the three groundwater plumes that have migrated offsite into residential areas. The potential for future groundwater risks was evaluated using groundwater data collected from monitoring wells located onsite and associated with the four onsite groundwater plumes. Groundwater data from 2015, 2016, 2017, and 2018 were used for the initial screening level risk evaluation to best represent current and potential future groundwater quality. We used this data set because these data best represent current groundwater quality at BAAP. Source removal and groundwater remediation activities occurred

---

[1] A monitoring well is placed in an area for the specific purpose of monitoring groundwater quality as part of a site investigation, but a monitoring well is not constructed in a way that would allow it to be used to provide drinking water. A residential well, on the other hand, is constructed specifically to provide drinking water.

at BAAP until 2015, so historical groundwater data collected before these activities occurred would not accurately reflect current groundwater quality conditions.

The analyses were focused on areas influenced by the following four groundwater plumes:

- Propellant Burning Ground Plume
- Deterrent Burning Ground Plume
- Central Plume
- Nitrocellulose Production Area Plume.

The assessment used standard U.S. Environmental Protection Agency (EPA) risk assessment methods to evaluate current groundwater risks from consumption. The approach used to estimate groundwater risks for this screening level evaluation was conservative in nature (i.e., more likely to overestimate risk). Maximum concentrations of analytes in offsite or onsite wells associated with each plume were used to estimate risks. Therefore, the risks presented in this screening level groundwater risk evaluation should be viewed as upper bound estimates of the potential groundwater risks within a specific area and do not reflect the risk associated with drinking water from any specific residential or groundwater monitoring well. The remaining sections document the screening risk methods used to estimate the groundwater risks by area and the results of the screening level groundwater risk evaluation by plume.

Screening Level Groundwater Risk Assessment Methods

A screening level groundwater risk evaluation was conducted for each of the four plume areas using EPA human health risk assessment (HHRA) methods (U.S. EPA 1989, 1991). The screening risk evaluation was conducted in two steps. First, site concentrations were compared to health-based screening levels to identify chemicals of potential concern (COPCs). Second, risk estimates were calculated for COPCs that exceeded screening levels.

Methods for Screening of Chemicals of Potential Concern

For this screening evaluation, we relied on the EPA's November 2018 tapwater regional screening levels (RSLs)[2] and Wisconsin Department of Natural Resources' (WDNR's) NR140 groundwater standards (WDNR 2017) to screen the groundwater data. A summary of the groundwater screening levels from these two sources are provided in Table 1. For purposes of the groundwater screening evaluation, we compared the maximum concentration of the chemicals detected in each plume area to the lowest groundwater screening value available for

---

[2] The tapwater RSLs table used for the screening process was based on a target cancer risk of one-in-a-million (1E-06) and a noncancer target hazard quotient (THQ) of 0.1.

each chemical.[3] Chemicals with a maximum detected concentration that exceeded the lowest available groundwater screening value for the chemical are considered at the screening level stage to be COPCs.

Groundwater Risk Calculation Methods

Based on EPA risk assessment guidance, COPCs can be further evaluated in the HHRA to provide site-specific risk estimates. The site-specific HHRA is part of the remedial investigation process that serves to document potential risks associated with exposure to chemicals in environmental media at a specific site. This screening level groundwater evaluation is an initial step in the HHRA being completed by SpecPro. The groundwater risk estimates were calculated by plume area using a simple EPA scaling method described in Section 2.6.1 of the online Regional Screening Levels (RSLs) – User’s Guide (November 2018), a copy of which is provided as Appendix A of this memorandum.[4] For each COPC, the following calculations were used to estimate potential cancer and noncancer risks, as applicable.

$$\text{Cancer Risk} = (C_{gw} \times TR) / RSL_{\text{tapwater (based on cancer effect)}}$$
$$\text{Noncancer HQ} = (C_{gw} \times THQ) / RSL_{\text{tapwater (based on noncancer effect)}}$$

where:

Cancer Risk = a unitless probability of an individual developing cancer over a lifetime.
HQ = hazard quotient; a unitless ratio of exposure to chemicals in groundwater to a reference dose at which no health effects are expected to occur.
C_{gw} = Groundwater concentration in units of µg/L or mg/L.
TR = Target cancer risk that the RSL is based on (1E-06).
THQ = Target hazard quotient that the RSL is based on.
$RSL_{tapwater}$ = Tapwater RSL (U.S. EPA November 2018) in the same units as C_{gw} for the applicable effect (i.e., cancer or noncancer).

We calculated cancer risks for all COPCs considered potential carcinogens. Cancer risk is expressed as an upper bound probability that an individual will develop cancer as a result of exposure to a chemical in the groundwater over their lifetime. For example, a 1E-06 cancer risk represents a one-in-a-million upper bound risk of an individual contracting cancer during their lifetime from the specific chemical exposure. This cancer risk is in addition to the background level risk of contracting cancer of any kind during one’s lifetime unrelated to groundwater

---

[3] For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluene for each sample. The total dinitrotoluene value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because some of the dinitrotoluene isomers did not have screening values.

[4] https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide

chemical exposure, which is approximately 40.8% in males (a little less than one in two) and approximately 37.5% in females (a little more than one in three).[5]

We also calculated noncancer risks for each COPC. The chemical-specific noncancer risks are represented by hazard quotient (HQ) values derived by comparing the groundwater chemical concentrations to chemical-specific tapwater RSLs.[6] If the resultant HQ value is less than or equal to 1, then adverse health effects associated with exposure to that chemical in the groundwater are unlikely to occur even among sensitive individuals. An HQ greater than 1 does not necessarily indicate that a health effect will occur but does indicate that there is the potential for a health effect with increasing exposures and that additional analysis is necessary.

EPA's tapwater RSLs are risk-based concentrations developed using specific generic exposure assumptions that represent reasonable maximum exposure (RME) to groundwater. The tapwater RSLs were developed considering potential exposure to chemicals in groundwater associated with domestic use of the groundwater as a drinking water source, as well as other normal domestic water uses, such as bathing, doing laundry, and washing dishes. Exposure to chemicals in groundwater are incorporated into the tapwater RSL for ingestion, dermal contact with the water, and inhalation of the portion of the chemicals in groundwater that are volatilized from the water as it is used (e.g., for bathing). Tapwater RSLs based on noncancer effects are also developed separately for adults and children, and then the lower of the two RSLs is selected for evaluating risks to people. RSLs based on cancer incorporate exposure during both childhood and adulthood. For this reason, the tapwater RSLs are considered a conservative risk-based benchmark on which to calculate risk associated with groundwater chemical exposure.

The potential risk associated with groundwater in each plume area was calculated for each COPC using maximum groundwater concentrations and tapwater RSLs in the equations presented above.[7] The total groundwater risks for an area were estimated by adding the individual cancer risks or noncancer HQs for all COPCs together for a given area. The process of adding these COPC-specific risks together is described in detail in Section 5.15.2 of the online Regional Screening Levels (RSLs) – User's Guide (May 2018). The sum of all cancer risks for the COPC within an area is referred to as the cumulative cancer risk. The sum of all noncancer risks (i.e., HQs) for the COPC within an area is referred to as the hazard index (HI). The groundwater risk evaluation approach used to develop the cumulative cancer risk and

---

[5] American Cancer Society PowerPoint presentation titled "cancer-statistics-presentation-2017.pptx" located at https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2017.html.

[6] The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a THQ of 0.1. Therefore, the noncancer-based risks were estimated using a THQ of 0.1 in the equation presented herein.

[7] For total dinitrotoluene, the risk was calculated two ways (refer to Tables 2b through 8b). First, the risk was estimated using the total dinitrotoluene concentration, and then the risk was calculated by summing the risks for the individual dinitrotoluene isomer(s) that made up the total dinitrotoluene concentration. The second method was used as a check because one of the isomers is more toxic (i.e., 2,6-dinitrotoluene) than the other isomers. Therefore, if the total dinitrotoluene concentration is dominated by 2,6-dinitrotolune, the risk using the total value can slightly underestimate the risk. The maximum total dinitrotoluene risk calculated by the two methods was used as the total risk estimate for an area.

noncancer HI is conservative in nature because it assumes people would be exposed to the maximum concentrations of all COPCs, although not all maximum COPC concentrations within an area occur in the same well. For this reason, the well with the maximum COPC concentration within the area for which the risk was estimated is identified in the risk tables presented in the next section.

Interpretation of Risk Estimates

Although the determination of an acceptable site-specific target cancer risk level is ultimately a decision for risk managers, we provide perspective on the calculated values by comparing them to the range of cancer risk levels cited in EPA's National Contingency Plan (NCP) (U.S. EPA 1990), which EPA describes as the "blueprint for the Superfund law." The NCP (40 CFR 300.430 [e] [2]) states, "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} [1E-04] and 10^{-6} [1E-06] using information on the relationship between dose and response." A later EPA memo states that "where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4} [1E-04] and the non-carcinogenic hazard quotient is less than 1,[8] action generally is not warranted unless there are adverse environmental impacts." The memo further states:

> A risk manager may also decide that a baseline [cancer] risk level less than 10^{-4} is unacceptable due to site-specific reasons, and that remedial action is warranted … Other chemical-specific ARARs [Applicable or Relevant and Appropriate Requirements] may also be used to determine whether a site warrants remediation. (U.S. EPA 1991)

To provide perspective on the estimated risks associated with groundwater use, the values are compared to the risk management criteria described above (i.e., cumulative cancer risk range or an HI of 1). Based on the NCP and EPA guidance, cumulative carcinogenic risks below 1E-06 are generally considered to represent a negligible risk, cumulative risks between 1E-06 and 1E-04 are within a range considered acceptable under most conditions, and cumulative cancer risks above 1E-04 indicate unacceptable levels of risk where remedial action or further evaluation needs to be considered. In other words, cumulative cancer risks that fall within the range of 1E-06 and 1E-04 are generally considered acceptable and require no action, but exceptions to this general rule can be made on a site-specific basis as discussed above and presented below. For noncancer effects there is no similar "risk range"; rather, any HI greater than 1 indicates further evaluation is required to determine whether the exposure presents a health concern. In other words, an HI equal to or less than 1 is not considered to pose a potential health concern.

However, as described above, risk managers may elect to consider risks within the risk range of 1E-06 and 1E-04 for remedial action. The Army risk managers have decided that in offsite areas where the Army does not have control over the use of the groundwater as a drinking water

---

[8] While the NCP refers to an HQ less than 1 as the risk management criterion, in practice, the cumulative noncancer HI is used as the risk management criterion to determine whether potential noncancer health concerns require further evaluation.

source they will consider cumulative cancer risks above 1E-06 for potential action or additional evaluation. For onsite areas where the Army has control over the use of the groundwater as a drinking water source, they will use a cumulative risk management goal of less than or equal to 1E-04. Using a different remedial cumulative cancer risk goal onsite (1E-04) versus offsite (1E-06) affects the selection of contaminants of concern (COCs) in these two areas (offsite versus onsite), as discussed below.

A summary of the COPCs identified as COCs based on the results of the screening level groundwater risk assessment is presented by plume area in the next sections of this memorandum. COCs are analytes found to significantly contribute to the cumulative risk in a particular area (onsite or offsite) where risk was estimated to be above the risk management criteria selected for that area. For onsite areas, where the Army controls the use of groundwater, the risk management criteria used for defining a chemical as a COC is a cumulative cancer risk >1E-04 or an HI >1. For offsite areas, where the Army does not control the use of the groundwater, the risk management criteria used for defining a chemical as a COC is a cumulative cancer risk >1E-06 or an HI >1. As mentioned above, a cumulative cancer risk greater than 1E-04 is typically considered unacceptable, and an HI greater than 1 indicates a level of exposure that needs to be evaluated further to determine whether a health concern exists. However, in the case of the offsite areas, the Army has decided to take a much more health protective approach and use a lower cumulative cancer risk criterion of greater than 1E-06. For this reason, two different sets of risk management criteria are used in the following sections to put the cumulative risk estimates into perspective in terms of the need for potential action or additional evaluation.

Because of the different risk management criteria applied to onsite and offsite areas, risks by plume area are assessed and described separately for onsite and offsite areas in the following sections. There are currently no residential drinking water wells onsite, so only onsite monitoring well data were used to estimate risks. For offsite portions of each plume, both monitoring well and residential well data were used to estimate risks. Like the onsite area, the monitoring wells in offsite areas are not used as a drinking water source. However, the residential wells in offsite areas are used as a drinking water source. Therefore, risks calculated for a particular offsite plume area may have been based on monitoring well data or residential well data depending on the type of well in which the maximum chemical concentration was detected. For offsite portions of a plume, we specify whether the risk estimate is based on monitoring well or residential well data or a combination of both. The plume-specific risk tables specify the well where the maximum concentration of each chemical was identified.

Screening Risk Evaluation for the Propellant Burning Ground Plume

Risks associated with hypothetical future and current use of groundwater were calculated based on data collected from the Propellant Burning Ground Plume in 2015, 2016, 2017, and 2018. Onsite monitoring well data were used to estimate hypothetical future onsite risks. The Army currently prohibits the use of onsite groundwater as a drinking water source and anticipates continuing this practice in the future. Therefore, it is unlikely that onsite groundwater will be used as a drinking water source in the future. Data from both offsite monitoring wells and residential drinking water wells were used to evaluate current offsite risks.

Future Onsite Risk Evaluation

Table 2a summarizes the results of the onsite COPC screening for the Propellant Burning Ground Plume. Hypothetical future risks were calculated for the COPCs identified in the onsite monitoring well data. Cancer and noncancer risk estimates are summarized in Table 2b for individual COPCs and for cumulative risks. A COPC may be identified as a COC because of its noncancer and/or cancer risks.

For onsite areas *where groundwater use is under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-04 or an HI >1. The cumulative risk estimates are considered hypothetical in nature, as groundwater onsite would not be expected to be used in these areas in the future because of the restrictions placed on groundwater use by the Army.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a hypothetical future onsite residential scenario, along with the maximum observed concentration of each COPC identified in the onsite monitoring wells from the Propellant Burning Ground Plume area, yielded a cumulative cancer risk estimate of 6E-03, which exceeds the upper limit of EPA’s target cancer risk range. The only COC that contributed to that exceedance was dinitrotoluenes.

Noncancer Risk Summary

Based on the same hypothetical future onsite residential scenario, the noncancer HI (which is the sum of all HQs for individual COPCs) for the onsite Propellant Burning Ground Plume was 53, indicating the need for additional analysis. The COCs contributing to the HI >1 were dinitrotoluenes, ethyl ether, and trichloroethene.

Current Offsite Risk Evaluation

Table 3a summarizes the results of the offsite COPC screening for the Propellant Burning Ground Plume. Current risks were calculated for the COPCs identified in the offsite monitoring and residential well data. Cancer and noncancer risk estimates are summarized in Table 3b for individual COPCs and for cumulative risks. For offsite areas *where groundwater use is not under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-06 or an HI >1.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a current offsite residential scenario, along with the maximum observed concentration of each COPC identified in the offsite portion of the Propellant Burning Ground Plume area, yielded a cumulative cancer risk estimate of 1E-04. This is within EPA's target cancer risk range where remedial action or additional evaluation is typically considered unnecessary. However, the risk estimate exceeds the lower cumulative cancer risk goal of 1E-06 selected by the Army. All maximum concentrations of COPCs were from offsite monitoring wells, and none were from a residential well. The COCs that contributed to that exceedance were carbon tetrachloride, chloroform, dinitroluenes, and trichloroethene.

Noncancer Risk Summary

Based on the same current offsite residential scenario, the noncancer HI for the offsite portion of the Propellant Burning Ground Plume was 5, indicating the need for additional analysis. The only COC contributing to the HI >1 was trichloroethene (monitoring well).

Summary of Risks for the Propellant Burning Ground Plume

Based on the maximum risk scenario, both the onsite and offsite areas of the Propellant Burning Ground Plume represent zones where cumulative risk estimates exceed the risk management criteria selected by the Army. The cumulative cancer and noncancer risks (i.e., HI) are summarized separately in the table below. A COPC may be a COC because it exceeds the noncancer HI and/or cumulative cancer risk management criterion. As discussed previously, for offsite areas *where groundwater use is not under the control of the Army* the risk management criteria used to determine which chemicals are COCs are a cumulative cancer risk >1E-06 or an HI >1, whereas the risk management criteria for onsite areas are a cumulative cancer risk >1E-04 or an HI >1.

Summary of Risk Estimates for Propellant Burning Ground Plume

Location	Cumulative Cancer Risk	Noncancer Hazard Index	Contaminants of Concern*
Onsite (Hypothetical Future Risk)	6E-03	53	Ethyl Ether, Dinitrotoluenes, Trichloroethene
Offsite (Current Risk)	1E-04	5	Carbon Tetrachloride, Chloroform, Dinitrotoluenes, Trichloroethene

* A chemical is considered a contaminant of concern (COC) if either the cancer risk or the noncancer hazard quotient (HQ) for that chemical *exceeds* the risk management criteria.

Screening Risk Evaluation for the Deterrent Burning Ground Plume

Risks associated with hypothetical future and current use of groundwater were calculated based on data collected from the Deterrent Burning Ground Plume in 2015, 2016, 2017, and 2018. Onsite monitoring well data were used to estimate hypothetical future onsite risks. The Army currently prohibits the use of onsite groundwater as a drinking water source and anticipates continuing this practice in the future. Therefore, it is unlikely that onsite groundwater will be used as a drinking water source in the future. Data from both offsite monitoring wells and residential drinking water wells were used to evaluate current offsite risks.

Future Onsite Risk Evaluation

Table 4a summarizes the results of the onsite COPC screening for the Deterrent Burning Ground Plume. Hypothetical future risks were calculated for the COPCs identified in the onsite monitoring well data. Cancer and noncancer risk estimates are summarized in Table 4b for individual COPCs and for cumulative risks. A COPC may be identified as a COC because of its noncancer and/or cancer risks.

For onsite areas *where groundwater use is under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-04 or an HI >1. The cumulative risk estimates are considered hypothetical in nature, as groundwater onsite would not be expected to be used in these areas in the future because of the restrictions placed on groundwater use by the Army.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a hypothetical future onsite residential scenario, along with the maximum observed concentration of each COPC identified in the onsite monitoring wells from the Deterrent Burning Ground Plume area, yielded a cumulative cancer risk estimate of 9E-05, which is within EPA’s target cancer risk range of 1E-06 to 1E-04 and meets the risk management criterion for the site. Therefore, there are no COCs based on cancer risk.

Noncancer Risk Summary

Based on the same hypothetical future onsite residential scenario, the noncancer HI for the onsite Deterrent Burning Ground Plume was 3, indicating the need for additional analysis. The only COC contributing to the HI >1 was 1,1,2-trichloroethane.

Current Offsite Risk Evaluation

Table 5a summarizes the results of the offsite COPC screening for the Deterrent Burning Ground Plume. Current risks were calculated for the COPCs identified in the offsite monitoring and residential well data. Cancer and noncancer risk estimates are summarized in Table 5b for individual COPCs and for cumulative risks. For offsite areas *where groundwater use is not under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-06 or an HI >1.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a current offsite residential scenario, along with the maximum observed concentration of each COPC identified in the offsite residential or monitoring wells from the Deterrent Burning Ground Plume area, yielded a cumulative cancer risk estimate of 2E-05. This is within EPA’s target cancer risk range where remedial action or additional evaluation is typically considered unnecessary. However, the risk estimate exceeds the lower cumulative cancer risk goal of 1E-06 selected by the Army. The COCs that contributed to that exceedance were chloroform (residential well), dinitrotoluenes (monitoring well), and trichloroethene (residential well).

Noncancer Risk Summary

Based on the same current offsite residential scenario, the noncancer HI for the offsite portion of the Deterrent Burning Ground Plume was 2, indicating the need for additional analysis. The only COC contributing to the HI >1 was trichloroethene (residential well).

The HI for the offsite Deterrent Burning Ground Plume area is the result of one residential well with a maximum concentration of trichloroethene (4.7 µg/L) associated with an HQ[9] of 2; HQs for all other chemicals were less than 1. There were no other residential wells within the offsite Deterrent Burning Ground Plume area with chemical concentrations that would be associated with an HQ greater than 1. These results indicate that noncancer risks associated with use of groundwater from residential wells in this plume area would be within the risk management range except for the single residential well located in the Deterrent Burning Ground Plume area. However, this cumulative risk estimate was based on the maximum concentration of trichloroethene detected in the well. Evaluation of long-term trends of trichloroethene indicates that over the last twelve years (2007 through 2018) the concentration of trichloroethene in the Hendershot residential well ranged from a minimum value of 0.4 µg/L to a maximum value of 4.7 µg/L, with arithmetic and geometric mean concentrations of 1.2 and 0.86 µg/L, respectively (Table 5c).

---

[9] The term hazard quotient or HQ is used to represent the risk associated with a given chemical in contrast to the term hazard index or HI, which refers to the sum of the multiple chemical-specific HQs. When discussing risk of a given chemical, the term HQ is used. If a given chemical in an area has an HQ greater than 1, then by default, the HI will be greater than 1 too.

Summary of Risks for Deterrent Burning Ground Plume

Based on the maximum risk scenario, both the onsite and offsite areas of the Deterrent Burning Ground Plume represent zones where cumulative risk estimates exceed the risk management criteria selected by the Army. The cumulative cancer and noncancer risks (i.e., HI) are summarized separately in the table below. A COPC may be a COC because it exceeds the noncancer HI and/or cumulative cancer risk management criterion. As discussed previously, for offsite areas *where groundwater use is not under the control of the Army* the risk management criteria used to determine which chemicals are COCs are a cumulative cancer risk >1E-06 or an HI >1, whereas the risk management criteria for onsite areas are cumulative cancer risk >1E-04 or an HI >1.

Summary of Risk Estimates for the Deterrent Burning Ground Plume

Location	Cumulative Cancer Risk	Noncancer Hazard Index	Contaminants of Concern*
Onsite (Hypothetical Future Risk)	9E-05	3	1,1,2-Trichloroethane
Offsite (Current Risk)	2E-05	2	Chloroform, Dinitrotoluenes, Trichloroethene

* A chemical is considered a contaminant of concern (COC) if either the cancer risk or the noncancer hazard quotient (HQ) for that chemical *exceeds* the risk management criteria.

Screening Risk Evaluation for the Central Plume

Risks associated with hypothetical future and current use of groundwater were calculated based on data collected from the Central Plume in 2015, 2016, 2017, and 2018. Onsite monitoring well data were used to estimate hypothetical future onsite risks. The Army currently prohibits the use of onsite groundwater as a drinking water source and anticipates continuing this practice in the future. Therefore, it is unlikely that onsite groundwater will be used as a drinking water source in the future. Data from both offsite monitoring wells and residential drinking water wells were used to evaluate current offsite risks.

Future Onsite Risk Evaluation

Table 6a summarizes the results of the onsite COPC screening for the Central Plume. Hypothetical future risks were calculated for the COPCs identified in the onsite monitoring well data. Cancer and noncancer risk estimates are summarized in Table 6b for individual COPCs and for cumulative risks. A COPC may be identified as a COC because of its noncancer and/or cancer risks.

For onsite areas *where groundwater use is under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-04 or an HI >1. The cumulative risk estimates are considered hypothetical in nature, as groundwater onsite would not be expected to be used in these areas in the future because of the restrictions placed on groundwater use by the Army.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a hypothetical future onsite residential scenario, along with the maximum observed concentration of each COPC identified in the onsite monitoring wells from the Central Plume area, yielded a cumulative cancer risk estimate of 3E-06, which is within EPA’s target cancer risk range of 1E-06 to 1E-04 and meets the risk management criterion for the site. Therefore, there are no COCs based on cancer risk.

Noncancer Risk Summary

Based on the same hypothetical future onsite residential scenario, the noncancer HI for the onsite portion of the Central Plume was 0.02, which meets the risk management criterion (HI≤1). Therefore, there are no COCs for the onsite Central Plume area and additional analysis is unnecessary.

Current Offsite Risk Evaluation

Table 7a summarizes the results of the offsite COPC screening for the Central Plume. Current risks were calculated for the COPCs identified in the offsite monitoring and residential well data. Cancer and noncancer risk estimates are summarized in Table 7b for individual COPCs and for cumulative risks. For offsite areas *where groundwater use is not under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-06 or an HI >1.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a current offsite residential scenario, along with the maximum observed concentration of each COPC identified in the offsite portion of the Central Plume area, yielded a cumulative cancer risk estimate of 4E-05. This is within EPA’s target cancer risk range where remedial action or additional evaluation is typically considered unnecessary. However, the risk estimate exceeds the lower cumulative cancer risk criteria of 1E-06 selected by the Army. The COCs that contributed to that exceedance were 1,2-dichloroethane (monitoring well), benzene (monitoring well), chloroform (residential well), and dinitrotoluenes (monitoring well).

Noncancer Risk Summary

Based on the same current offsite residential scenario, the noncancer HI for the offsite portion of the Central Plume was 0.4, which meets the risk management criterion (HI≤1). Therefore, there are no COCs for the offsite portion of the Central Plume area and additional analysis is unnecessary.

Summary of Risks for Central Plume

Based on the maximum risk scenario, the offsite area of the Central Plume represents a zone where cumulative risk estimates exceed the risk management criteria selected by the Army. The onsite area of the Central Plume meets the risk management criteria. The cumulative cancer and noncancer risks (i.e., HI) are summarized separately in the table below. A COPC may be a COC because it exceeds the noncancer HI and/or cumulative cancer risk management criterion. As discussed previously, for offsite areas *where groundwater use is not under the control of the Army* the risk management criteria used to determine which chemicals are COCs are a cumulative cancer risk >1E-06 or an HI >1, whereas the risk management criteria for onsite areas are cumulative cancer risk >1E-04 or an HI >1.

Summary of Risk Estimates for the Central Plume

Location	Cumulative Cancer Risk	Noncancer Hazard Index	Contaminants of Concern*
Onsite (Hypothetical Future Risk)	3E-06	0.02	None
Offsite (Current Risk)	4E-05	0.4	1,2-Dichloroethane, Benzene, Chloroform, Dinitrotoluenes

* A chemical is considered a contaminant of concern (COC) if either the cancer risk or the noncancer hazard quotient (HQ) for that chemical *exceeds* the risk management criteria.

Screening Risk Evaluation for the Nitrocellulose Production Area Plume

Risks associated with hypothetical future use of groundwater were calculated based on data collected from the Nitrocellulose Production Area Plume in 2015, 2016, 2017, and 2018. Onsite monitoring well data were used to estimate hypothetical future onsite risks. The Army currently prohibits the use of onsite groundwater as a drinking water source and anticipates continuing this practice in the future. Therefore, it is unlikely that onsite groundwater will be used as a drinking water source in the future. The Nitrocellulose Production Area Plume is contained onsite, so there are no offsite exposures associated with this plume and a current offsite risk evaluation was not conducted.

Future Onsite Risk Evaluation

Table 8a summarizes the results of the onsite COPC screening for the Nitrocellulose Production Area Plume. Hypothetical future risks were calculated for the COPCs identified in the onsite monitoring well data. Cancer and noncancer risk estimates are summarized in Table 8b for individual COPCs and for cumulative risks. A COPC may be identified as a COC because of its noncancer and/or cancer risks.

For onsite areas *where groundwater use is under the control of the Army* the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-04 or an HI >1. The cumulative risk estimates are considered hypothetical in nature, as groundwater onsite would not be expected to be used in these areas in the future because of the restrictions placed on groundwater use by the Army.

Cancer Risk Summary

Cancer risks calculated using the simple scaling method for a hypothetical future onsite residential scenario, along with the maximum observed concentration of each COPC identified in the onsite monitoring wells from the Nitrocellulose Production Area Plume area, yielded a cumulative cancer risk estimate of 4E-06, which is within EPA’s target cancer risk range of 1E-06 to 1E-04 and meets the risk management criterion for the site. Therefore, there are no COCs based on cancer risk.

Noncancer Risk Summary

Based on the same hypothetical future onsite residential scenario, the noncancer HI for the onsite Nitrocellulose Production Area Plume was 0.04, which meets the risk management criterion (HI≤1). Therefore, there are no COCs for the onsite Nitrocellulose Production Area Plume and additional analysis is unnecessary.

Summary of Risks for the Nitrocellulose Production Area Plume

Based on the maximum risk scenario, the onsite area of the Nitrocellulose Production Area Plume meets the risk management criteria selected by the Army and there are no COCs. This plume is contained onsite and so there is no offsite exposure. The cumulative cancer and noncancer risks (i.e., HI) associated with hypothetical future onsite exposures are summarized separately in the table below.

Summary of Risk Estimates for Nitrocellulose Production Area Plume

Location	Cumulative Cancer Risk	Noncancer Hazard Index	Contaminants of Concern*
Onsite (Hypothetical Future Risk)	4E-06	0.04	None
Offsite (Current Risk)	NA	NA	NA

* A chemical is considered a contaminant of concern (COC) if either the cancer risk or the noncancer hazard quotient (HQ) for that chemical *exceeds* the risk management criteria.

Summary of Hypothetical Future and Current Groundwater Risks

A groundwater risk evaluation was conducted to estimate cumulative risks associated with hypothetical future residential exposure to onsite groundwater and current exposure to offsite groundwater. The hypothetical groundwater risks were evaluated using monitoring well data collected from four plume areas located onsite, where the Army maintains control over the use of the groundwater, and therefore, residential wells are not expected to be constructed in the future. Current risks were estimated by evaluating groundwater data collected for residential wells and offsite monitoring wells sampled downgradient from three plume areas that have migrated offsite. Groundwater data from 2015, 2016, 2017, and 2018 were used for the initial screening level risk evaluation to best represent current and future groundwater quality for each evaluation unless otherwise noted.

Hypothetical Future Onsite Groundwater Risk Evaluation

Based on the results of the future onsite groundwater risk evaluation of the monitoring well data in each plume area, the potential for future risks was evaluated under the hypothetical scenario that residential wells are constructed in each plume area where no residential wells currently exist. For onsite areas where groundwater use is under the control of the Army, the risk management criteria used to determine which chemicals are COCs were a cumulative cancer risk >1E-04 or an HI >1. The cumulative risk estimates are considered hypothetical in nature, as groundwater onsite would not be expected to be used in these areas in the future because of the restrictions placed on groundwater use by the Army.

Based on the maximum risk scenario for each of four onsite plume areas using the monitoring well data, the Propellant Burning Ground Plume and Deterrent Burning Ground Plume areas represent zones that would be associated with cumulative risks that exceed the risk management criteria if onsite groundwater were used as a source of residential drinking water in the future. The onsite portions of the Propellant Burning Ground Plume and Deterrent Burning Ground Plume exceed the noncancer criterion (HI>1), whereas only the Propellant Burning Ground Plume exceeds the cancer criterion (>1E-04).

The following COCs were identified in onsite areas:

- Propellant Burning Ground Plume – ethyl ether, dinitrotoluenes, and trichloroethene
- Deterrent Burning Ground Plume – 1,1,2-trichloroethane.

The cumulative risk estimates meet the risk management criteria in the onsite portions of the Central Plume and Nitrocellulose Production Area Plume, and no COCs were identified.

Current Offsite Groundwater Risk Evaluation

Based on the maximum risk scenario for the offsite portions of the Propellant Burning Ground Plume, Deterrent Burning Ground Plume, and the Central Plume using both monitoring well and private residential well data, all three plume areas are associated with cumulative risks that exceed the risk management criteria. As noted previously, the Army has elected to use a stricter cancer risk management criterion in offsite areas (>1E-06) to provide an extra level of public health protection. All three plumes exceed this lower cancer risk management criterion, whereas only the Propellant Burning Ground Plume and Deterrent Burning Ground Plume exceed the noncancer criterion (HI>1). No risk evaluation of the Nitrocellulose Production Area Plume was necessary offsite, because this plume is contained onsite and so has not affected offsite residential areas.

The following COCs were identified in offsite areas:

- Propellant Burning Ground Plume – carbon tetrachloride, chloroform, dinitrotoluenes, and trichloroethene
- Deterrent Burning Ground Plume – chloroform, dinitrotoluenes, and trichloroethene
- Central Plume – 1,2-dichloroethane, benzene, chloroform, and dinitrotoluenes.

References

U.S. EPA. 1989. Risk assessment guidance for Superfund—Volumes I and II: human health evaluation manual (Part A). Interim final. EPA/540/1-89/002. U.S. Environmental Protection Agency, Office of Solid Waste and Remedial Response, Washington, DC.

U.S. EPA. 1990. National oil and hazardous substances pollution contingency plan. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC. (40 CFR Part 300, revised March 1990.)

U.S. EPA. 1991. Internal memorandum from D.R. Clay to Directors, Waste Management Division, Regions I, IV, V, VII, VIII; Director, Emergency and Remedial Response Division, Region II; Directors, Hazardous Waste Management Division, Regions III, VI, IX; and Director, Hazardous Waste Division, Region X, regarding role of the baseline risk assessment in Superfund remedy selection decision, dated April 22, 1991. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

U.S. EPA. 2018. Regional Screening Levels (RSLs) - Generic Tables (November 2018). Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables. Updated November 2018. U.S. Environmental Protection Agency.

WDNR. 2017. Chapter NR 140. Groundwater quality. Wisconsin Administrative Code Register, No. 715. Available at: https://docs.legis.wisconsin.gov/code/admin_code/nr/100/140. Wisconsin Department of Natural Resources. February.

Tables

Table 1. Summary of Groundwater Screening Levels Used for the Screening Level Groundwater Risk Evaluation
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Minimum Value	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)[1]	NR 140 ES	NR 140 PAL	Units
71-55-6	1,1,1-Trichloroethane	40	NA	800	200	40	µg/L
79-00-5	1,1,2-Trichloroethane	0.041	0.28	0.041	5	0.5	µg/L
75-34-3	1,1-Dichloroethane	2.8	2.8	380	850	85	µg/L
75-35-4	1,1-Dichloroethene	0.7	NA	28	7	0.7	µg/L
95-63-6	1,2,4-Trimethylbenzene	5.6	NA	5.6	480	96	µg/L
95-50-1	1,2-Dichlorobenzene	30	NA	30	600	60	µg/L
107-06-2	1,2-Dichloroethane	0.17	0.17	1.3	5	0.5	µg/L
78-87-5	1,2-Dichloropropane	0.5	0.85	0.82	5	0.5	µg/L
108-67-8	1,3,5-Trimethylbenzene	6	NA	6	480	96	µg/L
602-01-7	2,3-Dinitrotoluene	NA	NA	NA	NA	NA	µg/L
121-14-2	2,4-Dinitrotoluene	0.005	0.24	3.8	0.05	0.005	µg/L
619-15-8	2,5-Dinitrotoluene	NA	NA	NA	NA	NA	µg/L
606-20-2	2,6-Dinitrotoluene	0.005	0.049	0.57	0.05	0.005	µg/L
78-93-3	2-Butanone	560	NA	560	4000	800	µg/L
610-39-9	3,4-Dinitrotoluene	NA	NA	NA	NA	NA	µg/L
618-85-9	3,5-Dinitrotoluene	NA	NA	NA	NA	NA	µg/L
67-64-1	Acetone	1400	NA	1400	9000	1800	µg/L
71-43-2	Benzene	0.46	0.46	3.3	5	0.5	µg/L
75-27-4	Bromodichloromethane	0.06	0.13	38	0.6	0.06	µg/L
75-15-0	Carbon disulfide	81	NA	81	1000	200	µg/L
56-23-5	Carbon tetrachloride	0.46	0.46	4.9	5	0.5	µg/L
75-00-3	Chloroethane	80	NA	2100	400	80	µg/L
67-66-3	Chloroform	0.22	0.22	9.7	6	0.6	µg/L
74-87-3	Chloromethane	3	NA	19	30	3	µg/L
156-59-2	cis-1,2-Dichloroethene	3.6	NA	3.6	70	7	µg/L
124-48-1	Dibromochloromethane	0.87	0.87	38	60	6	µg/L
75-71-8	Dichlorodifluoromethane	20	NA	20	1000	200	µg/L
75-43-4	Dichlorofluoromethane	NA	NA	NA	NA	NA	µg/L
60-29-7	Ethyl ether	100	NA	390	1000	100	µg/L
100-41-4	Ethylbenzene	1.5	1.5	81	700	140	µg/L
98-82-8	Isopropylbenzene	45	NA	45	NA	NA	µg/L
179601-23-1	m & p-Xylene	19	NA	19	2000	400	µg/L
91-20-3	Naphthalene	0.17	0.17	0.61	100	10	µg/L
14797-55-8	Nitrate	2	NA	3.2	10	2	mg/L
103-65-1	n-Propylbenzene	66	NA	66	NA	NA	µg/L
95-47-6	o-Xylene	19	NA	19	2000	400	µg/L
100-42-5	Styrene	10	NA	120	100	10	µg/L
14808-79-8	Sulfate	125	NA	NA	250	125	mg/L
98-06-6	tert-Butylbenzene	69	NA	69	NA	NA	µg/L
127-18-4	Tetrachloroethene	0.5	11	4.1	5	0.5	µg/L
109-99-9	Tetrahydrofuran	10	NA	340	50	10	µg/L
108-88-3	Toluene	110	NA	110	800	160	µg/L
25321-14-6	Total Dinitrotoluenes	0.005	0.1	1.1	0.05	0.005	µg/L
156-60-5	trans-1,2-Dichloroethene	20	NA	36	100	20	µg/L
79-01-6	Trichloroethene	0.28	0.49	0.28	5	0.5	µg/L
75-69-4	Trichlorofluoromethane	520	NA	520	3490	698	µg/L

Footnote 1. The U.S. Environmental Protection Agency (EPA) noncancer-based tapwater regional screening levels (RSLs) presented in this table are based on a target hazard quotient (THQ) of 0.1. A THQ of 0.1 is used at the screening step in the risk assessment as a conservative means to select chemicals of potential concern (COPCs).

Table 2a. Summary of Screening Assessment - Propellant Burning Ground Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
71-55-6	1,1,1-Trichloroethane	40	µg/L	Monitoring	674	PBN-9303C	9/24/18	1.9
75-34-3	1,1-Dichloroethane	2.8	µg/L	Monitoring	793	PBN-1404D	9/28/15	0.53
75-35-4	1,1-Dichloroethene	0.7	µg/L	Monitoring	674	PBN-9303C	9/24/18	0.37
95-63-6	1,2,4-Trimethylbenzene	5.6	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.11
107-06-2	1,2-Dichloroethane	0.17	µg/L	Monitoring	686	PBN-9304C	3/3/16	0.064
108-67-8	1,3,5-Trimethylbenzene	6	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.037
71-43-2	Benzene	0.46	µg/L	Monitoring	655	PBN-8912B	4/12/18	0.3
75-27-4	Bromodichloromethane	0.06	µg/L	Monitoring	669	PBN-9301C	4/23/18	0.16
75-15-0	Carbon disulfide	81	µg/L	Monitoring	794	PBN-1405F	9/26/16	0.39
56-23-5	Carbon tetrachloride	0.46	µg/L	Monitoring	632	PBN-8502A	4/18/18	16
75-00-3	Chloroethane	80	µg/L	Monitoring	775	PBN-1303B	9/12/17	1.4
67-66-3	Chloroform	0.22	µg/L	Monitoring	632	PBN-8502A	9/28/15	4.3
74-87-3	Chloromethane	3	µg/L	Monitoring	633	PBN-8503A	9/25/18	0.14
75-71-8	Dichlorodifluoromethane	20	µg/L	Monitoring	726	SPN-9104D	9/24/15	0.037
60-29-7	Ethyl ether	100	µg/L	Monitoring	687	PBN-9304D	4/14/15	6900
100-41-4	Ethylbenzene	1.5	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.069
179601-23-1	m & p-Xylene	19	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.17
91-20-3	Naphthalene	0.17	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.053
14797-55-8	Nitrate	2	mg/L	Monitoring	368	PBM-0002	9/20/17	4.6
95-47-6	o-Xylene	19	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.075
98-06-6	tert-Butylbenzene	69	µg/L	Monitoring	655	PBN-8912B	9/27/16	0.047
127-18-4	Tetrachloroethene	0.5	µg/L	Monitoring	655	PBN-8912B	4/12/18	0.12
108-88-3	Toluene	110	µg/L	Monitoring	655	PBN-8912B	9/27/16	3.5
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	613	PBN-8202A	5/14/18	420.294
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	78
121-14-2	2,4-Dinitrotoluene	0.005	µg/L	Monitoring	613	PBN-8202A	5/14/18	33
619-15-8	2,5-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	0.094
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	613	PBN-8202A	5/14/18	270
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	35
618-85-9	3,5-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	4.2
79-01-6	Trichloroethene	0.28	µg/L	Monitoring	686	PBN-9304C	4/5/16	7.3

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 within this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

NA - A screening value is not available for the analyte.

Table 2b. Summary of Hypothetical Future Risks - Propellant Burning Ground Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
75-27-4	Bromodichloromethane	0.06	µg/L	Monitoring	669	PBN-9301C	4/23/18	0.16	0.13	38	1E-06	0.0004
56-23-5	Carbon tetrachloride	0.46	µg/L	Monitoring	632	PBN-8502A	4/18/18	16	0.46	4.9	3E-05	0.3
67-66-3	Chloroform	0.22	µg/L	Monitoring	632	PBN-8502A	9/28/15	4.3	0.22	9.7	2E-05	0.04
60-29-7	Ethyl ether	100	µg/L	Monitoring	687	PBN-9304D	4/14/15	6900	NA	390	NA	2
14797-55-8	Nitrate	2	mg/L	Monitoring	368	PBM-0002	9/20/17	4.6	NA	3.2	NA	0.1
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	613	PBN-8202A	5/14/18	420.294	0.1	1.1	4E-03	38
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	78	NA	NA	NA	NA
121-14-2	2,4-Dinitrotoluene	0.005	µg/L	Monitoring	613	PBN-8202A	5/14/18	33	0.24	3.8	1E-04	0.9
619-15-8	2,5-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	0.094	NA	NA	NA	NA
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	613	PBN-8202A	5/14/18	270	0.049	0.57	6E-03	47
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	35	NA	NA	NA	NA
618-85-9	3,5-Dinitrotoluene	NA	µg/L	Monitoring	613	PBN-8202A	5/14/18	4.2	NA	NA	NA	NA
79-01-6	Trichloroethene	0.28	µg/L	Monitoring	686	PBN-9304C	4/5/16	7.3	0.49	0.28	1E-05	3
											6E-03	53
											Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water samples are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Table 3a. Summary of Screening Assessment - Propellant Burning Ground Plume - Offsite Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
71-55-6	1,1,1-Trichloroethane	40	µg/L	Monitoring	561	PBN-9101C	10/3/16	0.45
75-34-3	1,1-Dichloroethane	2.8	µg/L	Monitoring	695	PBN-9903D	9/26/16	0.3
75-35-4	1,1-Dichloroethene	0.7	µg/L	Monitoring	561	PBN-9101C	10/3/16	0.084
107-06-2	1,2-Dichloroethane	0.17	µg/L	Monitoring	574	SWN-9103E	10/4/16	0.032
71-43-2	Benzene	0.46	µg/L	Monitoring	574	SWN-9103E	9/14/17	0.22
75-27-4	Bromodichloromethane	0.06	µg/L	Monitoring	561	PBN-9101C	4/9/15	0.079
75-15-0	Carbon disulfide	81	µg/L	Monitoring	561	PBN-9101C	10/3/16	0.072
56-23-5	Carbon tetrachloride	0.46	µg/L	Monitoring	561	PBN-9101C	4/9/15	29
75-00-3	Chloroethane	80	µg/L	Residential	875	Krumenauer	10/2/15	0.075
67-66-3	Chloroform	0.22	µg/L	Monitoring	561	PBN-9101C	9/17/15	3
60-29-7	Ethyl ether	100	µg/L	Monitoring	695	PBN-9903D	4/14/15	3100
108-88-3	Toluene	110	µg/L	Monitoring	574	SWN-9103E	9/14/17	0.79
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	561	PBN-9101C	4/12/18	0.082
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	561	PBN-9101C	4/12/18	0.082
79-01-6	Trichloroethene	0.28	µg/L	Monitoring	561	PBN-9101C	4/9/15	9.6

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 within this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

NA - A screening value is not available for the analyte.

Table 3b. Summary of Current Risks - Propellant Burning Ground Plume - Offsite Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
75-27-4	Bromodichloromethane	0.06	µg/L	Monitoring	561	PBN-9101C	4/9/15	0.079	0.13	38	6E-07	0.0002
56-23-5	Carbon tetrachloride	0.46	µg/L	Monitoring	561	PBN-9101C	4/9/15	29	0.46	4.9	6E-05	0.6
67-66-3	Chloroform	0.22	µg/L	Monitoring	561	PBN-9101C	9/17/15	3	0.22	9.7	1E-05	0.03
60-29-7	Ethyl ether	100	µg/L	Monitoring	695	PBN-9903D	4/14/15	3100	NA	390	NA	0.8
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	561	PBN-9101C	4/12/18	0.082	0.1	1.1	8E-07	0.01
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	561	PBN-9101C	4/12/18	0.082	0.049	0.57	2E-06	0.01
79-01-6	Trichloroethene	0.28	µg/L	Monitoring	561	PBN-9101C	4/9/15	9.6	0.49	0.28	2E-05	3
											1E-04	5
											Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water samples are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Table 4a. Summary of Screening Assessment - Deterrent Burning Ground Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
71-55-6	1,1,1-Trichloroethane	40	µg/L	Monitoring	472	DBN-1001B	4/21/16	1.7
79-00-5	1,1,2-Trichloroethane	0.041	µg/L	Monitoring	211	ELN-8203B	4/26/18	0.98
75-34-3	1,1-Dichloroethane	2.8	µg/L	Monitoring	210	ELN-8203A	4/18/16	0.044
75-35-4	1,1-Dichloroethene	0.7	µg/L	Monitoring	216	ELM-8901	4/21/16	0.054
95-50-1	1,2-Dichlorobenzene	30	µg/L	Monitoring	236	S1134R	4/20/15	0.15
107-06-2	1,2-Dichloroethane	0.17	µg/L	Monitoring	234	ELM-9501	4/28/15	0.17
78-87-5	1,2-Dichloropropane	0.5	µg/L	Monitoring	211	ELN-8203B	4/24/17	0.41
67-66-3	Chloroform	0.22	µg/L	Monitoring	301	DBM-8201	4/21/16	0.075
74-87-3	Chloromethane	3	µg/L	Monitoring	220	ELM-8907	4/18/16	0.034
156-59-2	cis-1,2-Dichloroethene	3.6	µg/L	Monitoring	210	ELN-8203A	4/20/15	0.057
75-71-8	Dichlorodifluoromethane	20	µg/L	Monitoring	211	ELN-8203B	4/26/18	0.38
75-43-4	Dichlorofluoromethane	NA	µg/L	Monitoring	210	ELN-8203A	4/18/16	0.029
60-29-7	Ethyl ether	100	µg/L	Monitoring	210	ELN-8203A	4/24/17	0.77
100-42-5	Styrene	10	µg/L	Monitoring	316	DBN-9501C	4/27/15	0.03
14808-79-8	Sulfate	125	mg/L	Monitoring	210	ELN-8203A	4/26/18	1100
127-18-4	Tetrachloroethene	0.5	µg/L	Monitoring	225	ELN-8904A	4/20/15	0.12
109-99-9	Tetrahydrofuran	10	µg/L	Monitoring	211	ELN-8203B	4/18/16	20
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	302	DBM-8202	4/24/17	8.58
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	302	DBM-8202	4/24/17	5
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	302	DBM-8202	4/24/17	0.22
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	302	DBM-8202	4/24/17	0.26
618-85-9	3,5-Dinitrotoluene	NA	µg/L	Monitoring	302	DBM-8202	4/24/17	3.1
75-69-4	Trichlorofluoromethane	520	µg/L	Monitoring	302	DBM-8202	4/21/15	0.043

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 within this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

NA - A screening value is not available for the analyte.

Table 4b. Summary of Hypothetical Future Risks - Deterrent Burning Ground Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
79-00-5	1,1,2-Trichloroethane	0.041	µg/L	Monitoring	211	ELN-8203B	4/26/18	0.98	0.28	0.041	4E-06	2
107-06-2	1,2-Dichloroethane	0.17	µg/L	Monitoring	234	ELM-9501	4/28/15	0.17	0.17	1.3	1E-06	0.01
14808-79-8	Sulfate	125	mg/L	Monitoring	210	ELN-8203A	4/26/18	1100	NA	NA	NA	NA
109-99-9	Tetrahydrofuran	10	µg/L	Monitoring	211	ELN-8203B	4/18/16	20	NA	340	NA	0.01
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	302	DBM-8202	4/24/17	8.58	0.1	1.1	9E-05	0.8
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	302	DBM-8202	4/24/17	5	NA	NA	NA	NA
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	302	DBM-8202	4/24/17	0.22	0.049	0.57	4E-06	0.04
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	302	DBM-8202	4/24/17	0.26	NA	NA	NA	NA
618-85-9	3,5-Dinitrotoluene	NA	µg/L	Monitoring	302	DBM-8202	4/24/17	3.1	NA	NA	NA	NA
											9E-05	3
											Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Table 5a. Summary of Screening Assessment - Deterrent Burning Ground Plume - Offsite Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
71-55-6	1,1,1-Trichloroethane	40	µg/L	Residential	163	Purcell-D	4/23/18	0.11
79-00-5	1,1,2-Trichloroethane	0.041	µg/L	Residential	803	Spear	10/5/15	0.25
78-93-3	2-Butanone	560	µg/L	Residential	428	Schumann	10/1/15	1.7
71-43-2	Benzene	0.46	µg/L	Residential	411	Anderson-R	10/1/15	0.012
67-66-3	Chloroform	0.22	µg/L	Residential	426	Cornelius	10/1/15	0.37
74-87-3	Chloromethane	3	µg/L	Residential	426	Cornelius	8/21/18	0.11
75-71-8	Dichlorodifluoromethane	20	µg/L	Residential	412	Curto	8/21/18	0.17
91-20-3	Naphthalene	0.17	µg/L	Residential	428	Schumann	10/1/15	0.072
100-42-5	Styrene	10	µg/L	Residential	428	Schumann	10/1/15	0.054
108-88-3	Toluene	110	µg/L	Residential	428	Schumann	10/1/15	1.8
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.32
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.078
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.072
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.17
156-60-5	trans-1,2-Dichloroethene	20	µg/L	Residential	428	Schumann	10/1/15	0.37
79-01-6	Trichloroethene	0.28	µg/L	Residential	418	Hendershot	8/29/16	4.7
75-69-4	Trichlorofluoromethane	520	µg/L	Residential	803	Spear	10/5/15	0.043

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 within this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

NA - A screening value is not available for the analyte.

Table 5b. Summary of Current Risks - Deterrent Burning Ground Plume - Offsite Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
79-00-5	1,1,2-Trichloroethane	0.041	µg/L	Residential	803	Spear	10/5/15	0.25	0.28	0.041	9E-07	0.6
67-66-3	Chloroform	0.22	µg/L	Residential	426	Roll	10/1/15	0.37	0.22	9.7	2E-06	0.004
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.32	0.1	1.1	3E-06	0.03
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.078	NA	NA	NA	NA
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.072	0.049	0.57	1E-06	0.013
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	468	ELN-1003B	11/15/18	0.17	NA	NA	NA	NA
79-01-6	Trichloroethene	0.28	µg/L	Residential	418	Hendershot	8/29/16	4.7	0.49	0.28	1E-05	2
											2E-05	2
											Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Table 5c. Time Trends of Trichloroethene in Hendershot Residential Well: 2007 to 2018

Screening Level Groundwater Risk Evaluation (Draft)

Badger Army Ammunition Plant

CAS	Analyte	Well ID	Well Name	Date Sampled	Result	Units
79-01-6	Trichloroethene	418	Hendershot	8/6/07	0.40	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/24/10	0.60	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/24/11	0.49	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/22/12	0.61	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/20/13	1.28	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/5/14	0.76	µg/L
79-01-6	Trichloroethene	418	Hendershot	10/2/15	0.42	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/29/16	4.70	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/28/17	0.82	µg/L
79-01-6	Trichloroethene	418	Hendershot	8/21/18	2	µg/L
				Arithmetic Mean	1.2	µg/L
				Geometric Mean	0.86	µg/L

Table 6a. Summary of Screening Assessment - Central Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
56-23-5	Carbon tetrachloride	0.46	µg/L	Monitoring	542	RIN-1502C	12/7/15	0.028
67-66-3	Chloroform	0.22	µg/L	Monitoring	540	RIN-1501D	12/7/15	0.27
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.209
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.061
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.058
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.09

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 ithin this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

NA - A screening value is not available for the analyte.

Table 6b. Summary of Hypothetical Future Risks - Central Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
67-66-3	Chloroform	0.22	µg/L	Monitoring	540	RIN-1501D	12/7/15	0.27	0.22	9.7	1E-06	0.003
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.209	0.1	1.1	2E-06	0.02
602-01-7	2,3-Dinitrotoluene	NA	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.061	NA	NA	NA	NA
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.058	0.049	0.57	1E-06	0.01
610-39-9	3,4-Dinitrotoluene	NA	µg/L	Monitoring	331	NLN-1001A	6/26/18	0.09	NA	NA	NA	NA

3E-06	0.02
Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Table 7a.   Summary of Screening Assessment - Central Plume - Offsite Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
95-63-6	1,2,4-Trimethylbenzene	5.6	µg/L	Monitoring	586	SEN-0503B	6/12/17	0.68
107-06-2	1,2-Dichloroethane	0.17	µg/L	Monitoring	586	SEN-0503B	6/12/17	0.3
108-67-8	1,3,5-Trimethylbenzene	6	µg/L	Monitoring	586	SEN-0503B	6/12/17	0.34
71-43-2	Benzene	0.46	µg/L	Monitoring	586	SEN-0503B	6/12/17	10
75-27-4	Bromodichloromethane	0.06	µg/L	Monitoring	581	SEN-0501B	4/22/15	0.031
75-15-0	Carbon disulfide	81	µg/L	Monitoring	580	SEN-0501A	11/7/16	0.11
56-23-5	Carbon tetrachloride	0.46	µg/L	Monitoring	581	SEN-0501B	6/12/17	0.22
67-66-3	Chloroform	0.22	µg/L	Residential	164	WE-SQ017	10/5/15	2
100-41-4	Ethylbenzene	1.5	µg/L	Monitoring	586	SEN-0503B	6/12/17	1.9
98-82-8	Isopropylbenzene	45	µg/L	Monitoring	586	SEN-0503B	11/7/16	0.03
179601-23-1	m & p-Xylene	19	µg/L	Monitoring	586	SEN-0503B	6/12/17	6.7
103-65-1	n-Propylbenzene	66	µg/L	Monitoring	586	SEN-0503B	6/12/17	0.21
95-47-6	o-Xylene	19	µg/L	Monitoring	586	SEN-0503B	6/12/17	2.6
100-42-5	Styrene	10	µg/L	Monitoring	586	SEN-0503B	6/12/17	0.21
108-88-3	Toluene	110	µg/L	Monitoring	586	SEN-0503B	6/12/17	35
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	586	SEN-0503B	11/15/18	0.08
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	586	SEN-0503B	11/15/18	0.08

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 within this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

NA - A screening value is not available for the analyte.

Table 7b. Summary of Current Risks - Central Plume - Offsite Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
107-06-2	1,2-Dichloroethane	0.17	µg/L	Monitoring	586	SEN-0503B	6/12/17	0.3	0.17	1.3	2E-06	0.02
71-43-2	Benzene	0.46	µg/L	Monitoring	586	SEN-0503B	6/12/17	10	0.46	3.3	2E-05	0.3
67-66-3	Chloroform	0.22	µg/L	Residential	164	WE-SQ017	10/5/15	2	0.22	9.7	9E-06	0.02
100-41-4	Ethylbenzene	1.5	µg/L	Monitoring	586	SEN-0503B	6/12/17	1.9	1.5	81	1E-06	0.002
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	586	SEN-0503B	11/15/18	0.08	0.1	1.1	8E-07	0.007
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	586	SEN-0503B	11/15/18	0.08	0.049	0.57	2E-06	0.01
											4E-05	0.4
											Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Table 8a. Summary of Screening Assessment - Nitrocellulose Production Area Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	478	RIM-1002	9/26/18	0.22
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	478	RIM-1002	9/26/18	0.22

Notes:

1. Those analytes detected at least once in a well in 2015, 2016, 2017 or 2018 within this specific plume area are presented in this table.
2. Those analytes that have a maximum concentration greater than the screening level are highlighted in yellow and represent chemicals of potential concern (COPCs) for which further evaluation of risk will be conducted.
3. For the screening assessment, all dinitrotoluene isomers (e.g., 2,4-dinitrotoluene, 3,4-dinitrotoluene, etc.) were summed together to calculate a total dinitrotoluenes for each sample. The total dinitrotoluenes value was then compared to the lowest screening value available for the dinitrotoluene isomers. This conservative approach was used because many of the dinitrotoluene isomers did not have screening values. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting for informational purposes.

Table 8b. Summary of Hypothetical Future Risks - Nitrocellulose Production Area Plume - Onsite Monitoring Wells
Screening Level Groundwater Risk Evaluation (Draft)
Badger Army Ammunition Plant

CAS	Analyte	Screening Level	Units	Well Type	Well ID	Well Name	Date Sampled	Result (maximum)	EPA Cancer-based Tapwater RSL	EPA Noncancer-based Tapwater RSL (Based on THQ=0.1)	Cancer Risk[1]	Noncancer Hazard Quotient (HQ)[1]
25321-14-6	Total Dinitrotoluenes	0.005	µg/L	Monitoring	478	RIM-1002	9/26/2018	0.22	0.1	1.1	2E-06	0.02
606-20-2	2,6-Dinitrotoluene	0.005	µg/L	Monitoring	478	RIM-1002	9/26/2018	0.22	0.049	0.57	4E-06	0.04

4E-06	0.04
Cumulative Cancer Risk	Hazard Index (HI)

Notes:

1. For each chemical of potential concern (COPC) identified for the plume area, a cancer risk and noncancer hazard quotient (HQ) were calculated if appropriate U.S. Environmental Protection Agency (EPA) tapwater regional screening levels (RSLs) were available for an analyte.
2. The noncancer HQ for each chemical was calculated using the EPA noncancer-based tapwater RSLs based on a target hazard quotient (THQ) of 0.1.
3. The cumulative cancer risk is calculated by summing the individual cancer risks for each COPC. The total noncancer risk is calculated by summing the analyte-specific HQs to develop a hazard index (HI).
4. The total dinitrotoluenes concentration represents the sum of all isomers of dinitrotoluene detected in the water sample. The individual isomers that make up the total dinitrotoluenes concentration for the water sample are provided below the total value in gray highlighting. The risks associated with dinitrotoluene are based on the total value and the individual isomers. The highest of the two risk estimates (i.e., based on total or the sum of individual isomers) are used in calculating the total risk for the plume area.

NA - A screening value and/or tapwater RSL was not available for the analyte. Where a tapwater RSL was not available, risk was not estimated.

Footnote:

1. All risk values are rounded to one significant figure by convention. In some cases the cumulative cancer risk or hazard index may be different from the sum of the individual cancer risks or HQs as presented because they are summed from the unrounded values.

Appendix A

Regional Screening Levels (RSLs) – User's Guide (November 2018)

EPA United States Environmental Protection Agency

Regional Screening Levels (RSLs) - User's Guide

November 2018

Regional Screening Levels (RSLs)

- Home Page
- User's Guide
- What's New
- Frequent Questions
- Equations
- RSL Calculator
- Generic Tables
- Contact Us

For assistance/questions please use the Regional Screening Levels (RSLs) contact us page.

Disclaimer

This guidance sets forth a recommended, but not mandatory, approach based upon currently available information with respect to risk assessment for response actions at CERCLA sites. This document does not establish binding rules. Alternative approaches for risk assessment may be found to be more appropriate at specific sites (e.g., where site circumstances do not match the underlying assumptions, conditions and models of the guidance). The decision whether to use an alternative approach and a description of any such approach should be documented for such sites.

Accordingly, when comments are received at individual CERCLA sites questioning the use of the approaches recommended in this guidance, the comments should be considered and an explanation provided for the selected approach.

It should also be noted that the screening levels (SLs) in these tables are based upon human health risk and do not address potential ecological risk. Some sites in sensitive ecological settings may also need to be evaluated for potential ecological risk. EPA's guidance "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment" contains an eight step process for using benchmarks for ecological effects in the remedy selection process.

On this page:

1. Introduction

The purpose of this website is to provide default screening tables and a calculator to assist Remedial Project Managers (RPMs), On Scene Coordinators (OSC's), risk assessors and others involved in decision-making concerning CERCLA hazardous waste sites and to determine whether levels of contamination found at the site may warrant further investigation or site cleanup, or whether no further investigation or action may be required.

Users within and outside the CERCLA program should use the tables or calculator results at their own discretion and they should take care to understand the assumptions incorporated in these results and to apply the SLs appropriately.

The SLs presented in the Generic Tables are chemical-specific concentrations for individual contaminants in air, drinking water and soil that may warrant further investigation or site cleanup. The SLs generated from the calculator may be site-specific concentrations for individual chemicals in soil, air, water and fish. **It should be emphasized that SLs are not cleanup standards**. We also do not recommend that the RSLs be used as cleanup levels for Superfund Sites until the recommendations in EPA's Supplemental Guidance to Risk Assessment Guidance for Superfund, Volume I, Part A ("Community Involvement in Superfund Risk Assessments (PDF)" (24 pp, 156 K) have been addressed. SLs should not be used as cleanup levels for a CERCLA site until the other remedy selections identified in the relevant portions of the National Contingency Plan (NCP), 40 CFR Part 300, have been evaluated and considered. PRGs (Preliminary Remediation Goals) is a term used to describe a project team's early and evolving identification of possible remedial goals. PRGs may be initially identified early in the Remedial Investigation/ Feasibility Study (RI/FS) process (e.g., at RI scoping) to select appropriate detection limits for RI sampling. Typically, it is necessary for PRGs to be more generic early in the process and to become more refined and site-specific as data collection and assessment progress. The SLs identified on this website are likely to serve as PRGs early in the process--e.g., at RI scoping and at screening of chemicals of potential concern (COPCs) for the baseline risk assessment. However, once the baseline risk assessment has been performed, PRGs can be derived from the calculator using site-specific risks, and the SLs in the Generic Tables are less likely to apply. PRGs developed in the FS will usually be based on site-specific risks and Applicable or Relevant and Appropriate Requirements (ARARs) and not on generic SLs.

2. Understanding the Screening Tables

2.1 General Considerations

Risk-based SLs are derived from equations combining exposure assumptions with chemical-specific toxicity values.

2.2 Exposure Assumptions

Generic SLs are based on default exposure parameters and factors that represent Reasonable Maximum Exposure (RME) conditions for long-term/chronic exposures and are based on the methods outlined in EPA's Risk Assessment Guidance for Superfund, Part B Manual (1991) (PDF) (68 pp, 721 K) and Soil Screening Guidance documents (1996 (PDF) (89 pp, 863 K) and 2002 (PDF) (187 pp, 2.2MB).

Site-specific information may warrant modifying the default parameters in the equations and calculating site-specific SLs, which may differ from the values in these tables. In completing such calculations, the user should answer some fundamental questions about the site. For example, information is needed on the contaminants detected at the site, the land use, impacted media and the likely pathways for human exposure.

Whether these generic SLs or site-specific screening levels are used, it is important to clearly demonstrate the equations and exposure parameters used in deriving SLs at a site. A discussion of the assumptions used in the SL calculations should be included in the documentation for a CERCLA site.

2.3 Toxicity Values

In 2003, EPA's Superfund program revised its hierarchy of human health toxicity values, providing three tiers of toxicity values in a memo (PDF) (4 pp, 225 K). Three tier 3 sources were identified in that guidance, but it was acknowledged that additional tier 3 sources may exist. The 2003 guidance did not attempt to rank or put the identified tier 3 sources into a hierarchy of their own. However, when developing the screening tables and calculator presented on this website, EPA needed to establish a hierarchy among the tier 3 sources. The toxicity values used as “defaults” in these tables and calculator are consistent with the 2003 guidance. Chronic and subchronic toxicity values from the following sources, in the order in which they are presented below, are used as the defaults in these tables and calculator.

1. EPA's Integrated Risk Information System (IRIS).

2. The Provisional Peer Reviewed Toxicity Values (PPRTVs) derived by EPA's Superfund Health Risk Technical Support Center (STSC) for the EPA Superfund program. PPRTVs are archived (removed) when an IRIS profile is released, even if the IRIS profile indicates a toxicity value could not be derived. PPRTVs will retain subchronic values if IRIS releases a profile without subchronic values.

3. EPA's Office of Pesticide Programs (OPP) Human Health Benchmarks for Pesticides (HHBPs). IRIS has archived 51 chemical assessments for pesticides and for these pesticides has instead recommended the use of the toxicity values presented in the HHBP table. These include RfDs (also referred to as chronic PADs) and OSFs (referred to as cancer quantification values). OPP lists 363 pesticides in the HHBP table. Only the 51 archived by IRIS will be used in the RSL calculations.

4. The Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs). An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. These substance specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites.

5. The California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA) provides toxicity values for the State of California. The OEHHA Toxicity Criteria Database website should be monitored for any updates to the toxicity values.

6. In the Fall 2009, this new source of toxicity values used was added: screening toxicity values in an appendix to certain PPRTV assessments. While we have less confidence in a screening toxicity value than in a PPRTV, we put these ahead of HEAST toxicity values because these appendix screening toxicity values are more recent and use current EPA methodologies in the derivation, and because the PPRTV appendix screening toxicity values also receive external peer review. To alert users when these values are used, the key presents an "X" (for Appendix) rather than a "P" (for PPRTV). The following is taken from a PPRTV appendix and states the intended usage of appendix screening levels.

   However, information is available for this chemical, which although insufficient to support derivation of a provisional toxicity value, under current guidelines, may be of limited use to risk assessors. In such cases, the Superfund Health Risk Technical Support Center summarizes available information in an appendix and develops a "screening value." Appendices receive the same level of internal and external scientific peer review as the PPRTV documents to ensure their appropriateness within the limitations detailed in the document. Users of screening toxicity values in an appendix to a PPRTV assessment should understand that there is considerably more uncertainty associated with the derivation of an appendix screening toxicity value than for a value presented in the body of the assessment. Questions or concerns about the appropriate use of screening values should be directed to the Superfund Health Risk Technical Support Center.

7. The EPA Superfund program's Health Effects Assessment Summary Table. Values in HEAST are archived (removed) when an IRIS profile or a PPRTV paper is released, even if the PPRTV paper indicates a toxicity value could not be derived.

Users of these screening tables and calculator wishing to consider using other toxicity values, including toxicity values from additional sources, may find the discussions and seven preferences on selecting toxicity values in the attached Environmental Council of States paper useful for this purpose (ECOS website, ECOS paper(DOC)).

When using toxicity values, users are encouraged to carefully review the basis for the value and to document the basis of toxicity values used on a CERCLA site.

Please contact a Superfund risk assessor in your Region for help with chemicals that lack toxicity values in the sources outlined above.

2.3.1 Reference Doses

The current, or recently completed, EPA toxicity assessments used in these screening tables (IRIS and PPRTVs) define a reference dose, or RfD, as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, or using categorical regression, with uncertainty factors generally applied to reflect limitations of the data used. RfDs are generally the toxicity value used most often in evaluating noncancer health effects at Superfund sites. Various types of RfDs are available depending on the critical effect (developmental or other) and the length of exposure being evaluated (chronic or subchronic). Some of the SLs in these tables also use Agency for Toxic Substances and Disease Registry (ATSDR) chronic oral minimal risk levels (MRLs) as an oral chronic RfD. Screening toxicity values in an appendix to certain

PPRTV assessments were added to the hierarchy in the fall of 2009. The HEAST RfDs used in these SLs were based upon then current EPA toxicity methodologies, but did not use the more recent benchmark dose or categorical regression methodologies. Chronic oral reference doses and ATSDR chronic oral MRLs are expressed in units of (mg/kg-day).

2.3.1.1 Chronic Reference Doses

Chronic oral RfDs are specifically developed to be protective for long-term exposure to a compound. As a guideline for Superfund program risk assessments, chronic oral RfDs generally should be used to evaluate the potential noncarcinogenic effects associated with exposure periods greater than 7 years (approximately 10 percent of a human lifetime). However, this is not a bright line. Note, that ATSDR defines chronic exposure as greater than 1 year for use of their values. The calculator requires the user to select between chronic and subchronic toxicity values.

2.3.1.2 Subchronic Reference Doses

Subchronic oral RfDs are specifically developed to be protective for short-term exposure to a compound. As a guideline for Superfund program risk assessments, subchronic oral RfDs should generally be used to evaluate the potential noncarcinogenic effects of exposure periods between two weeks and seven years. However, this is not a bright line. Note, that ATSDR defines subchronic exposure as less than 1 year for use of their values. The calculator requires the user to select between chronic and subchronic toxicity values.

2.3.2 Reference Concentrations

The current, or recently completed, EPA toxicity assessments used in these screening tables (IRIS and PPRTV assessments) define a reference concentration (RfC) as an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, or using categorical regression with uncertainty factors generally applied to reflect limitations of the data used. Various types of RfCs are available depending on the critical effect (developmental or other) and the length of exposure being evaluated (chronic or subchronic). These screening tables also use ATSDR chronic inhalation MRLs as a chronic RfC, intermediate inhalation MRLs as a subchronic RfC and California Environmental Protection Agency (chronic) Reference Exposure Levels (RELs) as chronic RfCs. Screening toxicity values in an appendix to certain PPRTV assessments were added to the hierarchy in the fall of 2009. These screening tables may also use some RfCs from EPA's HEAST tables.

2.3.2.1 Chronic Reference Concentrations

The chronic inhalation reference concentration is generally used for continuous or near continuous inhalation exposures that occur for 7 years or more. However, this is not a bright line, and ATSDR chronic MRLs are based on exposures longer than 1 year. EPA chronic inhalation reference concentrations are expressed in units of (mg/m^3). Cal EPA RELs are presented in $\mu g/m^3$ and have been converted to mg/m^3 for use in these screening tables. Some ATSDR inhalation MRLs are derived in parts per million (ppm) and some in mg/m^3. For use in this table all were converted into mg/m^3. The calculator requires the user to select between chronic and subchronic toxicity values.

2.3.2.2 Subchronic reference Concentrations

The subchronic inhalation reference concentration is generally used for exposures that are between 2 weeks and 7 years. However, this is not a bright line, and ATSDR subchronic MRLs are based on exposures less than 1 year. EPA subchronic inhalation reference concentrations are expressed in units of (mg/m^3). Cal EPA RELs are presented in µg/m^3 and have been converted to mg/m^3 for use in these screening tables. Some ATSDR intermediate inhalation MRLs are derived in parts per million (ppm) and some in mg/m^3. For use in this table all were converted into mg/m^3. The calculator requires the user to select between chronic and subchronic toxicity values.

2.3.3 Slope Factors

A slope factor and the accompanying weight-of-evidence determination are the toxicity data most commonly used to evaluate potential human carcinogenic risks. Generally, the slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used in risk assessments to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. Slope factors should always be accompanied by the weight-of-evidence classification to indicate the strength of the evidence that the agent is a human carcinogen.

Oral slope factors are toxicity values for evaluating the probability of an individual developing cancer from oral exposure to contaminant levels over a lifetime. Oral slope factors are expressed in units of (mg/kg-day)$^{-1}$. When available, oral slope factors from EPA's IRIS or PPRTV assessments are used. The ATSDR does not derive cancer toxicity values (e.g. slope factors or inhalation unit risks). Some oral slope factors used in these screening tables were derived by the California Environmental Protection Agency, whose methodologies are quite similar to those used by EPA's IRIS and PPRTV assessments. Screening toxicity values in an appendix to certain PPRTV assessments were added to the hierarchy in the fall of 2009. When oral slope factors are not available in IRIS then PPRTVs, Cal EPA assessments, PPRTV appendices or values from HEAST are used.

2.3.4 Inhalation Unit Risk

The IUR is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/m^3 in air. Inhalation unit risk toxicity values are expressed in units of (µg/m^3)$^{-1}$.

When available, inhalation unit risk values from EPA's IRIS or PPRTV assessments are used. The ATSDR does not derive cancer toxicity values (e.g. slope factors or inhalation unit risks). Some inhalation unit risk values used in these screening tables were derived by the California Environmental Protection Agency, whose methodologies are quite similar to those used by EPA's IRIS and PPRTV assessments. Screening toxicity values in an appendix to certain PPRTV assessments were added to the hierarchy in the fall of 2009. When inhalation unit risk values are not available in IRIS then PPRTVs, Cal EPA assessments, PPRTV appendices or values from HEAST are used.

2.3.5 Toxicity Equivalence Factors

Some chemicals are members of the same family and exhibit similar toxicological properties; however, they differ in the degree of toxicity. Therefore, a toxicity equivalence factor (TEF) must first be applied to adjust the measured concentrations to a toxicity equivalent concentration.

The following table contains the various dioxin-like toxicity equivalency factors for Dioxins, Furans and dioxin-like PCBs (Van den Berg et al. 2006 (PDF) (19 pp, 290 K)), which are the World Health Organization 2005 values. These TEFs are also presented in the May 2013 fact sheet, " Use of Dioxin TEFs in Calculating Dioxin TEQs at CERCLA and RCRA Sites (PDF)" (8 pp, 105 K) which references the 2010 EPA report, "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds (PDF)" (38 pp, 532 K).

Dioxin Toxicity Equivalence Factors

CASRN	Dioxins and Furans	TEF
Chlorinated dibenzo-p-dioxins		
1746-01-6	2,3,7,8-TCDD	1
40321-76-4	1,2,3,7,8-PeCDD	1
39227-28-6	1,2,3,4,7,8-HxCDD	0.1
57653-85-7	1,2,3,6,7,8-HxCDD	0.1
57653-85-7	1,2,3,7,8,9-HxCDD	0.1
35822-46-9	1,2,3,4,6,7,8-HpCDD	0.01
3268-87-9	OCDD	0.0003
Chlorinated dibenzofurans		
51207-31-9	2,3,7,8-TCDF	0.1
57117-41-6	1,2,3,7,8-PeCDF	0.03
57117-31-4	2,3,4,7,8-PeCDF	0.3
70648-26-9	1,2,3,4,7,8-HxCDF	0.1
57117-44-9	1,2,3,6,7,8-HxCDF	0.1

CASRN	**Dioxins and Furans**		**TEF**
72918-21-9	1,2,3,7,8,9-HxCDF		0.1
60851-34-5	2,3,4,6,7,8-HxCDF		0.1
35822-46-9	1,2,3,4,6,7,8-HpCDF		0.01
55673-89-7	1,2,3,4,7,8,9-HpCDF		0.01
39001-02-0	OCDF		0.0003
PCBs			
	IUPAC No.	**Structure**	
Non-*ortho*			
32598-13-3	77	3,3',4,4'-TetraCB	0.0001
70362-50-4	81	3,4,4',5-TetraCB	0.0003
57465-28-8	126	3,3',4,4',5-PeCB	0.1
32774-16-6	169	3,3',4,4',5,5'-HxCB	0.03
Mono-*ortho*			
32598-14-4	105	2,3,3',4,4'-PeCB	0.00003
74472-37-0	114	2,3,4,4',5-PeCB	0.00003
31508-00-6	118	2,3',4,4',5-PeCB	0.00003
65510-44-3	123	2',3,4,4',5-PeCB	0.00003
38380-08-4	156	2,3,3',4,4',5-HxCB	0.00003

CASRN	Dioxins and Furans		TEF
69782-90-7	157	2,3,3',4,4',5'-HxCB	0.00003
52663-72-6	167	2,3',4,4',5,5'-HxCB	0.00003
39635-31-9	189	2,3,3',4,4',5,5'-HpCB	0.00003
Di-*ortho**			
35065-30-6	170	2,2',3,3',4,4',5-HpCB	0.0001
35065-29-3	180	2,2',3,4,4',5,5'-HpCB	0.00001

* Di-ortho values come from Ahlborg, U.G., et al. (1994), which are the WHO 1994 values from Toxic equivalency factors for dioxin-like PCBs: Report on WHO-ECEH and IPCS consultation, December 1993 Chemosphere, Volume 28, Issue 6, March 1994, Pages 1049-1067 (PDF) (19 pp, 880 K).

2.3.6 Relative Potency Factors (RPFs)

Some chemicals are members of the same family and exhibit similar toxicological properties; however, they differ in the degree of toxicity. Therefore, a relative potency factor (RPF) must first be applied to adjust the oral slope factor or inhalation unit risk based on the realtive potency to the primary compound.

Carcinogenic polycyclic aromatic hydrocarbons

Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons (EPA/600/R-93/089, July 1993), recommends that a RPF be used to convert concentrations of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) to an equivalent concentration of benzo(a)pyrene when assessing the cancer risks posed by these substances from oral exposures. These RPFs are based on the potency of each compound relative to that of benzo(a)pyrene. For the toxicity value database, these RPFs have been applied to the toxicity values. Although this is not in complete agreement with the direction in the aforementioned documents, this approach was used so that toxicity values could be generated for each cPAH. Additionally, it should be noted that computationally it makes little difference whether the RPFs are applied to the concentrations of cPAHs found in environmental samples or to the toxicity values as long as the RPFs are not applied to both. However, if the adjusted toxicity values are used, the user will need to sum the risks from all cPAHs as part of the risk assessment to derive a total risk from all cPAHs. A total risk from all cPAHs is what is derived when the RPFs are applied to the environmental concentrations of cPAHs and not to the toxicity values. These RPFs are not needed, and should not be used, with the Cal EPA toxicity values, **nor should they be used when calculating non-cancer risk**.

The IRIS Profile gives the following instructions for RPF application:

"It (BaP) also serves as an index chemical for deriving relative potency factors to estimate the carcinogenicity of other PAH congeners, such as in EPA's Relative Potency Factor approach for the assessment of the carcinogenicity of PAHs (U.S. EPA, 1993) (PDF) (28 pp, 1.4 MB)."

and

"The inhalation unit risk for benzo[a]pyrene is derived with the intention that it will be paired with EPA's relative potency factors for the assessment of the carcinogenicity of PAH mixtures. In addition, regarding the assessment of early life exposures, because cancer risk values calculated for benzo[a]pyrene were derived from adult animal exposures, and because benzo[a]pyrene carcinogenicity occurs via a mutagenic mode of action, exposures that occur during development should include the application of ADAFs (see Section 2.5)."

The following table presents the RPFs for cPAHs recommended in Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons (PDF) (28 pp, 1.4 MB).

Relative Potency Factors for Carcinogenic Polycyclic Aromatic Hydrocarbons

CASRN	Compound	RPF
50-32-8	Benzo(a)pyrene	1.0
56-55-3	Benz(a)anthracene	0.1
205-99-2	Benzo(b)fluoranthene	0.1
207-08-9	Benzo(k)fluoranthene	0.01
218-01-9	Chrysene	0.001
53-70-3	Dibenz(a,h)anthracene	1.0
193-39-5	Indeno(1,2,3-c,d)pyrene	0.1

2.4 Chemical-specific Parameters

Several chemical specific parameters are needed for development of the SLs.

2.4.1 Sources

Many sources are used to populate the database of chemical-specific parameters. They are briefly described below.

1. The Physical Properties Database (PhysProp EXIT) was developed by Syracuse Research Corporation (SRC). The PhysProp database contains chemical structures, names and physical properties for over 41,000 chemicals. Physical properties collected from a wide variety of sources include experimental, extrapolated and estimated values.

2. The Estimation Programs Interface (EPI Suite^{TM}) was developed by the US Environmental Protection Agency's Office of Pollution Prevention and Toxics and SRC. These programs estimate various chemical-specific properties. The calculations for these SL tables use the experimental values for a property over the estimated values.

3. EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (SSL) and Appendix A-C (39 pp, 681 K), "Chemical Properties and Regulatory/Human Health Benchmarks for SSL Calculations". Table C-1: Chemical-Specific Properties used in SSL Calculations and Table C-4: Metal Kd Values (L/kg) as a Function of pH.

4. WATER9 Version 2.0 is the Windows-based wastewater treatment model containing a database listing many organic compounds and procedures for obtaining reports of constituent fates, including air emissions and treatment effectiveness. This program supersedes WATER8, Chem9, and Chemdat8 WATER9.

5. CHEMFATE Database. CHEMFATE is part of the Environmental Fate Data Bases (EFDB) software developed by SRC under sponsorship of the U.S. Environmental Protection Agency. CHEMFATE contains physical property values, rate constants, and monitoring data for approximately 1700 chemicals.

6. Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds. Knovel, 2003.

7. Baes, C.F. 1984. Oak Ridge National Laboratory. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Values are also found in Superfund Chemical Data Matrix (SCDM).

8. NIOSH Pocket Guide to Chemical Hazards (NPG), NIOSH Publication No. 97-140, February 2004.

9. CRC Handbook of Chemistry and Physics EXIT . (Various Editions)

10. Perry's Chemical Engineers' Handbook (Various Editions).McGraw-Hill. Online version available here EXIT . Green, Don W.; Perry, Robert H. (2008).

11. Lange's Handbook of Chemistry (Various Editions). Online version available here EXIT . Speight, James G. (2005). McGraw-Hill.

12. U.S. EPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP. July 2004. Document (PDF) (186 pp, 4.2 MB) and website.

13. The ARS Pesticide Properties Database: U.S. Department of Agriculture, Agricultural Research Service. 2009. Document (PDF) (393 pp, 775 K) and website.

14. The PubChem website published by the National Center for Biotechnology Information, U.S. National Library of Medicine, 8600 Rockville Pike, Bethesda, MD20894, USA.

15. The Hazardous Substance Data Bank (HSDB) website published by the U.S. National Library of Medicine 8600 Rockville Pike, Bethesda, MD 20894 National Institutes of Health, Health & Human Services.

16. The Agency for Toxic Substances & Disease Registry (ATSDR) Toxicological Profiles. Agency for Toxic Substances and Disease Registry, 4770 Buford Hwy NE, Atlanta, GA 30341.

2.4.2 Hierarchy by Parameter

Generally, the hierarchies below will work for organic and inorganic compounds.

1. Organic Carbon Partition Coefficient (K_{oc}) (L/kg). Not applicable for inorganics. EPI estimated values; SSL, Yaw estimated values; EPI experimental values; Yaw Experimental values. The exception to this hierarchy are the nine ionizable organics identified in table 42 of Part 5 of the Soil Screening Guidance Technical Background Document (PDF) (28 pp, 523 K). Appendix L goes into detail on the derivation of these values. The table is reproduced below:

Compound	**K_{oc} pH=6.8F**
Benzoic acid	0.6
2-chlorophenol	388
2,4-dichlorophenol	147
2,4-dinitrophenol	0.01
pentachlorophenol (PCP)	592
2,3,4,5-tetrachlorophenol	4742
2,3,4,6-tetrachlorophenol	280
2,4,5-trichlorophenol	1597
2,4,6-trichlorophenol	381

2. Dermal Permeability Coefficient (K_p) (cm/hour). EPI estimated values; RAGS Part E.

3. Effective Predictive Domain (EPD). Calculated based on RAGS Part E criteria for MW and log Kow.

4. Fraction Absorbed (FA). RAGS Part E Exhibit B-3; Calculated. Calculated FA values less than zero

are set to zero.

5. Molecular Weight (MW) (g/mole). PHYSPROP; EPI; CRC89; Perry's; Lange's; Yaws.
6. Water Solubility (S) (mg/L at 25 °C, unless otherwise stated in the source). PHYSPROP experimental values; EPI experimental values; CRC; YAWS experimental values; PERRY; LANGE; PHYSPROP estimated values; Yaws estimated values; EPI estimated values (WATERNT v.1.01, WSKOWWIN v1.42 respectively).
7. Unitless Henry's Law Constant (H' at 25 °C, unless otherwise stated in the source.). PHYSPROP experimental values; EPI experimental values; YAWS experimental values; PHYSPROP extrapolated values; PHYSPROP estimated values; EPI group-estimated values; EPI bond-estimated values; PHYSPROP.
8. Henry's Law Constant (atm-m^3/mole at 25 °C, unless otherwise stated in the source). PHYSPROP experimental values; EPI experimental values; YAWS experimental values; PHYSPROP extrapolated values; PHYSPROP estimated values; EPI group-estimated values; EPI bond-estimated values; PHYSPROP.
9. Diffusivity in Air (D_{ia}) (cm^2/s). WATER9 equations.
10. Diffusivity in Water (D_{iw}) (cm^2/s). WATER9 equations.
11. Fish Bioconcentration Factor (BCF) (L/kg). EPI experimental values; EPI estimated values.
12. Soil-Water Partition Coefficient (K_d) (cm^3/g). SSL; BAES.
13. Density (g/cm^3). CRC; Perry's; Lange's; IRIS.
14. Melting Point (MP °C). PHYSPROP; EPI experimental values; CRC; Perry's; Lange's; Yaws freezing point; EPI estimated values.
15. log Octanol-Water Partition Coefficient (logKow). PHYSPROP, EPI experimental values; Yaws experimental values; EPI estimated values; Yaws estimated values.
16. Vapor Pressure (VP). PHYSPROP experimental values, EPI experimental values; PHYSPROP extrapolated values; PHYSPROP estimated values; EPI estimated values.
17. Critical Temperature (T_c °K). CRC; Yaws Experimental; Yaws Estimated.
18. Enthalpy of vaporization at the normal boiling point (cal/mol). CRC, Yaws Extrapolated, Yaws Estimated.

2.5 Maximum Contaminant Levels (MCLs)

The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. SDWA authorizes the United States Environmental Protection Agency (US EPA) to set national health based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water.

US EPA sets national standards for drinking water based on sound science to protect against health risks, considering available technology and costs. These National Primary Drinking Water Regulations set enforceable maximum contaminant levels (MCLs) for contaminants in drinking water or required ways to treat water to remove contaminants. The MCLs are published here (PDF) (6 pp, 924 K).

US EPA sets primary drinking water standards through a three-step process: First, US EPA identifies contaminants that may adversely affect public health and occur in drinking water with a frequency and at levels that pose a threat to public health. Second, US EPA determines a maximum contaminant level goal (MCLG) for contaminants it decides to regulate. This goal is the level of a contaminant in drinking water below which there is no known or expected risk to health. Third, US EPA specifies a MCL, the maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system. These levels are enforceable standards, and are set as close to the MCLGs as feasible.

MCLs are provided in the RSL tables and the calculator output for users' information. A few things should be understood about the differences between RSLs and MCLs.

- RSLs are generated by and for the Superfund program, and MCLs are generated by the Office of Water although they are both used by other federal and state programs.
- The RSL calculations may result in a lower concentration than the MCL for a contaminant. The most common reason for this is that the RSLs represent risk-based concentrations considering only the relationship between exposure and risk.
- RSLs are calculated considering ingestion, inhalation, and dermal exposure to tap water.
- MCLs are set as close to risk-based goals, or Maximum Contaminant Level Goal (MCLG), as feasible. MCLGs are non-enforceable public health goals. MCLGs consider only public health and not the limits of detection and treatment technology effectiveness. Conversely, MCLs take the best available analytical and treatment technologies and cost into consideration.
- MCLGs for noncancer effects are based on a Reference Dose and consider ingestion of drinking water with a relative source contribution. The relative source contribution is the percentage of total drinking water exposure for the general population, after considering other exposure routes (for example, food, inhalation).
- For chemical contaminants that are carcinogens, EPA sets the MCLG at zero if: 1) there is evidence that a chemical may cause cancer and 2) there is no dose below which the chemical is considered safe. If a chemical is carcinogenic, and a safe dose can be determined, EPA sets the MCLG at a level above zero that is safe.
- If you have questions about the use of MCLs and/or RSLs at a Superfund site, consult your regional risk assessor.

2.6 Understanding Risk Output on the RSL Website

The RSL calculator provides an option to select risk output. In the calculator, select yes if risk output is desired. Selecting risk output requires the calculator to be run in "Site Specific" mode. In site specific mode, the user will be required to enter site concentrations for each media and chemical selected. The "Soil to Groundwater" medium does not have risk output and the risk option will become disabled when selected. The risk and hazard index values presented on this site are chemical-specific values for individual contaminants in air, water, soil, and fish that may warrant further investigation or site cleanup.

This portion of the risk assessment process is generally referred to as "Risk Characterization". This step incorporates the outcome of the exposure and toxicity assessments to calculate the risk resulting from potential exposure to chemicals via the pathways and routes of exposure determined appropriate for the source area.

2.6.1 How Risk is Calculated

The process used to calculate risk (carcinogenic risk and hazard quotient) in this calculator does not follow the traditional method of first calculating a Chronic Daily Intake (CDI). Rather, risk is derived using a simple method that relies on the linear nature of the relationship between concentration and risk. Using the equation below, an RSL, the target risk or target hazard quotient used to calculate the RSL, and a concentration entered by the user are all that is required to calculate risk.

Carcinogenic: TR / RSL = Risk / C

Noncarcinogenic: THQ / RSL = HQ / C

The linear equation above is then rearranged to solve for risk:

Carcinogenic: Risk = (C × TR) / RSL

Noncarcinogenic: HQ = (C × THQ) / RSL

where:

Risk = a unitless probability of an individual developing cancer over a lifetime, determined with the equation above;
HQ = a unitless ratio of exposure concentration to reference concentration where a value greater than unity indicates an individual will likely experience adverse health effects;
C = Concentration entered by the user in site-specific mode [mg/kg ; µg/m^3 ; µg/L]
TR = Target Risk provided by the user in site-specific mode
THQ = Target Hazard Quotient provided by the user in site-specific mode
RSL = Regional Screening Level, determined by the values entered by the user in site-specific mode [mg/kg ; µg/m^3 ; µg/L]

2.6.2 One-Hit Rule for Carcinogenic Risk

The linear risk equation, listed above, is valid only at low risk levels (below estimated risks of 0.01). For sites where chemical intakes might be high (estimated risks above 0.01, an alternate calculation should be used. The one-hit equation, which is consistent with the linear low-dose model, should be used instead (RAGS, part A, ch. 8). The results presented use this rule. In the following instances, the one-hit rule is used independently in the risk output tables:

- Risk from a single exposure route for a single chemical.
- Summation of single chemical risk (without one-hit rule applied to single chemical results) for multiple exposure routes (right of each row).
- Summation of risk (without one-hit rule applied to single chemical results) from a single exposure route for multiple chemicals (bottom of each column).
- Summation of total risk (without one-hit rule applied to single chemical results or summations listed above) from multiple chemicals across multiple exposure routes (bottom right hand cell).

3. Using the SL Tables

The "Generic Tables" page provides generic concentrations in the absence of site-specific exposure assessments. These concentrations can be used for:

- Prioritizing multiple sites or operable units or areas of concern within a facility or exposure units
- Setting risk-based detection limits for contaminants of potential concern (COPCs)
- Focusing future site investigation and risk assessment efforts (e.g., selecting COPCs for the baseline risk assessment)
- Identifying contamination which may warrant cleanup
- Identifying sites, or portions of sites, which warrant no further action or investigation
- Initial cleanup goals when site-specific data are lacking

Generic SLs are provided for multiple exposure pathways and for chemicals with both carcinogenic and noncarcinogenic effects. A Summary Table is provided that contains SLs corresponding to either a 10^{-6} risk level for carcinogens or a Hazard Quotient (HQ) of 1 for non-carcinogens. The summary table identifies whether the SL is based on cancer or noncancer effects by including a "c" or "n" after the SL. The Supporting Tables provide SLs corresponding to a 10^{-6} risk level for carcinogens and an HQ of 1 for noncarcinogens. Site specific SLs corresponding to an HQ of less than 1 may be appropriate for those sites where multiple chemicals are present that have RfDs or RfCs based on the same toxic endpoint. Site specific SLs based upon a cancer risk greater than 10^{-6} can be calculated and may be appropriate based upon site specific considerations. However, caution is recommended to ensure that cumulative cancer risk for all actual and potential carcinogenic contaminants found at the site does not have a residual (after site cleanup, or when it has been determined that no site cleanup is required) cancer risk exceeding 10^{-4}. Also, changing the target risk or HI may change the balance between the cancer and noncancer endpoints. At some concentrations, the cancer-risk concerns predominate; at other concentrations, noncancer-HI concerns predominate. The user must take care to consider both when adjusting target risks and hazards.

Tables are provided in either MS Excel or in PDF format. The following lists the tables provided and a description of what is contained in each:

- Summary Table - provides a list of contaminants, toxicity values, MCLs and the lesser (more protective) of the cancer and noncancer SLs for resident soil, industrial soil, resident air, industrial air and tapwater.
- Residential Soil Supporting Table - provides a list of contaminants, toxicity values and the cancer and noncancer SLs for resident soil.
- Industrial Soil Supporting Table - provides a list of contaminants, toxicity values and the cancer and noncancer SLs for industrial soil.
- Residential Air Supporting Table - provides a list of contaminants, toxicity values and the cancer and noncancer SLs for resident air.
- Industrial Air Supporting Table - provides a list of contaminants, toxicity values and the cancer and noncancer SLs for industrial air.
- Residential Tapwater Supporting Table - provides a list of contaminants, toxicity values, MCLs and the cancer and noncancer SLs for tapwater.

3.1 Developing a Conceptual Site Model

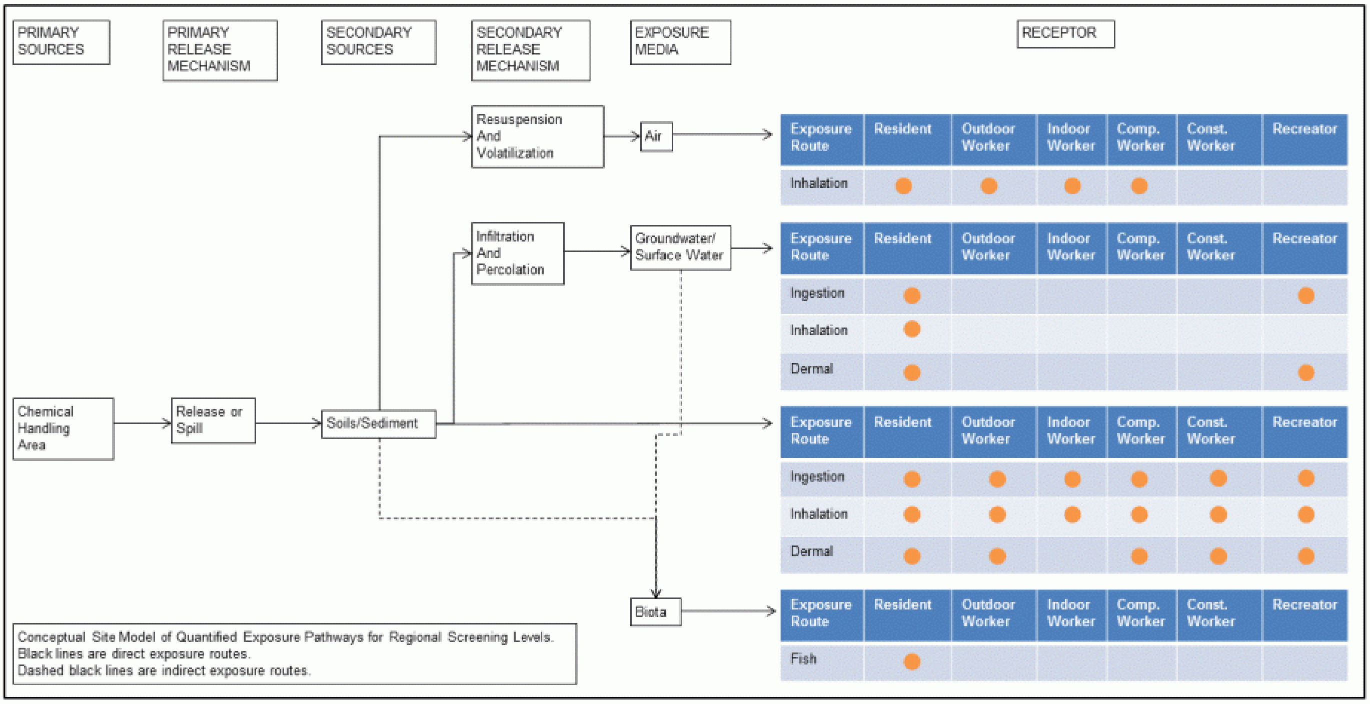
When using generic SLs at a site, the exposure pathways of concern and site conditions should match those used in developing the SLs presented here. (Note, however, that future uses may not match current uses. Future uses are potential site uses that may occur in the future. At Superfund sites, future uses should be considered as well as current uses. RAGS Part A, Chapter 6, provides guidance on selecting future-use receptors.) Thus, it is necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors. This information can be used to determine the applicability of SLs at the site and the need for additional information. The final CSM diagram represents linkages among contaminant sources, release mechanisms, exposure pathways, and routes and receptors based on historical information. It summarizes the understanding of the contamination problem. A separate CSM for ecological receptors can be useful. Part 2 and Attachment A of the Soil Screening Guidance for Superfund: Users Guide (EPA 1996) contains the steps for developing a CSM.

As a final check, the CSM should address the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those used in the SL calculations (i.e., residential and commercial/industrial)?
- Are there other likely human exposure pathways that were not considered in development of the SLs?
- Are there unusual site conditions (e.g. large areas of contamination, high fugitive dust levels, potential for indoor air contamination)?

The SLs and later PRGs may need to be adjusted to reflect the answers to these questions.

Below is a potential CSM of the quantified pathways addressed in the SL Tables.



Exposure Route	Resident	Outdoor Worker	Indoor Worker	Comp. Worker	Const. Worker	Recreator
Inhalation	●	●	●	●		

Exposure Route	Resident	Outdoor Worker	Indoor Worker	Comp. Worker	Const. Worker	Recreator
Ingestion	●					●
Inhalation	●					
Dermal	●					●

Exposure Route	Resident	Outdoor Worker	Indoor Worker	Comp. Worker	Const. Worker	Recreator
Ingestion	●	●	●	●	●	●
Inhalation	●	●	●	●	●	●
Dermal	●	●		●	●	●

Exposure Route	Resident	Outdoor Worker	Indoor Worker	Comp. Worker	Const. Worker	Recreator
Fish	●					

Conceptual Site Model of Quantified Exposure Pathways for Regional Screening Levels.
Black lines are direct exposure routes.
Dashed black lines are indirect exposure routes.

Conceptual Site Model of Qantified Exposure Pathways for Regional Screening Levels. Click image to view full size image.

3.2 Background

EPA may be concerned with two types of background at sites: naturally occurring and anthropogenic. Natural background is usually limited to metals whereas anthropogenic (i.e. human-made) “background” includes both organic and inorganic contaminants.

Please note that the SL tables, which are purely risk-based, may yield SLs lower than naturally occurring background concentrations of some chemicals in some areas. However, background considerations may be incorporated into the assessment and investigation of sites, as acknowledged in existing EPA guidance. Background levels should be addressed as they are for other contaminants at CERCLA sites. For further information see EPA's guidance Role of Background in the CERCLA Cleanup Program (PDF) (13 pp, 144 K), April 2002, (OSWER 9285.6-07P) and Guidance for Comparing Background and Chemical Concentration in Soil for CERCLA Sites (PDF) (89 pp, 1.2 MB), September 2002, (OSWER 9285.7-41).

Generally EPA does not clean up below natural background. In some cases, the predictive risk-based models generate SL concentrations that lie within or even below typical background concentrations for the same element or compound. Arsenic, aluminum, iron and manganese are common elements in soils that have background levels that may exceed risk-based SLs. This does not mean that these metals cannot be site-related, or that these metals should automatically be attributed to background. Attribution of chemicals to background is a site-specific decision; consult your regional risk assessor.

Where anthropogenic “background” levels exceed SLs and EPA has determined that a response action is necessary and feasible, EPA's goal will be to develop a comprehensive response to the widespread contamination. This will often require coordination with different authorities that have jurisdiction over the sources of contamination in the area.

3.3 Potential Problems

As with any risk based screening table or tool, the potential exists for misapplication. In most cases, this results from not understanding the intended use of the SLs or PRGs. In order to prevent misuse of the SLs, the following should be avoided:

- Applying SLs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios.
- Not considering the effects from the presence of multiple contaminants, where appropriate.
- Use of the SLs as cleanup levels without adequate consideration of the other NCP remedy selection criteria on CERCLA sites.
- Use of SL as cleanup levels without verifying numbers with a toxicologist or regional risk assessor.
- Use of outdated SLs when tables have been superseded by more recent values.
- Not considering the effects of additivity when screening multiple chemicals.

- Applying inappropriate target risks or changing a cancer target risk without considering its effect on noncancer, or vice versa.
- Not performing additional screening for pathways not included in these SLs (e.g,. vapor intrusion, fish consumption).
- Adjusting SLs upward by factors of 10 or 100 without consulting a toxicologist or regional risk assessor.

4. Land Use Descriptions, Equations and Technical Documentation

The SLs consider human exposure to individual contaminants in air, drinking water and soil. The equations and technical discussion are aimed at developing risk-based SLs or PRGs. The following text presents the land use equations and their exposure routes. Table 1 presents the definitions of the variables and their default values. Any alternative values or assumptions used in developing SLs on a site should be presented with supporting rationale in the decision document on CERCLA sites.

4.1 Resident

4.1.1 Resident Soil

This receptor spends most, if not all, of the day at home. The activities for this receptor involve typical home making chores (cooking, cleaning and laundering) as well as outdoor activities. The resident is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with soil, inhalation of volatiles and fugitive dust. Adults and children exhibit different ingestion rates for soil. For example, the child resident is assumed to ingest 200 mg per day while the adult ingests 100 mg per day. To account for changes in intake as the receptor ages, age adjusted intake equations were developed.

Note that the soil ingestion rates are intended to also represent ingestion of indoor dust. According to U.S. EPA 2011, “The source of the soil in these recommendations could be outdoor soil, indoor containerized soil used to support growth of indoor plants, or a combination of both outdoor soil and containerized indoor soil. The inhalation and subsequent swallowing of soil particles is accounted for in these recommended values, therefore, this pathway does not need to be considered separately.” Further, according to U.S. EPA 1997, “Although the recommendations presented below are derived from studies which were mostly conducted in the summer, exposure during the winter months when the ground is frozen or snow covered should not be considered as zero. Exposure during these months, although lower than in the summer months, would not be zero because some portion of the house dust comes from outdoor soil.”

This land use is for developing residential default screening levels that are presented in the RSL Generic Tables.

4.1.1.1 Noncarcinogenic-child

The residential soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}\,(\text{mg/kg}) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\text{ days}}{\text{year}} \times ED_{res\text{-}c}\,(6\text{ years})\right) \times BW_{res\text{-}c}\,(15\text{ kg})}{EF_{res\text{-}c}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res\text{-}c}\,(6\text{ years}) \times \frac{RBA}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IRS_{res\text{-}c}\left(\frac{200\text{ mg}}{\text{day}}\right) \times \frac{10^{-6}\text{kg}}{1\text{mg}}}$$

- dermal contact with soil

$$SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}c}\,(\text{mg/kg}) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\text{ days}}{\text{year}} \times ED_{res\text{-}c}\,(6\text{ years})\right) \times BW_{res\text{-}c}\,(15\text{ kg})}{EF_{res\text{-}c}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res\text{-}c}\,(6\text{ years}) \times \frac{1}{\left(RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right) \times GIABS\right)} \times SA_{res\text{-}c}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times AF_{res\text{-}c}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ABS_d \times \frac{10^{-6}\text{kg}}{1\text{mg}}}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}c}\,(\text{mg/kg}) = \frac{THQ \times AT_{res\text{-}c}\left(\frac{365\text{ days}}{\text{year}} \times ED_{res\text{-}c}\,(6\text{ years})\right)}{EF_{res\text{-}c}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res\text{-}c}\,(6\text{ years}) \times ET_{res\text{-}c}\left(\frac{24\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \frac{1}{RfC\left(\frac{\text{mg}}{\text{m}^3}\right)} \times \left(\frac{1}{VF_{ulim}\left(\frac{\text{m}^3}{\text{kg}}\right)} + \frac{1}{PEF\left(\frac{\text{m}^3}{\text{kg}}\right)}\right)}$$

- Total

$$SL_{res\text{-}soil\text{-}nc\text{-}tot\text{-}c}\,(\text{mg/kg}) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}c}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}c}}}$$

4.1.1.2 Noncarcinogenic-adult

The residential soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}a}\,(\text{mg/kg}) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}} \times ED_{res}\,(26\text{ years})\right) \times BW_{res\text{-}a}\,(80\text{ kg})}{EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res}\,(26\text{ years}) \times \frac{RBA}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IRS_{res\text{-}a}\left(\frac{100\text{ mg}}{\text{day}}\right) \times \frac{10^{-6}\text{kg}}{1\text{mg}}}$$

- dermal contact with soil

$$SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}a}\,(\text{mg/kg}) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}} \times ED_{res}\,(26\text{ years})\right) \times BW_{res\text{-}a}\,(80\text{ kg})}{EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res}\,(26\text{ years}) \times \frac{1}{\left(RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right) \times GIABS\right)} \times SA_{res\text{-}a}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) \times AF_{res\text{-}a}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) \times ABS_d \times \frac{10^{-6}\text{kg}}{1\text{mg}}}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}a}\,(\text{mg/kg}) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}} \times ED_{res}\,(26\text{ years})\right)}{EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res}\,(26\text{ years}) \times ET_{res\text{-}a}\left(\frac{24\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \frac{1}{RfC\left(\frac{\text{mg}}{\text{m}^3}\right)} \times \left(\frac{1}{VF_{ulim}\left(\frac{\text{m}^3}{\text{kg}}\right)} + \frac{1}{PEF\left(\frac{\text{m}^3}{\text{kg}}\right)}\right)}$$

- Total

$$SL_{res\text{-}soil\text{-}nc\text{-}tot\text{-}a}\left(mg/kg\right) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}a}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}a}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}a}}}$$

4.1.1.3 Carcinogenic

The residential soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{res\text{-}soil\text{-}ca\text{-}ing}\left(mg/kg\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) = \left(\begin{array}{c}\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \\ \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\end{array}\right)$$

- dermal contact with soil

$$SL_{res\text{-}soil\text{-}ca\text{-}der}\left(mg/kg\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right) = \left(\begin{array}{c}\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times SA_{res\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \\ \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times SA_{res\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{res\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\end{array}\right)$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{res\text{-}soil\text{-}ca\text{-}inh}\left(mg/kg\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times EF_{res}\left(\frac{350\ days}{year}\right) \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right) \times ED_{res}\left(26\ years\right) \times ET_{res}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right)}$$

- Total

$$SL_{res\text{-}soil\text{-}ca\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}ing}} + \frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}der}} + \frac{1}{SL_{res\text{-}soil\text{-}ca\text{-}inh}}}$$

4.1.1.4 Mutagenic

The residential soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{res\text{-}soil\text{-}mu\text{-}ing}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\,(2\ years) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\,(4\ years) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\,(10\ years) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)} \end{array}\right)$$

- dermal contact with soil

$$SL_{res\text{-}soil\text{-}mu\text{-}der}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\,(2\ years) \times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\,(4\ years) \times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) \times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\,(10\ years) \times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)} \end{array}\right)$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{res\text{-}soil\text{-}mu\text{-}inh}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{\begin{array}{c} IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \\ \left(\begin{array}{l} \left(ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\,(2\ years) \times 10\right) + \\ \left(ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\,(4\ years) \times 3\right) + \\ \left(ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\,(10\ years) \times 3\right) + \\ \left(ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\,(10\ years) \times 1\right) \end{array}\right) \end{array}}$$

- Total

$$SL_{res\text{-}soil\text{-}mu\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}mu\text{-}ing}} + \frac{1}{SL_{res\text{-}soil\text{-}mu\text{-}der}} + \frac{1}{SL_{res\text{-}soil\text{-}mu\text{-}inh}}}$$

4.1.1.5 Vinyl Chloride - Carcinogenic

The residential soil land use equations, presented here, contain the following exposure routes:

- incidental ingestion of soil

$$SL_{\text{res-soil-ca-vc-ing}}\left(\text{mg/kg}\right)=\frac{TR}{\left(\frac{CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}\times RBA\times IFS_{\text{res-adj}}\left(\frac{36{,}750\ \text{mg}}{\text{kg}}\right)\times\frac{10^{-6}\text{kg}}{1\ \text{mg}}}{AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\left(70\ \text{years}\right)\right)}\right)+\left(\frac{CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}\times RBA\times IRS_{\text{res-c}}\left(\frac{200\ \text{mg}}{\text{day}}\right)\times\frac{10^{-6}\text{kg}}{1\ \text{mg}}}{BW_{\text{res-c}}\left(15\ \text{kg}\right)}\right)}$$

where:

$$IFS_{\text{res-adj}}\left(\frac{36{,}750\ \text{mg}}{\text{kg}}\right)=\left(\frac{EF_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{\text{res-c}}\left(6\ \text{years}\right)\times IRS_{\text{res-c}}\left(\frac{200\ \text{mg}}{\text{day}}\right)}{BW_{\text{res-c}}\left(15\ \text{kg}\right)}+\frac{EF_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\left(ED_{\text{res}}\left(26\ \text{years}\right)-ED_{\text{res-c}}\left(6\ \text{years}\right)\right)\times IRS_{\text{res-a}}\left(\frac{100\ \text{mg}}{\text{day}}\right)}{BW_{\text{res-a}}\left(80\ \text{kg}\right)}\right)$$

- dermal contact with soil

$$SL_{\text{res-soil-ca-vc-der}}\left(\text{mg/kg}\right)=\frac{TR}{\left(\frac{\frac{CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\times DFS_{\text{res-adj}}\left(\frac{103{,}390\ \text{mg}}{\text{kg}}\right)\times ABS_{d}\times\frac{10^{-6}\text{kg}}{1\ \text{mg}}}{AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\left(70\ \text{years}\right)\right)}\right)+\left(\frac{\frac{CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\times SA_{\text{res-c}}\left(\frac{2373\ \text{cm}^{2}}{\text{day}}\right)\times AF_{\text{res-c}}\left(\frac{0.2\ \text{mg}}{\text{cm}^{2}}\right)\times ABS\times\frac{10^{-6}\text{kg}}{1\ \text{mg}}}{BW_{\text{res-c}}\left(15\ \text{kg}\right)}\right)}$$

where:

$$DFS_{\text{res-adj}}\left(\frac{103{,}390\ \text{mg}}{\text{kg}}\right)=\left(\frac{EF_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{\text{res-c}}\left(6\ \text{years}\right)\times SA_{\text{res-c}}\left(\frac{2373\ \text{cm}^{2}}{\text{day}}\right)\times AF_{\text{res-c}}\left(\frac{0.2\ \text{mg}}{\text{cm}^{2}}\right)}{BW_{\text{res-c}}\left(15\ \text{kg}\right)}+\frac{EF_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\left(ED_{\text{res}}\left(26\ \text{years}\right)-ED_{\text{res-c}}\left(6\ \text{years}\right)\right)\times SA_{\text{res-a}}\left(\frac{6032\ \text{cm}^{2}}{\text{day}}\right)\times AF_{\text{res-a}}\left(\frac{0.07\ \text{mg}}{\text{cm}^{2}}\right)}{BW_{\text{res-a}}\left(80\ \text{kg}\right)}\right)$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{\text{res-soil-ca-vc-inh}}\left(\text{mg/kg}\right)=\frac{TR}{\left(\frac{IUR\left(\mu\text{g}/\text{m}^{3}\right)^{-1}\times EF_{\text{res}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{\text{res}}\left(26\ \text{years}\right)\times ET_{\text{res}}\left(\frac{24\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times\left(\frac{1000\ \mu\text{g}}{\text{mg}}\right)}{AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\left(70\ \text{years}\right)\right)\times VF_{\text{ulim}}\left(\frac{\text{m}^{3}}{\text{kg}}\right)}\right)+\left(\frac{IUR\left(\mu\text{g}/\text{m}^{3}\right)^{-1}}{VF_{\text{ulim}}\left(\frac{\text{m}^{3}}{\text{kg}}\right)}\times\left(\frac{1000\ \mu\text{g}}{\text{mg}}\right)\right)}$$

- Total

$$SL_{\text{res-soil-ca-vc-tot}}\left(\text{mg/kg}\right)=\frac{1}{\frac{1}{SL_{\text{res-soil-ca-vc-ing}}}+\frac{1}{SL_{\text{res-soil-ca-vc-der}}}+\frac{1}{SL_{\text{res-soil-ca-vc-inh}}}}$$

4.1.1.6 Trichloroethylene - Carcinogenic and Mutagenic

The residential soil land use equations, presented here, contain the following exposure routes:

- incidental ingestion of soil

$$\mathrm{SL}_{\text{res-soil-tce-ing}}\left(\mathrm{mg/kg}\right)=\frac{\mathrm{TR}\times\mathrm{AT}_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times\mathrm{LT}\left(70\ \text{years}\right)\right)}{\mathrm{CSF}_{\text{o}}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}\times\mathrm{RBA}\times\left(\frac{10^{-6}\,\text{kg}}{\text{mg}}\right)\times\left(\begin{array}{l}\left(\mathrm{CAF}_{\text{o}}\left(0.804\right)\times\mathrm{IFS}_{\text{res-adj}}\left(\frac{37{,}650\ \text{mg}}{\text{kg}}\right)\right)+\\\left(\mathrm{MAF}_{\text{o}}\left(0.202\right)\times\mathrm{IFSM}_{\text{res-adj}}\left(\frac{166{,}833\ \text{mg}}{\text{kg}}\right)\right)\end{array}\right)}$$

where:

$$\mathrm{IFS}_{\text{res-adj}}\left(\frac{36{,}750\ \text{mg}}{\text{kg}}\right)=\left(\begin{array}{l}\frac{\mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right)\times\mathrm{EF}_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRS}_{\text{res-c}}\left(\frac{200\ \text{mg}}{\text{day}}\right)}{\mathrm{BW}_{\text{res-c}}\left(15\ \text{kg}\right)}+\\\frac{\left(\mathrm{ED}_{\text{res}}\left(26\ \text{years}\right)-\mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right)\right)\times\mathrm{EF}_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRS}_{\text{res-a}}\left(\frac{100\ \text{mg}}{\text{day}}\right)}{\mathrm{BW}_{\text{res-a}}\left(80\ \text{kg}\right)}\end{array}\right)$$

where:

$$\mathrm{IFSM}_{\text{res-adj}}\left(\frac{166{,}833\ \text{mg}}{\text{kg}}\right)=\left(\begin{array}{l}\frac{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)\times\mathrm{EF}_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRS}_{0\text{-}2}\left(\frac{200\ \text{mg}}{\text{day}}\right)\times10}{\mathrm{BW}_{0\text{-}2}\left(15\ \text{kg}\right)}+\\\frac{\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)\times\mathrm{EF}_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRS}_{2\text{-}6}\left(\frac{200\ \text{mg}}{\text{day}}\right)\times3}{\mathrm{BW}_{2\text{-}6}\left(15\ \text{kg}\right)}+\\\frac{\mathrm{ED}_{6\text{-}16}\left(10\ \text{years}\right)\times\mathrm{EF}_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRS}_{6\text{-}16}\left(\frac{100\ \text{mg}}{\text{day}}\right)\times3}{\mathrm{BW}_{6\text{-}16}\left(80\ \text{kg}\right)}+\\\frac{\mathrm{ED}_{16\text{-}26}\left(10\ \text{years}\right)\times\mathrm{EF}_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRS}_{16\text{-}26}\left(\frac{100\ \text{mg}}{\text{day}}\right)\times1}{\mathrm{BW}_{16\text{-}26}\left(80\ \text{kg}\right)}\end{array}\right)$$

- dermal contact with soil

$$SL_{res\text{-}soil\text{-}tce\text{-}der}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times \left(\frac{10^{-6}kg}{mg}\right) \times \Big(\Big(CAF_o\,(0.804) \times DFS_{res\text{-}adj}\left(\frac{103{,}390\text{ mg}}{kg}\right) \times ABS_d\Big) + \Big(MAF_o\,(0.202) \times DFSM_{res\text{-}adj}\left(\frac{428{,}260\text{ mg}}{kg}\right) \times ABS_d}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{103{,}390\text{ mg}}{kg}\right) = \left(\begin{array}{c}\frac{ED_{res\text{-}c}\,(6\text{ years}) \times EF_{res\text{-}c}\left(\frac{350\text{ days}}{\text{year}}\right) \times SA_{res\text{-}c}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times AF_{res\text{-}c}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)}{BW_{res\text{-}c}\,(15\text{ kg})} + \\ \frac{(ED_{res}\,(26\text{ years}) - ED_{res\text{-}c}\,(6\text{ years})) \times EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) \times SA_{res\text{-}a}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) \times AF_{res\text{-}a}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right)}{BW_{res\text{-}a}\,(80\text{ kg})}\end{array}\right)$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428{,}260\text{ mg}}{kg}\right) = \left(\begin{array}{c}\frac{ED_{0\text{-}2}\,(2\text{ years}) \times EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right) \times AF_{0\text{-}2}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times SA_{0\text{-}2}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times 10}{BW_{0\text{-}2}\,(15\text{ kg})} + \\ \frac{ED_{2\text{-}6}\,(4\text{ years}) \times EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right) \times AF_{2\text{-}6}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times SA_{2\text{-}6}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times 3}{BW_{2\text{-}6}\,(15\text{ kg})} + \\ \frac{ED_{6\text{-}16}\,(10\text{ years}) \times EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right) \times AF_{6\text{-}16}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) \times 3}{BW_{6\text{-}16}\,(80\text{ kg})} + \\ \frac{ED_{16\text{-}26}\,(10\text{ years}) \times EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right) \times AF_{16\text{-}26}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) \times 1}{BW_{16\text{-}26}\,(80\text{ kg})}\end{array}\right)$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{res\text{-}soil\text{-}tce\text{-}inh}\,(mg/kg) = \frac{TR \times AT_{res}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right)}{\begin{array}{c}IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right) \times \left(\frac{1000\,\mu g}{mg}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \\ \left(\left(\begin{array}{l}CAF_i\,(0.756) \times EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right) \times \\ ED_{res}\,(26\text{ years}) \times ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right)\end{array}\right) + \left(\begin{array}{l}\left(ED_{0\text{-}2}\,(2\text{ years}) \times EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right) \times MAF_i\,(0.244) \times 10\right) + \\ \left(ED_{2\text{-}6}\,(4\text{ years}) \times EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right) \times MAF_i\,(0.244) \times 3\right) + \\ \left(ED_{6\text{-}16}\,(10\text{ years}) \times EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right) \times MAF_i\,(0.244) \times 3\right) + \\ \left(ED_{16\text{-}26}\,(10\text{ years}) \times EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right) \times MAF_i\,(0.244) \times 1\right)\end{array}\right)\right)\end{array}}$$

- Total.

$$SL_{res\text{-}soil\text{-}tce\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}tce\text{-}ing}} + \frac{1}{SL_{res\text{-}soil\text{-}tce\text{-}der}} + \frac{1}{SL_{res\text{-}soil\text{-}tce\text{-}inh}}}$$

A number of studies have shown that inadvertent ingestion of soil is common among children 6 years old and younger (Calabrese et al. 1989, Davis et al. 1990, Van Wijnen et al. 1990). Therefore, the dose method uses an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 26 years old. The equation is presented below. This health-protective approach is chosen to take into account the higher daily rates of soil ingestion in children as well as the longer duration of exposure that is anticipated for a long-term resident. For more on this method, see RAGS Part B.

4.1.1.7 Supporting Equations

- Child

$$ED_{res\text{-}c}\left(6\text{ years}\right) = ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)$$

$$BW_{res\text{-}c}\left(15\text{ kg}\right) = \frac{BW_{0\text{-}2}\left(15\text{ kg}\right) \times ED_{0\text{-}2}\left(2\text{ years}\right) + BW_{2\text{-}6}\left(15\text{ kg}\right) \times ED_{2\text{-}6}\left(4\text{ years}\right)}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)}$$

$$EF_{res\text{-}c}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{0\text{-}2}\left(2\text{ years}\right) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{2\text{-}6}\left(4\text{ years}\right)}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)}$$

$$ET_{res\text{-}c}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\text{ years}\right) + ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\text{ years}\right)}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)}$$

$$AF_{res\text{-}c}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) = \frac{AF_{0\text{-}2}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ED_{0\text{-}2}\left(2\text{ years}\right) + AF_{2\text{-}6}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ED_{2\text{-}6}\left(4\text{ years}\right)}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)}$$

$$SA_{res\text{-}c}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) = \frac{SA_{0\text{-}2}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\text{ years}\right) + SA_{2\text{-}6}\left(\frac{2373\text{ cm}^2}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\text{ years}\right)}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)}$$

$$IRS_{res\text{-}c}\left(\frac{200\text{ mg}}{\text{day}}\right) = \frac{IRS_{0\text{-}2}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{0\text{-}2}\left(2\text{ years}\right) + IRS_{2\text{-}6}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{2\text{-}6}\left(4\text{ years}\right)}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right)}$$

- Adult

$$ED_{res\text{-}a}\left(20\text{ years}\right) = ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)$$

$$BW_{res\text{-}a}\left(80\text{ kg}\right) = \frac{BW_{6\text{-}16}\left(80\text{ kg}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + BW_{16\text{-}26}\left(80\text{ kg}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$ET_{res\text{-}a}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{6\text{-}16}\left(2\text{ years}\right) + ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{16\text{-}26}\left(4\text{ years}\right)}{ED_{6\text{-}16}\left(2\text{ years}\right) + ED_{16\text{-}26}\left(4\text{ years}\right)}$$

$$AF_{res\text{-}a}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) = \frac{AF_{6\text{-}16}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + AF_{16\text{-}26}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$SA_{res\text{-}a}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) = \frac{SA_{6\text{-}16}\left(\frac{6032\text{ cm}^2}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + SA_{16\text{-}26}\left(\frac{6032\text{ cm}^2}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$IRS_{res\text{-}a}\left(\frac{100\text{ mg}}{\text{day}}\right) = \frac{IRS_{6\text{-}16}\left(\frac{100\text{ mg}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + IRS_{16\text{-}26}\left(\frac{100\text{ mg}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

- Age-adjusted

$$ED_{res}\left(26\text{ years}\right) = ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)$$

$$EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{\begin{array}{c}EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{0\text{-}2}\left(2\text{ years}\right) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{2\text{-}6}\left(4\text{ years}\right) + \\ EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)\end{array}}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{\begin{array}{c}ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{0\text{-}2}\left(2\text{ years}\right) + ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{2\text{-}6}\left(4\text{ years}\right) + \\ ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)\end{array}}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

4.1.2 Resident Tapwater

This receptor is exposed to chemicals in water that are delivered into a residence from sources such as groundwater or surface water. Ingestion of drinking water is an appropriate pathway for all chemicals. The inhalation exposure route is only calculated for volatile compounds. Activities such as showering, laundering, and dish washing contribute to contaminants in the air for inhalation. Dermal contact with tapwater is also considered for analytes determined to be within the effective predictive domain as described in Section 4.9.8.

This land use is for developing residential default screening levels that are presented in the RSL Generic Tables.

4.1.2.1 Noncarcinogenic-child

The tapwater land use equation, presented here, contains the following exposure routes:

- ingestion of water

$$SL_{\text{res-wat-nc-ing-c}}\left(\mu g/L\right) = \frac{THQ \times AT_{\text{res-c}}\left(\frac{365\text{ days}}{\text{year}} \times ED_{\text{res-c}}\left(6\text{ years}\right)\right) \times BW_{\text{res-c}}\left(15\text{ kg}\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{\text{res-c}}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{\text{res-c}}\left(6\text{ years}\right) \times \frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)} \times IRW_{\text{res-c}}\left(\frac{0.78\text{ L}}{\text{day}}\right)}$$

- dermal

FOR INORGANICS:

$$SL_{\text{res-wat-nc-der-c}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right) \times \left(\frac{1000\text{ cm}^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right) \times ET_{\text{event-res-c}}\left(\frac{0.54\text{ hours}}{\text{event}}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-res-c}}\left(\frac{0.54\text{ hours}}{\text{event}}\right) \leq t^*\left(\text{hours}\right)\text{, then } SL_{\text{res-wat-nc-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right) \times \left(\frac{1000\text{ cm}^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{\text{event}}\left(\frac{hours}{event}\right) \times ET_{\text{event-res-c}}\left(\frac{0.54\text{ hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-res-c}}\left(\frac{0.54\text{ hours}}{\text{event}}\right) > t^*\left(\text{hours}\right)\text{, then } SL_{\text{res-wat-nc-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right) \times \left(\frac{1000\text{ cm}^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{\text{event-res-c}}\left(\frac{0.54\text{ hours}}{\text{event}}\right)}{1+B} + 2 \times \tau_{\text{event}}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{\left(1+B\right)^2}\right)\right]}$$

where:

$$DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right) = \frac{THQ \times AT_{\text{res-c}}\left(\frac{365\text{ days}}{\text{year}} \times ED_{\text{res-c}}\left(6\text{ years}\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times BW_{\text{res-c}}\left(15\text{ kg}\right)}{\left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right) \times EV_{\text{res-c}}\left(\frac{1\text{ events}}{\text{day}}\right) \times ED_{\text{res-c}}\left(6\text{ years}\right) \times EF_{\text{res-c}}\left(\frac{350\text{ days}}{\text{year}}\right) \times SA_{\text{res-c}}\left(6365\text{ cm}^2\right)}$$

- inhalation of volatiles

$$SL_{\text{res-wat-nc-inh-c}}\left(\mu g/L\right) = \frac{THQ \times AT_{\text{res-c}}\left(\frac{365\text{ days}}{\text{year}} \times ED_{\text{res-c}}\left(6\text{ years}\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{\text{res-c}}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{\text{res-c}}\left(6\text{ years}\right) \times ET_{\text{res-c}}\left(\frac{24\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)} \times K\left(\frac{0.5\text{ L}}{m^3}\right)}$$

- Total

$$SL_{res\text{-}wat\text{-}nc\text{-}tot\text{-}c}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{res\text{-}wat\text{-}nc\text{-}ing\text{-}c}}+\frac{1}{SL_{res\text{-}wat\text{-}nc\text{-}der\text{-}c}}+\frac{1}{SL_{res\text{-}wat\text{-}nc\text{-}inh\text{-}c}}}$$

4.1.2.2 Noncarcinogenic-adult

The tapwater land use equation, presented here, contains the following exposure routes:

- ingestion of water

$$SL_{res\text{-}wat\text{-}nc\text{-}ing\text{-}a}\left(\mu g/L\right) = \frac{THQ\times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}}\times ED_{res}\left(26\text{ years}\right)\right)\times BW_{res\text{-}a}\left(80\text{ kg}\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{EF_{res\text{-}a}\left(350\ \frac{\text{days}}{\text{year}}\right)\times ED_{res}\left(26\text{ years}\right)\times\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)}\times IRW_{res\text{-}a}\left(\frac{2.5\text{ L}}{\text{day}}\right)}$$

- dermal

FOR INORGANICS:

$$SL_{res\text{-}wat\text{-}nc\text{-}der\text{-}a}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\text{ cm}^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right)\times ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right)\leq t^*\left(\text{hours}\right)\text{, then } SL_{res\text{-}wat\text{-}nc\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\text{ cm}^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right)>t^*\left(\text{hours}\right)\text{, then } SL_{res\text{-}wat\text{-}nc\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\text{ cm}^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{\left(1+B\right)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right) = \frac{THQ\times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}}\times ED_{res}\left(26\text{ years}\right)\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times BW_{res\text{-}a}\left(80\text{ kg}\right)}{\left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)\times GIABS}\right)\times EV_{res\text{-}a}\left(\frac{1\text{ events}}{\text{day}}\right)\times ED_{res}\left(26\text{ years}\right)\times EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right)\times SA_{res\text{-}a}\left(19652\text{ cm}^2\right)}$$

- inhalation of volatiles

$$SL_{res\text{-}wat\text{-}nc\text{-}inh\text{-}a}\left(\mu g/L\right) = \frac{THQ\times AT_{res\text{-}a}\left(\frac{365\text{ days}}{\text{year}}\times ED_{res}\left(26\text{ years}\right)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{res}\left(26\text{ years}\right)\times ET_{res\text{-}a}\left(\frac{24\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\frac{1}{RfC\left(mg/m^3\right)}\times K\left(\frac{0.5\text{ L}}{m^3}\right)}$$

- Total

$$SL_{res\text{-}wat\text{-}nc\text{-}tot\text{-}a}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{res\text{-}wat\text{-}nc\text{-}ing\text{-}a}}+\frac{1}{SL_{res\text{-}wat\text{-}nc\text{-}der\text{-}a}}+\frac{1}{SL_{res\text{-}wat\text{-}nc\text{-}inh\text{-}a}}}$$

4.1.2.3 Carcinogenic

The tapwater land use equation, presented here, contains the following exposure routes:

- ingestion of water

$$\mathrm{SL}_{\text{res-wat-ca-ing}}\left(\mu g/L\right) = \frac{\mathrm{TR} \times \mathrm{AT}_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}} \times \mathrm{LT}\left(70\ \text{years}\right)\right) \times \left(\frac{1000\ \mu g}{\text{mg}}\right)}{\mathrm{CSF}_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1} \times \left(\mathrm{IFW}_{\text{res-adj}}\left(\frac{327.95\ \text{L}}{\text{kg}}\right)\right)}$$

where:

$$\mathrm{IFW}_{\text{res-adj}}\left(\frac{327.95\ \text{L}}{\text{kg}}\right) = \left(\begin{array}{c} \frac{\mathrm{EF}_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right) \times \mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right) \times \mathrm{IRW}_{\text{res-c}}\left(\frac{0.78\ \text{L}}{\text{day}}\right)}{\mathrm{BW}_{\text{res-c}}\left(15\ \text{kg}\right)} + \\ \frac{\mathrm{EF}_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right) \times \left(\mathrm{ED}_{\text{res}}\left(26\ \text{years}\right) - \mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right)\right) \times \mathrm{IRW}_{\text{res-a}}\left(\frac{2.5\ \text{L}}{\text{day}}\right)}{\mathrm{BW}_{\text{res-a}}\left(80\ \text{kg}\right)} \end{array}\right)$$

- dermal

FOR INORGANICS:

$$SL_{\text{res-wat-ca-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-res-adj}}\left(\frac{\text{hours}}{\text{event}}\right)\leq t^*\ (\text{hours}),\text{then } SL_{\text{res-wat-ca-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{2\times FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-res-adj}}\left(\frac{\text{hours}}{\text{event}}\right)>t^*\ (\text{hours}),\text{then } SL_{\text{res-wat-ca-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times\left[\frac{ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}{1+B}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)=\frac{TR\times AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\,(70\ \text{years})\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)}{\left(\frac{CSF_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\right)\times DFW_{\text{res-adj}}\left(\frac{2{,}610{,}650\ \text{events-cm}^2}{\text{kg}}\right)}$$

where:

$$DFW_{\text{res-adj}}\left(\frac{2{,}610{,}650\ \text{events-cm}^2}{\text{kg}}\right)=\left(\begin{array}{c}\frac{EF_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times EV_{\text{res-c}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{\text{res-c}}\,(6\ \text{years})\times SA_{\text{res-c}}\left(6365\ \text{cm}^2\right)}{BW_{\text{reswc}}\,(15\ \text{kg})}+\\\frac{EF_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times EV_{\text{res-a}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times\left(ED_{\text{res}}\,(26\ \text{years})-ED_{\text{res-c}}\,(6\ \text{years})\right)\times SA_{\text{res-a}}\left(19652\ \text{cm}^2\right)}{BW_{\text{res-a}}\,(80\ \text{kg})}\end{array}\right)$$

and:

$$ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)=\left(\frac{\left(ET_{\text{event-res-c}}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)\times ED_{\text{res-c}}\,(6\ \text{years})+ET_{\text{event-res-a}}\left(\frac{0.71\ \text{hours}}{\text{event}}\right)\times\left(ED_{\text{res}}\,(26\ \text{years})-ED_{\text{res-c}}\,(6\ \text{years})\right)\right)}{ED_{\text{res}}\,(26\ \text{years})}\right)$$

- inhalation of volatiles

$$SL_{\text{res-wat-ca-inh}}\left(\mu g/L\right)=\frac{TR\times AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\,(70\ \text{years})\right)}{EF_{\text{res}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{\text{res}}\,(26\ \text{years})\times ET_{\text{res}}\left(\frac{24\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times IUR\left(\mu g/m^3\right)^{-1}\times K\left(\frac{0.5\ \text{L}}{\text{m}^3}\right)}$$

- Total

$$SL_{\text{res-wat-ca-tot}}\left(\mu g/L\right)=\frac{1}{\frac{1}{SL_{\text{res-wat-ca-ing}}}+\frac{1}{SL_{\text{res-wat-ca-der}}}+\frac{1}{SL_{\text{res-wat-ca-inh}}}}$$

4.1.2.4 Mutagenic

The tapwater land use equation, presented here, contains the following exposure routes:

- ingestion of water

$$SL_{res\text{-}wat\text{-}mu\text{-}ing}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\left(70\ \text{years}\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{kg}\right)}$$

where:

$$IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) \times IRW_{0\text{-}2}\left(\frac{0.78\ L}{\text{day}}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\left(\text{years}\right) \times IRW_{2\text{-}6}\left(\frac{0.78\ L}{\text{day}}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\left(\text{years}\right) \times IRW_{6\text{-}16}\left(\frac{2.5\ L}{\text{day}}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\left(\text{years}\right) \times IRW_{16\text{-}26}\left(\frac{2.5\ L}{\text{day}}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

- dermal

FOR INORGANICS:

$$SL_{\text{res-wat-mu-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) \times \left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{K_p\left(\frac{\text{cm}}{\text{hour}}\right) \times ET_{\text{event-res-madj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-res-madj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) \le t^{*}\ (\text{hours}), \text{then } SL_{\text{res-wat-mu-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) \times \left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{2 \times FA \times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6 \times \tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right) \times ET_{\text{event-res-madj}}\left(\frac{\text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-res-madj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) > t^{*}\ (\text{hours}), \text{then } SL_{\text{res-wat-mu-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) \times \left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{FA \times K_p\left(\frac{\text{cm}}{\text{hour}}\right) \times \left[\frac{ET_{\text{event-res-madj}}\left(\frac{\text{hours}}{\text{event}}\right)}{1+B} + 2 \times \tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) = \frac{TR \times AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right) \times \left(\frac{1000\ \mu g}{\text{mg}}\right)}{\left(\frac{CSF_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\right) \times DFWM_{\text{res-adj}}\left(\frac{8{,}191{,}633\ \text{events - cm}^2}{\text{kg}}\right)}$$

where:

$$DFWM_{\text{res-adj}}\left(\frac{8{,}191{,}633\ \text{events - cm}^2}{\text{kg}}\right) = \left[\begin{aligned} &\left(\frac{EV_{0\text{-}2}\left(\frac{1\ \text{events}}{\text{day}}\right) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\,(\text{years}) \times SA_{0\text{-}2}\left(6365\ \text{cm}^2\right) \times 10}{BW_{0\text{-}2}\,(15\ \text{kg})}\right) + \\ &\left(\frac{EV_{2\text{-}6}\left(\frac{1\ \text{events}}{\text{day}}\right) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\,(\text{years}) \times SA_{2\text{-}6}\left(6365\ \text{cm}^2\right) \times 3}{BW_{2\text{-}6}\,(15\ \text{kg})}\right) + \\ &\left(\frac{EV_{6\text{-}16}\left(\frac{1\ \text{events}}{\text{day}}\right) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\,(\text{years}) \times SA_{6\text{-}16}\left(19652\ \text{cm}^2\right) \times 3}{BW_{6\text{-}16}\,(80\ \text{kg})}\right) + \\ &\left(\frac{EV_{16\text{-}26}\left(\frac{1\ \text{events}}{\text{day}}\right) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\,(\text{years}) \times SA_{16\text{-}26}\left(19652\ \text{cm}^2\right) \times 1}{BW_{16\text{-}26}\,(80\ \text{kg})}\right) \end{aligned}\right]$$

and:

$$ET_{\text{event-res-madj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) = \frac{\left(\begin{aligned} &ET_{\text{event-res}(0\text{-}2)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right) \times ED_{0\text{-}2}\,(2\ \text{years}) + ET_{\text{event-res}(2\text{-}6)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right) \times ED_{2\text{-}6}\,(4\ \text{years}) + \\ &ET_{\text{event-res}(6\text{-}16)}\left(\frac{0.71\ \text{hours}}{\text{event}}\right) \times ED_{6\text{-}16}\,(10\ \text{years}) + ET_{\text{event-res}(16\text{-}26)}\left(\frac{0.71\ \text{hours}}{\text{event}}\right) \times ED_{16\text{-}26}\,(10\ \text{years}) \end{aligned}\right)}{ED_{0\text{-}2}\,(2\ \text{years}) + ED_{2\text{-}6}\,(4\ \text{years}) + ED_{6\text{-}16}\,(10\ \text{years}) + ED_{16\text{-}26}\,(10\ \text{years})}$$

- inhalation of volatiles

$$SL_{res\text{-}wat\text{-}mu\text{-}inh}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\left(70\ \text{years}\right)\right)}{IUR\left(\mu g/m^{3}\right)^{-1} \times K\left(\frac{0.5\ L}{m^{3}}\right) \times \left(\begin{array}{l}\left(EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times ED_{0\text{-}2}\left(2\ \text{years}\right) \times 10\right) + \\ \left(EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times ED_{2\text{-}6}\left(4\ \text{years}\right) \times 3\right) + \\ \left(EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{6\text{-}16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times ED_{6\text{-}16}\left(10\ \text{years}\right) \times 3\right) + \\ \left(EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{16\text{-}26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times ED_{16\text{-}26}\left(10\ \text{years}\right) \times 1\right)\end{array}\right)}$$

- Total

$$SL_{res\text{-}wat\text{-}mu\text{-}tot}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{res\text{-}wat\text{-}mu\text{-}ing}} + \frac{1}{SL_{res\text{-}wat\text{-}mu\text{-}der}} + \frac{1}{SL_{res\text{-}wat\text{-}mu\text{-}inh}}}$$

4.1.2.5 Vinyl Chloride - Carcinogenic

The tapwater land use equation, presented here, contains the following exposure routes:

- ingestion of water

$$SL_{res\text{-}wat\text{-}ca\text{-}vc\text{-}ing}\left(\mu g/L\right) = \frac{TR}{\left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right) \times \left(\frac{mg}{1000\ \mu g}\right)}{AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\left(70\ \text{years}\right)\right)}\right) + \left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{\text{day}}\right) \times \left(\frac{mg}{1000\ \mu g}\right)}{BW_{res\text{-}c}\left(15\ kg\right)}\right)}$$

where:

$$IFW_{res\text{-}adj}\left(\frac{327.95\ L}{kg}\right) = \left(\begin{array}{l}\frac{EF_{res\text{-}c}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{res\text{-}c}\left(6\ \text{years}\right) \times IRW_{res\text{-}c}\left(\frac{0.78\ L}{\text{day}}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \\ \frac{EF_{res\text{-}a}\left(\frac{350\ \text{days}}{\text{year}}\right) \times \left(ED_{res}\left(26\ \text{years}\right) - ED_{res\text{-}c}\left(6\ \text{years}\right)\right) \times IRW_{res\text{-}a}\left(\frac{2.5\ L}{\text{day}}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\end{array}\right)$$

- dermal

$$\text{IF ET}_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) \le t^{*}\ (\text{hours}), \text{then SL}_{\text{res-wat-ca-vc-der}}\ (\mu\text{g/L}) = \frac{\text{DA}_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{2\times\text{FA}\times\text{K}_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\text{ET}_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF ET}_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) > t^{*}\ (\text{hours}), \text{then SL}_{\text{res-wat-ca-vc-der}}\ (\mu\text{g/L}) = \frac{\text{DA}_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{\text{FA}\times\text{K}_p\left(\frac{\text{cm}}{\text{hour}}\right)\times\left[\frac{\text{ET}_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}{1+\text{B}}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3\text{B}+3\text{B}^2}{(1+\text{B})^2}\right)\right]}$$

where:

$$\text{DA}_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) = \frac{\text{TR}}{\left(\frac{\left(\frac{\text{CSF}_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{\text{GIABS}}\right)\times\text{DFW}_{\text{res-adj}}\left(\frac{2{,}610{,}650\ \text{events-cm}^2}{\text{kg}}\right)}{\text{AT}_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times\text{LT}\ (70\ \text{years})\right)\times\left(\frac{1000\ \mu\text{g}}{\text{mg}}\right)}\right)+\left(\frac{\left(\frac{\text{CSF}_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{\text{GIABS}}\right)\times\text{EV}_{\text{res-c}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times\text{SA}_{\text{res-c}}\left(6365\ \text{cm}^2\right)}{\text{BW}_{\text{res-c}}\ (15\ \text{kg})\times\left(\frac{1000\ \mu\text{g}}{\text{mg}}\right)}\right)}$$

where:

$$\text{DFW}_{\text{res-adj}}\left(\frac{2{,}610{,}650\ \text{events-cm}^2}{\text{kg}}\right) = \left(\frac{\text{EF}_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\text{EV}_{\text{res-c}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times\text{ED}_{\text{res-c}}\ (6\ \text{years})\times\text{SA}_{\text{res-c}}\left(6365\ \text{cm}^2\right)}{\text{BW}_{\text{res-c}}\ (15\ \text{kg})}+\frac{\text{EF}_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\text{EV}_{\text{res-a}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times\text{ED}_{\text{res-a}}\ (20\ \text{years})\times\text{SA}_{\text{res-a}}\left(19652\ \text{cm}^2\right)}{\text{BW}_{\text{res-a}}\ (80\ \text{kg})}\right)$$

and:

$$\text{ET}_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) = \left(\frac{\left(\text{ET}_{\text{event-res-c}}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)\times\text{ED}_{\text{res-c}}\ (6\ \text{years})+\text{ET}_{\text{event-res-a}}\left(\frac{0.71\ \text{hours}}{\text{event}}\right)\times\left(\text{ED}_{\text{res}}\ (26\ \text{years})-\text{ED}_{\text{res-c}}\ (6\ \text{years})\right)\right)}{\text{ED}_{\text{res}}\ (26\ \text{years})}\right)$$

- inhalation of volatiles

$$\text{SL}_{\text{res-wat-ca-vc-inh}}\ (\mu\text{g/L}) = \frac{\text{TR}}{\left(\frac{\text{IUR}\left(\mu\text{g}/\text{m}^3\right)^{-1}\times\text{EF}_{\text{res}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\text{ED}_{\text{res}}\ (26\ \text{years})\times\text{ET}_{\text{res}}\left(\frac{24\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times\text{K}\left(\frac{0.5\ \text{L}}{\text{m}^3}\right)}{\text{AT}_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times\text{LT}\ (70\ \text{years})\right)}\right)+\left(\text{IUR}\left(\mu\text{g}/\text{m}^3\right)^{-1}\times\text{K}\left(\frac{0.5\ \text{L}}{\text{m}^3}\right)\right)}$$

- Total

$$\text{SL}_{\text{res-wat-ca-vc-tot}}\ (\mu\text{g/L}) = \frac{1}{\frac{1}{\text{SL}_{\text{res-wat-ca-vc-ing}}}+\frac{1}{\text{SL}_{\text{res-wat-ca-vc-der}}}+\frac{1}{\text{SL}_{\text{res-wat-ca-vc-inh}}}}$$

4.1.2.6 Trichloroethylene - Carcinogenic and Mutagenic

The tapwater land use equation, presented here, contains the following exposure routes:

- ingestion of water

$$\mathrm{SL}_{\text{res-wat-tce-ing}}\left(\mu g/L\right)=\frac{\mathrm{TR}\times\mathrm{AT}_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times\mathrm{LT}\left(70\ \text{years}\right)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\mathrm{CSF}_{o}\left(\frac{mg}{\text{kg-day}}\right)^{-1}\times\left(\left(\mathrm{CAF}_{o}\left(0.804\right)\times\mathrm{IFW}_{\text{res-adj}}\left(\frac{327.95\ L}{kg}\right)\right)\right)+\left(\mathrm{MAF}_{o}\left(0.202\right)\times\mathrm{IFWM}_{\text{res-adj}}\left(\frac{1019.9\ L}{kg}\right)\right)}$$

where:

$$\mathrm{IFW}_{\text{res-adj}}\left(\frac{327.95\ L}{kg}\right)=\left(\begin{array}{c}\frac{\mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right)\times\mathrm{EF}_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRW}_{\text{res-c}}\left(\frac{0.78\ L}{\text{day}}\right)}{\mathrm{BW}_{\text{res-c}}\left(15\ kg\right)}+\\ \frac{\left(\mathrm{ED}_{\text{res}}\left(26\ \text{years}\right)-\mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right)\right)\times\mathrm{EF}_{\text{res-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRW}_{\text{res-a}}\left(\frac{2.5\ L}{\text{day}}\right)}{\mathrm{BW}_{\text{res-a}}\left(80\ kg\right)}\end{array}\right)$$

where:

$$\mathrm{IFWM}_{\text{res-adj}}\left(\frac{1019.9\ L}{kg}\right)=\left(\begin{array}{c}\frac{\mathrm{ED}_{0-2}\left(2\ \text{years}\right)\times\mathrm{EF}_{0-2}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRW}_{0-2}\left(\frac{0.78\ L}{\text{day}}\right)\times 10}{\mathrm{BW}_{0-2}\left(15\ kg\right)}+\\ \frac{\mathrm{ED}_{2-6}\left(4\ \text{years}\right)\times\mathrm{EF}_{2-6}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRW}_{2-6}\left(\frac{0.78\ L}{\text{day}}\right)\times 3}{\mathrm{BW}_{2-6}\left(15\ kg\right)}+\\ \frac{\mathrm{ED}_{6-16}\left(10\ \text{years}\right)\times\mathrm{EF}_{6-16}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRW}_{6-16}\left(\frac{2.5\ L}{\text{day}}\right)\times 3}{\mathrm{BW}_{6-16}\left(80\ kg\right)}+\\ \frac{\mathrm{ED}_{16-26}\left(10\ \text{years}\right)\times\mathrm{EF}_{16-26}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{IRW}_{16-26}\left(\frac{2.5\ L}{\text{day}}\right)\times 1}{\mathrm{BW}_{16-26}\left(80\ kg\right)}\end{array}\right)$$

- dermal

FOR ORGANICS:

$$\text{IF } ET_{\text{event-res-adj}}\left(\frac{\text{hours}}{\text{event}}\right) \leq t^{*}\ (\text{hours}), \text{then } SL_{\text{res-wat-tce-der}}\ (\mu g/L) = \frac{DA_{\text{tce-event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{2\times FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-res-adj}}\left(\frac{\text{hours}}{\text{event}}\right) > t^{*}\ (\text{hours}), \text{then } SL_{\text{res-wat-tce-der}}\ (\mu g/L) = \frac{DA_{\text{tce-event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times\left[\frac{ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right)}{1+B}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{\text{tce-event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) = \frac{TR\times AT_{\text{res}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\ (70\ \text{years})\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)}{\frac{CSF_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\times\left(\left(CAF_o\ (0.804)\ \times DFW_{\text{res-adj}}\left(\frac{2{,}610{,}650\ \text{events - cm}^2}{\text{kg}}\right)\right)+\left(MAF_o\ (0.202)\ \times DFWM_{\text{res-adj}}\left(\frac{8{,}191{,}633\ \text{events - cm}^2}{\text{kg}}\right)\right)\right)}$$

where:

$$DFW_{\text{res-adj}}\left(\frac{2{,}610{,}650\ \text{events - cm}^2}{\text{kg}}\right) = \left(\begin{array}{c}\frac{EV_{\text{res-c}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{\text{res-c}}\ (6\ \text{years})\ \times EF_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times SA_{\text{res-c}}\left(6365\ \text{cm}^2\right)}{BW_{\text{res-c}}\ (15\ \text{kg})}+\\ \frac{EV_{\text{res-a}}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{\text{res-a}}\ (20\ \text{years})\ \times EF_{\text{resw-a}}\left(\frac{350\ \text{days}}{\text{year}}\right)\times SA_{\text{res-a}}\left(19652\ \text{cm}^2\right)}{BW_{\text{res-a}}\ (80\ \text{kg})}\end{array}\right)$$

where:

$$DFWM_{\text{res-adj}}\left(\frac{8{,}191{,}633\ \text{events - cm}^2}{\text{kg}}\right) = \left[\begin{array}{c}\left(\frac{EV_{0\text{-}2}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{0\text{-}2}\ (2\ \text{years})\ \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right)\times SA_{0\text{-}2}\left(6365\ \text{cm}^2\right)\times 10}{BW_{0\text{-}2}\ (15\ \text{kg})}\right)+\\ \left(\frac{EV_{2\text{-}6}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{2\text{-}6}\ (4\ \text{years})\ \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right)\times SA_{2\text{-}6}\left(6365\ \text{cm}^2\right)\times 3}{BW_{2\text{-}6}\ (15\ \text{kg})}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{6\text{-}16}\ (10\ \text{years})\ \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right)\times SA_{6\text{-}16}\left(19652\ \text{cm}^2\right)\times 3}{BW_{6\text{-}16}\ (80\ \text{kg})}\right)+\\ \left(\frac{EV_{16\text{-}26}\left(\frac{1\ \text{events}}{\text{day}}\right)\times ED_{16\text{-}26}\ (10\ \text{years})\ \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right)\times SA_{16\text{-}26}\left(19652\ \text{cm}^2\right)\times 1}{BW_{16\text{-}26}\ (80\ \text{kg})}\right)\end{array}\right]$$

and:

$$ET_{\text{event-res-adj}}\left(\frac{0.6708\ \text{hours}}{\text{event}}\right) = \frac{\left(\begin{array}{c}ET_{\text{event-res}(0\text{-}2)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)\times ED_{0\text{-}2}\ (2\ \text{years})+ET_{\text{event-res}(2\text{-}6)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)\times ED_{2\text{-}6}\ (4\ \text{years})+\\ ET_{\text{event-res}(6\text{-}16)}\left(\frac{0.71\ \text{hours}}{\text{event}}\right)\times ED_{6\text{-}16}\ (10\ \text{years})+ET_{\text{event-res}(16\text{-}26)}\left(\frac{0.71\ \text{hours}}{\text{event}}\right)\times ED_{16\text{-}26}\ (10\ \text{years})\end{array}\right)}{ED_{0\text{-}2}\ (2\ \text{years})\ +ED_{2\text{-}6}\ (4\ \text{years})\ +ED_{6\text{-}16}\ (10\ \text{years})\ +ED_{16\text{-}26}\ (10\ \text{years})}$$

- inhalation of volatiles

$$SL_{res\text{-}wat\text{-}tce\text{-}inh}\left(\mu g/L\right) = \frac{TR \times AT_{res}\left(\frac{365\ \text{days}}{\text{year}} \times LT\left(70\ \text{years}\right)\right)}{\begin{array}{l} IUR\left(\frac{\mu g}{m^{3}}\right)^{-1} \times K\left(\frac{0.5\ L}{m^{3}}\right) \times \\ \Bigg(\Bigg(EF_{res}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{res}\left(26\ \text{years}\right) \times ET_{res}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times CAF_{i}\left(0.756\right)\Bigg) + \\ \Bigg(\Bigg(\Bigg(ED_{0-2}\left(2\ \text{years}\right) \times EF_{0-2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{0-2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times MAF_{i}\left(0.244\right) \times 10\Bigg) + \\ \Bigg(ED_{2-6}\left(4\ \text{years}\right) \times EF_{2-6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{2-6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times MAF_{i}\left(0.244\right) \times 3\Bigg) + \\ \Bigg(ED_{6-16}\left(10\ \text{years}\right) \times EF_{6-16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{6-16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times MAF_{i}\left(0.244\right) \times 3\Bigg) + \\ \Bigg(ED_{16-26}\left(10\ \text{years}\right) \times EF_{16-26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{16-26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times MAF_{i}\left(0.244\right) \times 1\Bigg)\Bigg)\Bigg)\Bigg) \end{array}}$$

- Total

$$SL_{res\text{-}wat\text{-}tce\text{-}tot}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{res\text{-}wat\text{-}tce\text{-}ing}} + \frac{1}{SL_{res\text{-}wat\text{-}tce\text{-}der}} + \frac{1}{SL_{res\text{-}wat\text{-}tce\text{-}inh}}}$$

4.1.2.7 Supporting Equations

- Child

$$\mathrm{ED}_{\text{res-c}}\left(6\ \text{years}\right)=\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)$$

$$\mathrm{BW}_{\text{res-c}}\left(15\ \text{kg}\right)=\frac{\mathrm{BW}_{0\text{-}2}\left(15\ \text{kg}\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{BW}_{2\text{-}6}\left(15\ \text{kg}\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$\mathrm{EV}_{\text{res-c}}\left(\frac{1\ \text{event}}{\text{day}}\right)=\frac{\mathrm{EV}_{0\text{-}2}\left(\frac{1\ \text{event}}{\text{day}}\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{EV}_{2\text{-}6}\left(\frac{1\ \text{event}}{\text{day}}\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$\mathrm{EF}_{\text{res-c}}\left(\frac{350\ \text{days}}{\text{year}}\right)=\frac{\mathrm{EF}_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{EF}_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$\mathrm{ET}_{\text{event-res-c}}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)=\frac{\mathrm{ET}_{\text{event}\,(0\text{-}2)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ET}_{\text{event}\,(2\text{-}4)}\left(\frac{0.54\ \text{hours}}{\text{event}}\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$\mathrm{ET}_{\text{res-c}}\left(\frac{24\ \text{hours}}{\text{day}}\right)=\frac{\mathrm{ET}_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ET}_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$\mathrm{SA}_{\text{res-c}}\left(6365\ \text{cm}^2\right)=\frac{\mathrm{SA}_{0\text{-}2}\left(6365\ \text{cm}^2\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{SA}_{2\text{-}6}\left(6365\ \text{cm}^2\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

$$\mathrm{IRW}_{\text{res-c}}\left(\frac{0.78\ \text{L}}{\text{day}}\right)=\frac{\mathrm{IRW}_{0\text{-}2}\left(\frac{0.78\ \text{L}}{\text{day}}\right)\times\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{IRW}_{2\text{-}6}\left(\frac{0.78\ \text{L}}{\text{day}}\right)\times\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}{\mathrm{ED}_{0\text{-}2}\left(2\ \text{years}\right)+\mathrm{ED}_{2\text{-}6}\left(4\ \text{years}\right)}$$

- Adult

$$ED_{res\text{-}a}\left(20\text{ years}\right) = ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)$$

$$BW_{res\text{-}a}\left(80\text{ kg}\right) = \frac{BW_{6\text{-}16}\left(80\text{ kg}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + BW_{16\text{-}26}\left(80\text{ kg}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$EV_{res\text{-}a}\left(\frac{1\text{ event}}{\text{day}}\right) = \frac{EV_{6\text{-}16}\left(\frac{1\text{ event}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + EV_{16\text{-}26}\left(\frac{1\text{ event}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$EF_{res\text{-}a}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$ET_{event\text{-}res\text{-}a}\left(\frac{0.71\text{ hours}}{\text{event}}\right) = \frac{ET_{event\left(6\text{-}16\right)}\left(\frac{0.71\text{ hours}}{\text{event}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + ET_{event\left(16\text{-}26\right)}\left(\frac{0.71\text{ hours}}{\text{event}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$ET_{res\text{-}a}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$SA_{res\text{-}a}\left(19652\text{ cm}^2\right) = \frac{SA_{6\text{-}16}\left(19652\text{ cm}^2\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + SA_{16\text{-}26}\left(19652\text{ cm}^2\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$IRW_{res\text{-}a}\left(\frac{2.5\text{ L}}{\text{day}}\right) = \frac{IRW_{6\text{-}16}\left(\frac{2.5\text{ L}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + IRW_{16\text{-}26}\left(\frac{2.5\text{ L}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right)}{ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

- Age-adjusted

$$ED_{res}\left(26\text{ years}\right) = ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)$$

$$EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{\begin{array}{c} EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{0\text{-}2}\left(2\text{ years}\right) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{2\text{-}6}\left(4\text{ years}\right) + \\ EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right) \end{array}}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

$$ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right) = \frac{\begin{array}{c} ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{0\text{-}2}\left(2\text{ years}\right) + ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{2\text{-}6}\left(4\text{ years}\right) + \\ ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{6\text{-}16}\left(10\text{ years}\right) + ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times ED_{16\text{-}26}\left(10\text{ years}\right) \end{array}}{ED_{0\text{-}2}\left(2\text{ years}\right) + ED_{2\text{-}6}\left(4\text{ years}\right) + ED_{6\text{-}16}\left(10\text{ years}\right) + ED_{16\text{-}26}\left(10\text{ years}\right)}$$

4.1.3 Resident Air

This receptor spends most, if not all, of the day at home. The activities for this receptor involve typical home making chores (cooking, cleaning and laundering) as well as outdoor activities. The resident is assumed to be exposed to contaminants via the following pathway: inhalation of ambient air. This land use has no assumptions of how contaminants get into the air and the RSLs derived should be compared to air samples.

This land use is for developing residential default screening levels that are presented in the RSL Generic Tables.

4.1.3.1 Noncarcinogenic

The air land use equation, presented here, contains the following exposure routes:

- inhalation

$$SL_{res\text{-}air\text{-}nc}\left(\mu g/m^3\right) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ days}{year} \times ED_{res}\left(26\ years\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{res}\left(\frac{350\ days}{year}\right) \times ED_{res}\left(26\ years\right) \times ET_{res}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left({}^{mg}\!/_{m^3}\right)}}$$

4.1.3.2 Carcinogenic

The air land use equation, presented here, contains the following exposure routes:

- inhalation

$$SL_{res\text{-}air\text{-}ca}\left(\mu g/m^3\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{EF_{res}\left(\frac{350\ days}{year}\right) \times ED_{res}\left(26\ years\right) \times ET_{res}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left({}^{\mu g}\!/_{m^3}\right)^{-1}}$$

4.1.3.3 Mutagenic

The air land use equation, presented here, contains the following exposure routes:

- inhalation

$$SL_{res\text{-}air\text{-}mu}\left(\mu g/m^3\right) = \frac{TR \times AT_{res}\left(\frac{365\text{ days}}{\text{year}} \times LT\left(70\text{ years}\right)\right)}{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \left(\begin{array}{l}\left(ED_{0\text{-}2}\left(2\text{ years}\right) \times EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right) \times 10\right) + \\ \left(ED_{2\text{-}6}\left(4\text{ years}\right) \times EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right) \times 3\right) + \\ \left(ED_{6\text{-}16}\left(10\text{ years}\right) \times EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right) \times 3\right) + \\ \left(ED_{16\text{-}26}\left(10\text{ years}\right) \times EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right) \times ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right) \times 1\right)\end{array}\right)}$$

4.1.3.4 Vinyl Chloride - Carcinogenic

The air land use equation, presented here, contains the following exposure routes:

- inhalation

$$SL_{res\text{-}air\text{-}ca\text{-}vc}\left(\mu g/m^3\right) = \frac{TR}{IUR\left(\frac{\mu g}{m^3}\right)^{-1} + \left(\frac{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{res}\left(26\text{ years}\right) \times ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right)}{AT_{res}\left(\frac{365\text{ days}}{\text{year}} \times LT\left(70\text{ years}\right)\right)}\right)}$$

4.1.3.5 Trichloroethylene - Carcinogenic and Mutagenic

The air land use equation, presented here, contains the following exposure routes:

- inhalation

$$SL_{res\text{-}air\text{-}tce}\left(\mu g/m^{3}\right)=\frac{TR\times AT_{res}\left(\frac{365\text{ days}}{\text{year}}\times LT\left(70\text{ years}\right)\right)}{\begin{array}{l}IUR\left(\mu g/m^{3}\right)^{-1}\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\\ \left(\begin{array}{l}\left(ED_{res}\left(26\text{ years}\right)\times EF_{res}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{res}\left(\frac{24\text{ hours}}{\text{day}}\right)\times CAF_{i}\left(0.756\right)\right)+\\ \left(\begin{array}{l}\left(ED_{0\text{-}2}\left(2\text{ years}\right)\times EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_{i}\left(0.244\right)\times 10\right)+\\ \left(ED_{2\text{-}6}\left(4\text{ years}\right)\times EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_{i}\left(0.244\right)\times 3\right)+\\ \left(ED_{6\text{-}16}\left(10\text{ years}\right)\times EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_{i}\left(0.244\right)\times 3\right)+\\ \left(ED_{16\text{-}26}\left(10\text{ years}\right)\times EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_{i}\left(0.244\right)\times 1\right)\end{array}\right)\end{array}\right)\end{array}}$$

4.2 Composite Worker

4.2.1 Composite Worker Soil

This is a long-term receptor exposed during the work day who is a full-time employee working on-site and spends most of the workday conducting maintenance activities outdoors. The activities for this receptor (e.g., moderate digging, landscaping) typically involve on-site exposure to surface soils. The composite worker is expected to have an elevated soil ingestion rate (100 mg per day) and is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with soil, inhalation of volatiles and fugitive dust. The composite worker combines the most protective exposure assumptions of the outdoor and indoor workers. The only difference between the outdoor worker and the composite worker is that the composite worker uses the more protective exposure frequency of 250 days/year from the indoor worker scenario.

This land use is for developing industrial default screening levels that are presented in the RSL Generic Tables.

4.2.1.1 Noncarcinogenic

The composite worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{w\text{-}soil\text{-}nc\text{-}ing}\left(mg/kg\right)=\frac{THQ\times AT_{w\text{-}a}\left(\frac{365\text{ days}}{\text{year}}\times ED_{w}\left(25\text{ years}\right)\right)\times BW_{w}\left(80\text{ kg}\right)}{EF_{w}\left(250\ \frac{\text{days}}{\text{year}}\right)\times ED_{w}\left(25\text{ years}\right)\times\frac{RBA}{RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)}\times IR_{w}\left(100\ \frac{mg}{day}\right)\times\left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- dermal exposure

$$SL_{w\text{-}soil\text{-}nc\text{-}der}\,(mg/kg) = \frac{THQ \times AT_{w\text{-}a}\left(\frac{365\ days}{year} \times ED_w\ (25\ years)\right) \times BW_w\ (80\ kg)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\ (25\ years) \times \left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right) \times SA_w\left(\frac{3527\ cm^2}{day}\right) \times AF_w\left(\frac{0.12\ mg}{cm^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{w\text{-}soil\text{-}nc\text{-}inh}\,(mg/kg) = \frac{THQ \times AT_{w\text{-}a}\left(\frac{365\ days}{year} \times ED_w\ (25\ years)\right)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\ (25\ years) \times ET_w\left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(mg/m^3\right)} \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right)}$$

- Total

$$SL_{w\text{-}soil\text{-}nc\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{w\text{-}soil\text{-}nc\text{-}ing}} + \frac{1}{SL_{w\text{-}soil\text{-}nc\text{-}der}} + \frac{1}{SL_{w\text{-}soil\text{-}nc\text{-}inh}}}$$

4.2.1.2 Carcinogenic

The composite worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{w\text{-}soil\text{-}ca\text{-}ing}\,(mg/kg) = \frac{TR \times AT_w\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times BW_w\ (80\ kg)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\ (25\ years) \times CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IR_w\left(100\ \frac{mg}{day}\right) \times \left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- dermal exposure

$$SL_{w\text{-}soil\text{-}ca\text{-}der}\,(mg/kg) = \frac{TR \times AT_w\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times BW_w\ (80\ kg)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\ (25\ years) \times \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times SA_w\left(\frac{3527\ cm^2}{day}\right) \times AF_w\left(\frac{0.12\ mg}{cm^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{w\text{-}soil\text{-}ca\text{-}inh}\,(mg/kg) = \frac{TR \times AT_w\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{EF_w\left(250\ \frac{days}{year}\right) \times ED_w\ (25\ years) \times ET_w\left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right)}$$

$$SL_{w\text{-}soil\text{-}ca\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{w\text{-}soil\text{-}ca\text{-}ing}} + \frac{1}{SL_{w\text{-}soil\text{-}ca\text{-}der}} + \frac{1}{SL_{w\text{-}soil\text{-}ca\text{-}inh}}}$$

- Total

4.2.2 Composite Worker Air

This is a long-term receptor exposed during the work day who is a full-time employee working on-site and spends most of the workday conducting maintenance activities indoors. The composite worker is assumed to be exposed to contaminants via the following pathway: inhalation of ambient air. The composite worker combines the most protective exposure assumptions of the outdoor and indoor workers. The only difference between the outdoor worker and the composite worker is that the composite worker uses the more protective exposure frequency of 250 days/year from the indoor worker scenario. This land use has no assumptions of how contaminants get into the air and the RSLs derived should be compared to air samples.

This land use is for developing industrial default screening levels that are presented in the RSL Generic Tables.

4.2.2.1 Noncarcinogenic

The air land use equation, presented here, contains the following exposure routes:

- Inhalation

$$SL_{w\text{-air-nc}}\left(\mu g/m^3\right) = \frac{THQ \times AT_w\left(\frac{365\ \text{days}}{\text{year}} \times ED_w\ (25\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_w\left(\frac{250\ \text{days}}{\text{year}}\right) \times ED_w\ (25\ \text{years}) \times ET_w\left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \frac{1}{RfC\left({}^{mg}/{}_{m^3}\right)}}$$

4.2.2.2 Carcinogenic

The air land use equation, presented here, contains the following exposure routes:

- Inhalation

$$SL_{w\text{-air-ca}}\left(\mu g/m^3\right) = \frac{TR \times AT_w\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{EF_w\left(\frac{250\ \text{days}}{\text{year}}\right) \times ED_w\ (25\ \text{years}) \times ET_w\left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times IUR\left({}^{\mu g}/{}_{m^3}\right)^{-1}}$$

4.3 Outdoor Worker

4.3.1 Outdoor Worker Soil

This is a long-term receptor exposed during the work day who is a full-time employee working on-site and spends most of the workday conducting maintenance activities outdoors. The activities for this receptor (e.g., moderate digging, landscaping) typically involve on-site exposure to surface soils. The outdoor worker is expected to have an elevated soil ingestion rate (100 mg per day) and is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with soil, inhalation of volatiles and fugitive dust. The outdoor worker receives more exposure than the indoor worker under commercial/industrial conditions.

The outdoor worker soil land use is not provided in the RSL Generic Tables but RSLs can be created by using the Calculator.

4.3.1.1 Noncarcinogenic

The outdoor worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{ow\text{-}soil\text{-}nc\text{-}ing}\left(mg/kg\right)=\frac{THQ\times AT_{ow\text{-}a}\left(\frac{365\ days}{year}\times ED_{ow}\left(25\ years\right)\right)\times BW_{ow}\left(80\ kg\right)}{EF_{ow}\left(225\ \frac{days}{year}\right)\times ED_{ow}\left(25\ years\right)\times\frac{RBA}{RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)}\times IR_{ow}\left(100\ \frac{mg}{day}\right)\times\left(\frac{10^{-6}\ kg}{1\ mg}\right.}$$

- dermal exposure

$$SL_{ow\text{-}soil\text{-}nc\text{-}der}\left(mg/kg\right)=\frac{THQ\times AT_{ow\text{-}a}\left(\frac{365\ days}{year}\times ED_{ow}\left(25\ years\right)\right)\times BW_{ow}\left(80\ kg\right)}{EF_{ow}\left(225\ \frac{days}{year}\right)\times ED_{ow}\left(25\ years\right)\times\left(\frac{1}{RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)\times GIABS}\right)\times SA_{ow}\left(\frac{3527\ cm^{2}}{day}\right)\times AF_{ow}\left(\frac{0.12\ mg}{cm^{2}}\right)\times ABS_{d}\times\left(\frac{10^{-6}\ kg}{1\ mg}\right.}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{ow\text{-}soil\text{-}nc\text{-}inh}\left(mg/kg\right)=\frac{THQ\times AT_{ow\text{-}a}\left(\frac{365\ days}{year}\times ED_{ow}\left(25\ years\right)\right)}{EF_{ow}\left(225\ \frac{days}{year}\right)\times ED_{ow}\left(25\ years\right)\times ET_{ow}\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\frac{1}{RfC\left(\frac{mg}{m^{3}}\right)}\times\left(\frac{1}{VF_{ulim}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF\left(\frac{m^{3}}{kg}\right)}\right)}$$

- Total

$$SL_{ow\text{-}soil\text{-}nc\text{-}tot}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{ow\text{-}soil\text{-}nc\text{-}ing}}+\frac{1}{SL_{ow\text{-}soil\text{-}nc\text{-}der}}+\frac{1}{SL_{ow\text{-}soil\text{-}nc\text{-}inh}}}$$

4.3.1.2 Carcinogenic

The outdoor worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil,

$$SL_{ow\text{-}soil\text{-}ca\text{-}ing}\left(mg/kg\right)=\frac{TR\times AT_{ow}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times BW_{ow}\left(80\ kg\right)}{EF_{ow}\left(225\ \frac{days}{year}\right)\times ED_{ow}\left(25\ years\right)\times CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IR_{ow}\left(100\ \frac{mg}{day}\right)\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- dermal exposure,

$$SL_{ow\text{-}soil\text{-}ca\text{-}der}\left(mg/kg\right)=\frac{TR\times AT_{ow}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times BW_{ow}\left(80\ kg\right)}{EF_{ow}\left(225\ \frac{days}{year}\right)\times ED_{ow}\left(25\ years\right)\times\left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times SA_{ow}\left(\frac{3527\ cm^{2}}{day}\right)\times AF_{ow}\left(\frac{0.12\ mg}{cm^{2}}\right)\times ABS_{d}\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- inhalation of volatiles and particulates emitted from soil,

$$SL_{\text{ow-soil-ca-inh}}\,(\text{mg/kg}) = \frac{TR \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right)}{EF_{ow}\left(225\ \frac{\text{days}}{\text{year}}\right) \times ED_{ow}\,(25\ \text{years}) \times ET_{ow}\ \left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times \left(\frac{1000\ \mu g}{\text{mg}}\right) \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right)}$$

- Total.

$$SL_{\text{ow-soil-ca-tot}}\,(\text{mg/kg}) = \frac{1}{\frac{1}{SL_{\text{ow-soil-ca-ing}}} + \frac{1}{SL_{\text{ow-soil-ca-der}}} + \frac{1}{SL_{\text{ow-soil-ca-inh}}}}$$

4.3.2 Outdoor Worker Air

This is a long-term receptor exposed during the work day who is a full-time employee working on-site and spends most of the workday conducting maintenance activities outdoors. The outdoor worker is assumed to be exposed to contaminants via the following pathway: inhalation of ambient air. This land use has no assumptions of how contaminants get into the air and the RSLs derived should be compared to air samples.

The outdoor worker air land use is not provided in the RSL Generic Tables but RSLs can be created by using the Calculator.

4.3.2.1 Noncarcinogenic

The air land use equation, presented here, contains the following exposure routes:

- Inhalation

$$SL_{\text{ow-air-nc}}\left(\mu g/m^3\right) = \frac{THQ \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times ED_{ow}\,(25\ \text{years})\right) \times \left(\frac{1000\ \mu g}{\text{mg}}\right)}{EF_{ow}\left(\frac{225\ \text{days}}{\text{year}}\right) \times ED_{ow}\,(25\ \text{years}) \times ET_{ow}\left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)}}$$

4.3.2.2 Carcinogenic

The air land use equation, presented here, contains the following exposure routes:

- Inhalation

$$SL_{\text{ow-air-ca}}\left(\mu g/m^3\right) = \frac{TR \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right)}{EF_{ow}\left(\frac{225\ \text{days}}{\text{year}}\right) \times ED_{ow}\,(25\ \text{years}) \times ET_{ow}\left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1}}$$

4.4 Indoor Worker

4.4.1 Indoor Worker Soil

This receptor spends most, if not all, of the workday indoors. Thus, an indoor worker has no direct dermal contact with outdoor soils. This worker may, however, be exposed to contaminants through ingestion of contaminated soils that have been incorporated into indoor dust and inhalation of volatiles and particulates from outside soils. RSLs calculated for this receptor are expected to be protective of both workers engaged in low intensity activities such as office work and those engaged in more strenuous activity (e.g., factory or warehouse workers).

The indoor worker soil land use is not provided in the Generic Tables but RSLs can be created by using the Calculator.

4.4.1.1 Noncarcinogenic

The indoor worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{iw\text{-}soil\text{-}nc\text{-}ing}\left(mg/kg\right)=\frac{THQ\times AT_{iw\text{-}a}\left(\frac{365\ days}{year}\times ED_{iw}\left(25\ years\right)\right)\times BW_{iw}\left(80\ kg\right)}{EF_{iw}\left(250\ \frac{days}{year}\right)\times ED_{iw}\left(25\ years\right)\times\frac{RBA}{RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)}\times IR_{iw}\left(50\ \frac{mg}{day}\right)\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{iw\text{-}soil\text{-}nc\text{-}inh}\left(mg/kg\right)=\frac{THQ\times AT_{iw\text{-}a}\left(\frac{365\ days}{year}\times ED_{iw}\left(25\ years\right)\right)}{EF_{iw}\left(250\ \frac{days}{year}\right)\times ED_{iw}\left(25\ years\right)\times ET_{iw}\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\frac{1}{RfC\left(mg/m^{3}\right)}\times\left(\frac{1}{VF_{ulim}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF\left(\frac{m^{3}}{kg}\right)}\right)}$$

- Total

$$SL_{iw\text{-}soil\text{-}nc\text{-}tot}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{iw\text{-}soil\text{-}nc\text{-}ing}}+\frac{1}{SL_{iw\text{-}soil\text{-}nc\text{-}inh}}}$$

4.4.1.2 Carcinogenic

The indoor worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{iw\text{-}soil\text{-}ca\text{-}ing}\left(mg/kg\right)=\frac{TR\times AT_{iw}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times BW_{iw}\left(80\ kg\right)}{EF_{iw}\left(250\ \frac{days}{year}\right)\times ED_{iw}\left(25\ years\right)\times CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IR_{iw}\left(50\ \frac{mg}{day}\right)\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{iw\text{-}soil\text{-}ca\text{-}inh}\left(mg/kg\right) = \frac{TR \times AT_{iw}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{EF_{iw}\left(250\ \frac{days}{year}\right) \times ED_{iw}\left(25\ years\right) \times ET_{iw}\ \left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\mu g\big/_{m^3}\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right)}$$

- Total

$$SL_{iw\text{-}soil\text{-}ca\text{-}tot}\left(mg/kg\right) = \frac{1}{\frac{1}{SL_{iw\text{-}soil\text{-}ca\text{-}ing}} + \frac{1}{SL_{iw\text{-}soil\text{-}ca\text{-}inh}}}$$

4.4.2 Indoor Worker Air

This is a long-term receptor exposed during the work day who is a full-time employee working on-site and spends most of the workday conducting maintenance activities indoors. The indoor worker is assumed to be exposed to contaminants via the following pathway: inhalation of ambient air. This land use has no assumptions of how contaminants get into the air and the RSLs derived should be compared to air samples.

The indoor worker air land use is not provided in the Generic Tables but RSLs can be created by using the Calculator.

4.4.2.1 Noncarcinogenic

The air land use equation, presented here, contains the following exposure routes:

- Inhalation

$$SL_{iw\text{-}air\text{-}nc}\left(\mu g/m^3\right) = \frac{THQ \times AT_{iw}\left(\frac{365\ days}{year} \times ED_{iw}\left(25\ years\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_{iw}\left(\frac{250\ days}{year}\right) \times ED_{iw}\left(25\ years\right) \times ET_{iw}\left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(mg\big/_{m^3}\right)}}$$

4.4.2.2 Carcinogenic

The air land use equation, presented here, contains the following exposure routes:

- Inhalation

$$SL_{iw\text{-}air\text{-}ca}\left(\mu g/m^3\right) = \frac{TR \times AT_{iw}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{EF_{iw}\left(\frac{250\ days}{year}\right) \times ED_{iw}\left(25\ years\right) \times ET_{iw}\left(\frac{8\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\mu g\big/_{m^3}\right)^{-1}}$$

4.5 Construction Worker

An assessment for the construction worker scenario is described in more detail in the Supplemental Soil Screening Guidance (SSSG, EPA, 2002). Despite the exposure duration of one year, carcinogenic risk is averaged over an assumed lifetime of 70 years, consistent with the assumption that the risk of developing cancer continues even after exposure has stopped. EPA guidance states that the averaging time for noncancer is to be set at the same length as exposure duration, even if the exposure duration is less than one year. For noncancer, the averaging time can be changed to be less than a year by changing the number of weeks worked (EW). Further, the examples given in the SSSG show that the time of traffic (Tt) is equivalent to EF and time of construction (T_c) is the averaging time (length of project).

The particulate emission factor (PEF) and volatilization factor (VF) equations used are unique to this scenario. See Section 4.9 for further information on subchronic VFs and PEFs. The PEFs calculated in these scenarios may predict much higher air concentrations than the standard wind-driven PEFs; however, the inhalation screening level will likely be dominated by the VF in the case of a volatile contaminant. VFs are commonly 5 orders of magnitude more protective than PEFs. Additionally, the ingestion route typically is the driving factor in most RSL calculations. Two types of mechanical soil disturbance are addressed: standard vehicle traffic (unpaved) and other construction activities (wind, grading, dozing, tilling and excavating). In general, the intake and contact rates are all greater than the outdoor worker. Exhibit 5-1 in the supplemental soil screening guidance presents the exposure parameters

The construction worker soil land use is not provided in the Generic Tables but RSLs can be created by using the Calculator.

4.5.1 Construction Worker Soil Exposure to Standard Vehicle Traffic

This is a short-term receptor exposed during the work day working around vehicles suspending dust in the air. The activities for this receptor (e.g., trenching, excavating) typically involve on-site exposure to surface soils. The construction worker is expected to have an elevated soil ingestion rate (330 mg per day) and is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with contaminants in soil, inhalation of volatiles and fugitive dust. The only difference between this construction worker and the one described in section 4.5.2 is that this construction worker uses a different PEF. The construction worker soil land use is not provided in the Generic Tables but RSLs can be created by using the Calculator. The construction land use is described in the supplemental soil screening guidance. This land use is limited to an exposure duration of 1 year and is thus, subchronic. Other unique aspects of this scenario are that the PEF is based on mechanical disturbance of the soil. Two types of mechanical soil disturbance are addressed: standard vehicle traffic and other than standard vehicle traffic (e.g. wind, grading, dozing, tilling and excavating). In general, the intakes and contact rates are all greater than the outdoor worker. Exhibit 5-1 in the supplemental soil screening guidance presents the exposure parameters.

4.5.1.1 Noncarcinogenic

The construction worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{cw\text{-}soil\text{-}nc\text{-}ing}\left(\text{mg/kg}\right) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\left(1\text{ year}\right)\right) \times BW_{cw}\left(80\text{ kg}\right)}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\left(1\text{ year}\right) \times \frac{RBA}{RfD_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IR_{cw}\left(330\,\frac{\text{mg}}{\text{day}}\right) \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- dermal exposure

$$SL_{cw\text{-}soil\text{-}nc\text{-}der}\,(\text{mg/kg}) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\,(1\text{ year})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times \left(\frac{1}{RfD_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right) \times GIABS}\right) \times SA_{cw}\left(\frac{3527\text{ cm}^{2}}{\text{day}}\right) \times AF_{cw}\left(\frac{0.3\text{ mg}}{\text{cm}^{2}}\right) \times ABS_{d} \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{cw\text{-}soil\text{-}nc\text{-}inh}\,(\text{mg/kg}) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\,(1\text{ year})\right)}{EF_{cw}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times ET_{cw}\,\left(\frac{8\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \frac{1}{RfC\left(\text{mg}/\text{m}^{3}\right)} \times \left(\frac{1}{VF_{ulim\text{-}sc}\left(\frac{\text{m}^{3}}{\text{kg}}\right)} + \frac{1}{PEF_{sc}\left(\frac{\text{m}^{3}}{\text{kg}}\right)}\right)}$$

- Total

$$SL_{cw\text{-}soil\text{-}nc\text{-}tot}\,(\text{mg/kg}) = \frac{1}{\frac{1}{SL_{cw\text{-}soil\text{-}nc\text{-}ing}} + \frac{1}{SL_{cw\text{-}soil\text{-}nc\text{-}der}} + \frac{1}{SL_{cw\text{-}soil\text{-}nc\text{-}inh}}}$$

4.5.1.2 Carcinogenic

The construction worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil,

$$SL_{cw\text{-}soil\text{-}ca\text{-}ing}\,(\text{mg/kg}) = \frac{TR \times AT_{cw}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1} \times RBA \times IR_{cw}\left(330\,\frac{\text{mg}}{\text{day}}\right) \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- dermal exposure,

$$SL_{cw\text{-}soil\text{-}ca\text{-}der}\,(\text{mg/kg}) = \frac{TR \times AT_{cw}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right) \times BW_{cw}\,(80\text{ kg})}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times \left(\frac{CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\right) \times SA_{cw}\left(\frac{3527\text{ cm}^{2}}{\text{day}}\right) \times AF_{cw}\left(\frac{0.3\text{ mg}}{\text{cm}^{2}}\right) \times ABS_{d} \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- inhalation of volatiles and particulates emitted from soil,

$$SL_{cw\text{-}soil\text{-}ca\text{-}inh}\,(\text{mg/kg}) = \frac{TR \times AT_{cw}\left(\frac{365\text{ days}}{\text{year}} \times LT\,(70\text{ years})\right)}{EF_{cw}\left(EW_{cw}\,\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\,\frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\,(1\text{ year}) \times ET_{cw}\,\left(\frac{8\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times IUR\left(\mu\text{g}/\text{m}^{3}\right)^{-1} \times \left(\frac{1000\ \mu\text{g}}{\text{mg}}\right) \times \left(\frac{1}{VF_{ulim\text{-}sc}\left(\frac{\text{m}^{3}}{\text{kg}}\right)} + \frac{1}{PEF_{sc}\left(\frac{\text{m}^{3}}{\text{kg}}\right)}\right)}$$

- Total.

$$SL_{cw\text{-}soil\text{-}ca\text{-}tot}\,(\text{mg/kg}) = \frac{1}{\frac{1}{SL_{cw\text{-}soil\text{-}ca\text{-}ing}} + \frac{1}{SL_{cw\text{-}soil\text{-}ca\text{-}der}} + \frac{1}{SL_{cw\text{-}soil\text{-}ca\text{-}inh}}}$$

4.5.2 Construction Worker Soil Exposure to Other Construction Activities

This is a short-term receptor exposed during the work day working around heavy vehicles suspending dust in the air. The activities for this receptor (e.g., dozing, grading, tilling, dumping, and excavating) typically involve on-site exposure to surface soils. The construction worker is expected to have an elevated soil ingestion rate (330 mg per day) and is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with contaminants in soil, inhalation of volatiles and fugitive dust. The only difference between this construction worker and the one described in section 4.5.1 is that this construction worker uses a different PEF. The construction worker soil land use is not provided in the Generic Tables but RSLs can be created by using the Calculator. The construction land use is described in the supplemental soil screening guidance. This land use is limited to an exposure duration of 1 year and is thus, subchronic. Other unique aspects of this scenario are that the PEF is based on mechanical disturbance of the soil. Two types of mechanical soil disturbance are addressed: standard vehicle traffic and other than standard vehicle traffic (e.g. wind, grading, dozing, tilling and excavating). In general, the intakes and contact rates are all greater than the outdoor worker. Exhibit 5-1 in the supplemental soil screening guidance presents the exposure parameters.

4.5.2.1 Noncarcinogenic

The construction worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{cw\text{-}soil\text{-}nc\text{-}ing}\left(\text{mg/kg}\right) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\left(1\text{ year}\right)\right) \times BW_{cw}\left(80\text{ kg}\right)}{EF_{cw}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\ \frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\left(1\text{ year}\right) \times \frac{RBA}{RfD_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IR_{cw}\left(330\frac{\text{mg}}{\text{day}}\right) \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- dermal exposure

$$SL_{cw\text{-}soil\text{-}nc\text{-}der}\left(\text{mg/kg}\right) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\left(1\text{ year}\right)\right) \times BW_{cw}\left(80\text{ kg}\right)}{EF_{cw}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\ \frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\left(1\text{ year}\right) \times \left(\frac{1}{RfD_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right) \times GIABS}\right) \times SA_{cw}\left(\frac{3527\text{ cm}^{2}}{\text{day}}\right) \times AF_{cw}\left(\frac{0.3\text{ mg}}{\text{cm}^{2}}\right) \times ABS_{d} \times \left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{cw\text{-}soil\text{-}nc\text{-}inh}\left(\text{mg/kg}\right) = \frac{THQ \times AT_{cw\text{-}a}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times \frac{7\text{ days}}{\text{week}} \times ED_{cw}\left(1\text{ year}\right)\right)}{EF_{cw}\left(EW_{cw}\frac{50\text{ weeks}}{\text{year}} \times DW_{cw}\ \frac{5\text{ days}}{\text{week}}\right) \times ED_{cw}\left(1\text{ year}\right) \times ET_{cw}\ \left(\frac{8\text{ hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \frac{1}{RfC\left(\text{mg}/\text{m}^{3}\right)} \times \left(\frac{1}{VF_{ulim\text{-}sc}\left(\frac{\text{m}^{3}}{\text{kg}}\right)} + \frac{1}{PEF'_{sc}\left(\frac{\text{m}^{3}}{\text{kg}}\right)}\right)}$$

- Total

$$SL_{cw\text{-}soil\text{-}nc\text{-}tot}\left(\text{mg/kg}\right) = \frac{1}{\frac{1}{SL_{cw\text{-}soil\text{-}nc\text{-}ing}} + \frac{1}{SL_{cw\text{-}soil\text{-}nc\text{-}der}} + \frac{1}{SL_{cw\text{-}soil\text{-}nc\text{-}inh}}}$$

4.5.2.2 Carcinogenic

The construction worker soil land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil

$$SL_{cw\text{-}soil\text{-}ca\text{-}ing}\left(mg/kg\right)=\frac{TR\times AT_{cw}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times BW_{cw}\left(80\ kg\right)}{EF_{cw}\left(EW_{cw}\frac{50\ weeks}{year}\times DW_{cw}\ \frac{5\ days}{week}\right)\times ED_{cw}\left(1\ year\right)\times CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IR_{cw}\left(330\frac{mg}{day}\right)\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- dermal exposure

$$SL_{cw\text{-}soil\text{-}ca\text{-}der}\left(mg/kg\right)=\frac{TR\times AT_{cw}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times BW_{cw}\left(80\ kg\right)}{EF_{cw}\left(EW_{cw}\frac{50\ weeks}{year}\times DW_{cw}\ \frac{5\ days}{week}\right)\times ED_{cw}\left(1\ year\right)\times\left(\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times SA_{cw}\left(\frac{3527\ cm^{2}}{day}\right)\times AF_{cw}\left(\frac{0.3\ mg}{cm^{2}}\right)\times ABS_{d}\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}$$

- inhalation of volatiles and particulates emitted from soil

$$SL_{cw\text{-}soil\text{-}ca\text{-}inh}\left(mg/kg\right)=\frac{TR\times AT_{cw}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}{EF_{cw}\left(EW_{cw}\frac{50\ weeks}{year}\times DW_{cw}\ \frac{5\ days}{week}\right)\times ED_{cw}\left(1\ year\right)\times ET_{cw}\ \left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times IUR\left({}^{\mu g}/_{m^{3}}\right)^{-1}\times\left(\frac{1000\ \mu g}{mg}\right)\times\left(\frac{1}{VF_{ulim\text{-}sc}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF'_{sc}\left(\frac{m^{3}}{kg}\right)}\right)}$$

- Total

$$SL_{cw\text{-}soil\text{-}ca\text{-}tot}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{cw\text{-}soil\text{-}ca\text{-}ing}}+\frac{1}{SL_{cw\text{-}soil\text{-}ca\text{-}der}}+\frac{1}{SL_{cw\text{-}soil\text{-}ca\text{-}inh}}}$$

4.6 Recreator

4.6.1 Recreator Soil or Sediment

This receptor spends time outside involved in recreational activities. The recreator is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with contaminants in soil, and inhalation of volatiles and fugitive dust. There are no default RSLs for this scenario; only site-specific.

The recreator soil land use is not provided in the Generic Tables but RSLs can be created by using the Calculator.

4.6.1.1 Noncarcinogenic - Child

The recreator soil or sediment land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil or sediment

$$SL_{rec\text{-}soil\text{-}nc\text{-}ing\text{-}c}\left(mg/kg\right)=\frac{THQ\times AT_{rec\text{-}c}\left(\frac{365\ days}{year}\times ED_{rec\text{-}c}\left(years\right)\right)\times BW_{rec\text{-}c}\left(15\ kg\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times ED_{rec\text{-}c}\left(years\right)\times\frac{RBA}{RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)}\times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right)\times\frac{10^{-6}kg}{1mg}}$$

- dermal contact with soil or sediment

$$SL_{rec\text{-}soil\text{-}nc\text{-}der\text{-}c}\left(mg/kg\right)=\frac{THQ\times AT_{rec\text{-}c}\left(\frac{365\ days}{year}\times ED_{rec\text{-}c}\left(years\right)\right)\times BW_{rec\text{-}c}\left(15\ kg\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times ED_{rec\text{-}c}\left(years\right)\times\frac{1}{\left(RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)\times GIABS\right)}\times SA_{rec\text{-}c}\left(\frac{2373\ cm^{2}}{day}\right)\times AF_{rec\text{-}c}\left(\frac{0.2\ mg}{cm^{2}}\right)\times ABS_{d}\times\frac{10^{-6}kg}{1mg}}$$

- inhalation of volatiles and particulates emitted from soil or sediment

$$SL_{rec\text{-}soil\text{-}nc\text{-}inh\text{-}c}\left(mg/kg\right)=\frac{THQ\times AT_{rec\text{-}c}\left(\frac{365\ days}{year}\times ED_{rec\text{-}c}\left(6\ years\right)\right)}{EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times ED_{rec\text{-}c}\left(6\ years\right)\times ET_{rec\text{-}c}\left(\frac{hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\frac{1}{RfC\left(\frac{mg}{m^{3}}\right)}\times\left(\frac{1}{VF_{ulim}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF\left(\frac{m^{3}}{kg}\right)}\right)}$$

- Total

$$SL_{rec\text{-}soil\text{-}nc\text{-}tot\text{-}c}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{rec\text{-}soil\text{-}nc\text{-}ing}}+\frac{1}{SL_{rec\text{-}soil\text{-}nc\text{-}der}}+\frac{1}{SL_{rec\text{-}soil\text{-}nc\text{-}inh}}}$$

4.6.1.2 Noncarcinogenic - Adult

The recreator soil or sediment land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil or sediment

$$SL_{rec\text{-}soil\text{-}nc\text{-}ing\text{-}a}\left(mg/kg\right)=\frac{THQ\times AT_{rec\text{-}a}\left(\frac{365\ days}{year}\times ED_{rec\text{-}a}\left(years\right)\right)\times BW_{rec\text{-}a}\left(80\ kg\right)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times ED_{rec\text{-}a}\left(years\right)\times\frac{RBA}{RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)}\times IRS_{rec\text{-}a}\left(\frac{100\ mg}{day}\right)\times\frac{10^{-6}kg}{1mg}}$$

- dermal contact with soil or sediment

$$SL_{rec\text{-}soil\text{-}nc\text{-}der\text{-}a}\left(mg/kg\right)=\frac{THQ\times AT_{rec\text{-}a}\left(\frac{365\ days}{year}\times ED_{rec\text{-}a}\left(years\right)\right)\times BW_{rec\text{-}a}\left(80\ kg\right)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times ED_{rec\text{-}a}\left(years\right)\times\frac{1}{\left(RfD_{o}\left(\frac{mg}{kg\text{-}day}\right)\times GIABS\right)}\times SA_{rec\text{-}a}\left(\frac{6032\ cm^{2}}{day}\right)\times AF_{rec\text{-}a}\left(\frac{0.07\ mg}{cm^{2}}\right)\times ABS_{d}\times\frac{10^{-6}kg}{1mg}}$$

- inhalation of volatiles and particulates emitted from soil or sediment

$$SL_{rec\text{-}soil\text{-}nc\text{-}inh\text{-}a}\left(mg/kg\right)=\frac{THQ\times AT_{rec\text{-}a}\left(\frac{365\ days}{year}\times ED_{rec\text{-}a}\left(20\ years\right)\right)}{EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times ED_{rec\text{-}a}\left(20\ years\right)\times ET_{rec\text{-}a}\left(\frac{hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\frac{1}{RfC\left(\frac{mg}{m^{3}}\right)}\times\left(\frac{1}{VF_{ulim}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF\left(\frac{m^{3}}{kg}\right)}\right)}$$

- Total

$$SL_{rec\text{-}soil\text{-}nc\text{-}tot\text{-}a}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{rec\text{-}soil\text{-}nc\text{-}ing\text{-}a}}+\frac{1}{SL_{rec\text{-}soil\text{-}nc\text{-}der\text{-}a}}+\frac{1}{SL_{rec\text{-}soil\text{-}nc\text{-}inh\text{-}a}}}$$

4.6.1.3 Carcinogenic

The recreator soil or sediment land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil or sediment

$$\mathrm{SL}_{\text{rec-soil-ca-ing}}\left(\text{mg/kg}\right) = \frac{\mathrm{TR}\times\mathrm{AT}_{\text{rec}}\left(\frac{365\ \text{days}}{\text{year}}\times\mathrm{LT}\left(70\ \text{years}\right)\right)}{\mathrm{CSF}_{\text{o}}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}\times\mathrm{RBA}\times\mathrm{IFS}_{\text{rec-adj}}\left(\frac{\text{mg}}{\text{kg}}\right)\times\left(\frac{10^{-6}\text{kg}}{\text{mg}}\right)}$$

where:

$$\mathrm{IFS}_{\text{rec-adj}}\left(\frac{\text{mg}}{\text{kg}}\right) = \left(\frac{\mathrm{ED}_{\text{rec-c}}\left(\text{years}\right)\times\mathrm{EF}_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times\mathrm{IRS}_{\text{rec-c}}\left(\frac{200\ \text{mg}}{\text{day}}\right)}{\mathrm{BW}_{\text{rec-c}}\left(15\ \text{kg}\right)}+\frac{\mathrm{ED}_{\text{rec-a}}\left(\text{years}\right)\times\mathrm{EF}_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times\mathrm{IRS}_{\text{rec-a}}\left(\frac{100\ \text{mg}}{\text{day}}\right)}{\mathrm{BW}_{\text{rec-a}}\left(80\ \text{kg}\right)}\right)$$

- dermal contact with soil or sediment

$$\mathrm{SL}_{\text{rec-soil-ca-der}}\left(\text{mg/kg}\right) = \frac{\mathrm{TR}\times\mathrm{AT}_{\text{rec}}\left(\frac{365\ \text{days}}{\text{year}}\times\mathrm{LT}\left(70\ \text{years}\right)\right)}{\left(\frac{\mathrm{CSF}_{\text{o}}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{\mathrm{GIABS}}\right)\times\mathrm{DFS}_{\text{rec-adj}}\left(\frac{\text{mg}}{\text{Kg}}\right)\times\mathrm{ABS}_{\text{d}}\times\left(\frac{10^{-6}\text{kg}}{\text{mg}}\right)}$$

where:

$$\mathrm{DFS}_{\text{rec-adj}}\left(\frac{\text{mg}}{\text{kg}}\right) = \left(\begin{array}{c}\frac{\mathrm{ED}_{\text{rec-c}}\left(\text{years}\right)\times\mathrm{EF}_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times\mathrm{SA}_{\text{rec-c}}\left(\frac{2373\ \text{cm}^2}{\text{day}}\right)\times\mathrm{AF}_{\text{rec-c}}\left(\frac{0.2\text{mg}}{\text{cm}^2}\right)}{\mathrm{BW}_{\text{rec-c}}\left(15\ \text{kg}\right)}+\\ \frac{\mathrm{ED}_{\text{rec-a}}\left(\text{years}\right)\times\mathrm{EF}_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times\mathrm{SA}_{\text{rec-a}}\left(\frac{6032\ \text{cm}^2}{\text{day}}\right)\times\mathrm{AF}_{\text{rec-a}}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right)}{\mathrm{BW}_{\text{rec-a}}\left(80\ \text{kg}\right)}\end{array}\right)$$

- inhalation of volatiles and particulates emitted from soil or sediment

$$\mathrm{SL}_{\text{rec-soil-ca-inh}}\left(\text{mg/kg}\right) = \frac{\mathrm{TR}\times\mathrm{AT}_{\text{rec}}\left(\frac{365\ \text{days}}{\text{year}}\times\mathrm{LT}\left(70\ \text{years}\right)\right)}{\mathrm{IUR}\left({}^{\mu\text{g}}\!/\!{}_{\text{m}^3}\right)^{-1}\times\left(\frac{1000\ \mu\text{g}}{\text{mg}}\right)\times\mathrm{EF}_{\text{rec}}\left(\frac{\text{days}}{\text{year}}\right)\times\left(\frac{1}{\mathrm{VF}_{\text{ulim}}\left(\frac{\text{m}^3}{\text{kg}}\right)}+\frac{1}{\mathrm{PEF}\left(\frac{\text{m}^3}{\text{kg}}\right)}\right)\times\mathrm{ED}_{\text{rec}}\left(26\ \text{years}\right)\times\mathrm{ET}_{\text{rec}}\left(\frac{\text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)}$$

- Total

$$\mathrm{SL}_{\text{rec-soil-ca-tot}}\left(\text{mg/kg}\right) = \frac{1}{\frac{1}{\mathrm{SL}_{\text{rec-soil-ca-ing}}}+\frac{1}{\mathrm{SL}_{\text{rec-soil-ca-der}}}+\frac{1}{\mathrm{SL}_{\text{rec-soil-ca-inh}}}}$$

4.6.1.4 Mutagenic

The recreator soil or sediment land use equation, presented here, contains the following exposure routes:

- incidental ingestion of soil or sediment,

$$SL_{rec\text{-}soil\text{-}mu\text{-}ing}\left(mg/kg\right) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right)}{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$IFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l} \frac{ED_{0\text{-}2}\left(years\right) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{ED_{2\text{-}6}\left(years\right) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{ED_{6\text{-}16}\left(years\right) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{ED_{16\text{-}26}\left(years\right) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

- dermal contact with soil or sediment

$$SL_{rec\text{-}soil\text{-}mu\text{-}der}\left(mg/kg\right)=\frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\times ABS_d\times\left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0\text{-}2}\left(years\right)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right)\times 10}{BW_{0\text{-}2}\left(15\ kg\right)}+\\ \frac{ED_{2\text{-}6}\left(years\right)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right)\times 3}{BW_{2\text{-}6}\left(15\ kg\right)}+\\ \frac{ED_{6\text{-}16}\left(years\right)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right)\times 3}{BW_{6\text{-}16}\left(80\ kg\right)}+\\ \frac{ED_{16\text{-}26}\left(years\right)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right)\times 1}{BW_{16\text{-}26}\left(80\ kg\right)}\end{array}\right)$$

- inhalation of volatiles and particulates emitted from soil or sediment

$$SL_{rec\text{-}soil\text{-}mu\text{-}inh}\left(mg/kg\right)=\frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}{IUR\left({}^{\mu g}\!/_{m^3}\right)^{-1}\times\left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times\left(\begin{array}{l}\left(ED_{0\text{-}2}\left(2\ years\right)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times ET_{0\text{-}2}\left(\frac{hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times 10\right)+\\ \left(ED_{2\text{-}6}\left(4\ years\right)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times ET_{2\text{-}6}\left(\frac{hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times 3\right)+\\ \left(ED_{6\text{-}16}\left(10\ years\right)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times ET_{6\text{-}16}\left(\frac{hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times 3\right)+\\ \left(ED_{16\text{-}26}\left(10\ years\right)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times ET_{16\text{-}26}\left(\frac{hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times 1\right)\end{array}\right)}$$

- Total

$$SL_{rec\text{-}soil\text{-}mu\text{-}tot}\left(mg/kg\right) = \frac{1}{\frac{1}{SL_{rec\text{-}soil\text{-}mu\text{-}ing}}+\frac{1}{SL_{rec\text{-}soil\text{-}mu\text{-}der}}+\frac{1}{SL_{rec\text{-}soil\text{-}mu\text{-}inh}}}$$

4.6.1.5 Vinyl Chloride - Carcinogenic

The recreator soil or sediment land use equations, presented here, contain the following exposure routes:

- incidental ingestion of soil or sediment

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}ing}\left(mg/kg\right) = \frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\times\frac{10^{-6}kg}{1\ mg}}{AT_{rec}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}\right)+\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right)\times\frac{10^{-6}kg}{1\ mg}}{BW_{rec\text{-}c}\left(15\ kg\right)}\right)}$$

- dermal contact with soil or sediment

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}der}\left(mg/kg\right) = \frac{TR}{\left(\frac{\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\times DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\times ABS_d\times\frac{10^{-6}kg}{1\ mg}}{AT_{rec}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}\right)+\left(\frac{\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\times SA_{rec\text{-}c}\left(\frac{2373\ cm^2}{day}\right)\times AF_{rec\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)\times ABS\times\frac{10^{-6}kg}{1\ mg}}{BW_{rec\text{-}c}\left(15\ kg\right)}\right)}$$

- inhalation of volatiles and particulates emitted from soil or sediment

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}inh}\left(\text{mg/kg}\right) = \frac{TR}{\left(\frac{IUR\left(\mu g/m^{3}\right)^{-1} \times EF_{rec}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{rec}\left(26\text{ years}\right) \times ET_{rec}\left(\frac{\text{hours}}{\text{day}}\right) \times \left(\frac{1\text{ day}}{24\text{ hours}}\right) \times \left(\frac{1000\ \mu g}{\text{mg}}\right)}{AT_{rec}\left(\frac{365\text{ days}}{\text{year}} \times LT\left(70\text{ years}\right)\right) \times VF_{ulim}\left(\frac{m^{3}}{kg}\right)}\right) + \left(\frac{IUR\left(\mu g/m^{3}\right)^{-1}}{VF_{ulim}\left(\frac{m^{3}}{kg}\right)} \times \left(\frac{1000\ \mu g}{\text{mg}}\right)\right)}$$

- Total

$$SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}tot}\left(\text{mg/kg}\right) = \frac{1}{\frac{1}{SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}ing}} + \frac{1}{SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}der}} + \frac{1}{SL_{rec\text{-}soil\text{-}ca\text{-}vc\text{-}inh}}}$$

4.6.1.6 Trichloroethylene - Carcinogenic and Mutagenic

The recreator soil or sediment land use equations, presented here, contain the following exposure routes:

- incidental ingestion of soil or sediment

$$SL_{rec\text{-}soil\text{-}tce\text{-}ing}\left(mg/kg\right) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times RBA\times\left(\frac{10^{-6}\ kg}{mg}\right)\times\left(\begin{array}{l}\left(CAF_{o}\ (0.804)\times IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\right)+\\ \left(MAF_{o}\ (0.202)\times IFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right)\right)\end{array}\right)}$$

where:

$$IFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l}\frac{ED_{rec\text{-}c}\ (years)\times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times IRS_{rec\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{rec\text{-}c}\ (15\ kg)}+\\ \frac{\left(ED_{rec}\ (years)-\ ED_{rec\text{-}c}\ (years)\right)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times IRS_{rec\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{rec\text{-}a}\ (80\ kg)}\end{array}\right)$$

where:

$$IFSM_{rec\text{-}adj\text{-}}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l}\frac{ED_{0\text{-}2}\ (years)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right)\times 10}{BW_{0\text{-}2}\ (15\ kg)}+\\ \frac{ED_{2\text{-}6}\ (years)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right)\times 3}{BW_{2\text{-}6}\ (15\ kg)}+\\ \frac{ED_{6\text{-}16}\ (years)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right)\times 3}{BW_{6\text{-}16}\ (80\ kg)}+\\ \frac{ED_{16\text{-}26}\ (years)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right)\times 1}{BW_{16\text{-}26}\ (80\ kg)}\end{array}\right)$$

- dermal contact with soil or sediment

$$SL_{rec\text{-}soil\text{-}tce\text{-}der}\,(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times \left(\frac{10^{-6}kg}{mg}\right) \times \left(\left(CAF_o\,(0.804) \times DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times ABS_d\right) + \left(MAF_o\,(0.202) \times DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) \times ABS_d\right)\right)}$$

where:

$$DFS_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l} \frac{ED_{rec\text{-}c}\,(years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times SA_{rec\text{-}c}\left(\frac{2373\ cm^2}{day}\right) \times AF_{rec\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{rec\text{-}c}\,(15\ kg)} + \\ \frac{\left(ED_{rec}\,(years) - ED_{rec\text{-}c}\,(years)\right) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times SA_{rec\text{-}a}\left(\frac{6032\ cm^2}{day}\right) \times AF_{rec\text{-}a}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{rec\text{-}a}\,(80\ kg)} \end{array}\right)$$

where:

$$DFSM_{rec\text{-}adj}\left(\frac{mg}{kg}\right) = \left(\begin{array}{l} \frac{ED_{0\text{-}2}\,(years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right) \times 10}{BW_{0\text{-}2}\,(15\ kg)} + \\ \frac{ED_{2\text{-}6}\,(years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right) \times 3}{BW_{2\text{-}6}\,(15\ kg)} + \\ \frac{ED_{6\text{-}16}\,(years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_{6\text{-}16}\,(80\ kg)} + \\ \frac{ED_{16\text{-}26}\,(years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_{16\text{-}26}\,(80\ kg)} \end{array}\right)$$

- inhalation of volatiles and particulates emitted from soil or sediment

$$SL_{rec\text{-}soil\text{-}tce\text{-}inh}\,(mg/kg) = \frac{TR \times AT_{rec}\left(\frac{365\ days}{year} \times LT\,(70\ years)\right)}{\begin{array}{c} IUR\left(\mu g/_{m^3}\right)^{-1} \times \left(\frac{1}{VF_{ulim}\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF\left(\frac{m^3}{kg}\right)}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \\ \left(\left(\begin{array}{l} CAF_i\,(0.756) \times EF_{rec}\left(\frac{days}{year}\right) \times \\ ED_{rec}\,(26\ years) \times ET_{rec}\left(\frac{hours}{day}\right) \end{array}\right) + \left(\begin{array}{l} \left(ED_{0\text{-}2}\,(2\ years) \times EF_{0\text{-}2}\left(\frac{days}{year}\right) \times ET_{0\text{-}2}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 10\right) + \\ \left(ED_{2\text{-}6}\,(4\ years) \times EF_{2\text{-}6}\left(\frac{days}{year}\right) \times ET_{2\text{-}6}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 3\right) + \\ \left(ED_{6\text{-}16}\,(10\ years) \times EF_{6\text{-}16}\left(\frac{days}{year}\right) \times ET_{6\text{-}16}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 3\right) + \\ \left(ED_{16\text{-}26}\,(10\ years) \times EF_{16\text{-}26}\left(\frac{days}{year}\right) \times ET_{16\text{-}26}\left(\frac{hours}{day}\right) \times MAF_i\,(0.244) \times 1\right) \end{array}\right)\right) \end{array}}$$

- Total

$$SL_{rec\text{-}soil\text{-}tce\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{rec\text{-}soil\text{-}tce\text{-}ing}} + \frac{1}{SL_{rec\text{-}soil\text{-}tce\text{-}der}} + \frac{1}{SL_{rec\text{-}soil\text{-}tce\text{-}inh}}}$$

A number of studies have shown that inadvertent ingestion of soil is common among children 6 years old and younger (Calabrese et al. 1989, Davis et al. 1990, Van Wijnen et al. 1990). Therefore, the dose method uses an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 26 years old. The equation is presented below. This health-protective approach is chosen to take into account the higher daily rates of soil ingestion in children as well as the longer duration of exposure that is anticipated for a long-term resident. For more on this method, see RAGS Part B (PDF) (68 pp, 721 K).

4.6.1.7 Supporting Equations

- Child

$$ED_{rec\text{-}c}\left(\text{years}\right) = ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)$$

$$BW_{rec\text{-}c}\left(\text{kg}\right) = \frac{BW_{0\text{-}2}\left(\text{kg}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + BW_{2\text{-}6}\left(\text{kg}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$AF_{rec\text{-}c}\left(\frac{\text{events}}{\text{day}}\right) = \frac{AF_{0\text{-}2}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + AF_{2\text{-}6}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$EF_{rec\text{-}c}\left(\frac{\text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + EF_{2\text{-}6}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$ET_{rec\text{-}c}\left(\frac{\text{hours}}{\text{day}}\right) = \frac{ET_{0\text{-}2}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + ET_{2\text{-}6}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$SA_{rec\text{-}c}\left(\frac{\text{cm}^2}{\text{day}}\right) = \frac{SA_{0\text{-}2}\left(\frac{\text{cm}^2}{\text{day}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + SA_{2\text{-}6}\left(\frac{\text{cm}^2}{\text{day}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$IRS_{rec\text{-}c}\left(\frac{\text{mg}}{\text{day}}\right) = \frac{IRS_{0\text{-}2}\left(\frac{\text{mg}}{\text{day}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + IRS_{2\text{-}6}\left(\frac{\text{mg}}{\text{day}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

- Adult

$$ED_{rec\text{-}a}\,(\text{years}) = ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})$$

$$BW_{rec\text{-}a}\,(\text{kg}) = \frac{BW_{6\text{-}16}\,(\text{kg}) \times ED_{6\text{-}16}\,(\text{years}) + BW_{16\text{-}26}\,(\text{kg}) \times ED_{16\text{-}26}\,(\text{years})}{ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

$$AF_{rec\text{-}a}\left(\frac{\text{events}}{\text{day}}\right) = \frac{AF_{6\text{-}16}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{6\text{-}16}\,(\text{years}) + AF_{16\text{-}26}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

$$EF_{rec\text{-}a}\left(\frac{\text{days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\,(\text{years}) + EF_{16\text{-}26}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

$$ET_{rec\text{-}a}\left(\frac{\text{hours}}{\text{day}}\right) = \frac{ET_{6\text{-}16}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{6\text{-}16}\,(\text{years}) + ET_{16\text{-}26}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

$$SA_{rec\text{-}a}\left(\frac{\text{cm}^2}{\text{day}}\right) = \frac{SA_{6\text{-}16}\left(\frac{\text{cm}^2}{\text{day}}\right) \times ED_{6\text{-}16}\,(\text{years}) + SA_{16\text{-}26}\left(\frac{\text{cm}^2}{\text{day}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

$$IRS_{rec\text{-}a}\left(\frac{\text{mg}}{\text{day}}\right) = \frac{IRS_{6\text{-}16}\left(\frac{\text{mg}}{\text{day}}\right) \times ED_{6\text{-}16}\,(\text{years}) + IRS_{16\text{-}26}\left(\frac{\text{mg}}{\text{day}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

- Age-adjusted

$$ED_{rec}\,(\text{years}) = ED_{0\text{-}2}\,(\text{years}) + ED_{2\text{-}6}\,(\text{years}) + ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})$$

$$EF_{rec}\left(\frac{\text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\,(\text{years}) + EF_{2\text{-}6}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\,(\text{years}) + EF_{6\text{-}16}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\,(\text{years}) + EF_{16\text{-}26}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{0\text{-}2}\,(\text{years}) + ED_{2\text{-}6}\,(\text{years}) + ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

$$ET_{rec}\left(\frac{\text{hours}}{\text{day}}\right) = \frac{ET_{0\text{-}2}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{0\text{-}2}\,(\text{years}) + ET_{2\text{-}6}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{2\text{-}6}\,(\text{years}) + ET_{6\text{-}16}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{6\text{-}16}\,(\text{years}) + ET_{16\text{-}26}\left(\frac{\text{hours}}{\text{day}}\right) \times ED_{16\text{-}26}\,(\text{years})}{ED_{0\text{-}2}\,(\text{years}) + ED_{2\text{-}6}\,(\text{years}) + ED_{6\text{-}16}\,(\text{years}) + ED_{16\text{-}26}\,(\text{years})}$$

4.6.2 Recreator Surface Water

This receptor is exposed to chemicals that are present in surface water. Ingestion of water and dermal contact with water are appropriate pathways. Dermal contact with surface water is also considered for analytes determined to be within the effective predictive domain as described in Section 4.9.8. Inhalation is not considered due to mixing with outdoor air. There are no default RSLs for this scenario; only site-specific.

The recreator surface water land use is not provided in the Generic Tables but RSLs can be created by using the Calculator.

4.6.2.1 Noncarcinogenic - Child

The recreator surface water land use equation, presented here, contains the following exposure routes:

- incidental ingestion of water

$$SL_{\text{rec-wat-nc-ing-c}}\left(\mu g/L\right)=\frac{THQ\times AT_{\text{rec-c}}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{\text{rec-c}}\left(6\ \text{years}\right)\right)\times BW_{\text{rec-c}}\left(15\ \text{kg}\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)}{EF_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times ED_{\text{rec-c}}\left(6\ \text{years}\right)\times\frac{1}{RfD_o\left(\frac{\text{mg}}{\text{kg-d}}\right)}\times IRW_{\text{rec-c}}\left(\frac{0.12\ L}{\text{hour}}\right)\times EV_{\text{rec-c}}\left(\frac{\text{events}}{\text{day}}\right)\times ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)}$$

- dermal

FOR INORGANICS:

$$SL_{\text{rec-wat-nc-der-c}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{L}\right)}{K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)\le t^*\left(\text{hour}\right)\text{,then } SL_{\text{rec-wat-nc-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{L}\right)}{2\times FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)>t^*\left(\text{hour}\right)\text{,then } SL_{\text{rec-wat-nc-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{L}\right)}{FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times\left[\frac{ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)}{1+B}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3B+3B^2}{\left(1+B\right)^2}\right)\right]}$$

where:

$$DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)=\frac{THQ\times AT_{\text{rec-c}}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{\text{rec-c}}\left(6\ \text{years}\right)\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)\times BW_{\text{rec-c}}\left(15\ \text{kg}\right)}{\left(\frac{1}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right)\times GIABS}\right)\times EV_{\text{rec-c}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-c}}\left(6\ \text{years}\right)\times EF_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{\text{rec-c}}\left(6365\ \text{cm}^2\right)}$$

- Total

$$SL_{\text{rec-wat-nc-tot-c}}\left(\mu g/L\right)=\frac{1}{\frac{1}{SL_{\text{rec-wat-nc-ing-c}}}+\frac{1}{SL_{\text{rec-wat-nc-der-c}}}}$$

4.6.2.2 Noncarcinogenic - Adult

The recreator surface water land use equation, presented here, contains the following exposure routes:

- incidental ingestion of water

$$SL_{\text{rec-wat-nc-ing-a}}\left(\mu g/L\right)=\frac{THQ\times AT_{\text{rec-a}}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{\text{rec-a}}\left(20\ \text{years}\right)\right)\times BW_{\text{rec-a}}\left(80\ \text{kg}\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)}{EF_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times ED_{\text{rec-a}}\left(20\ \text{years}\right)\times\frac{1}{RfD_o\left(\frac{\text{mg}}{\text{kg-d}}\right)}\times IRW_{\text{rec-a}}\left(\frac{0.071\ L}{\text{hour}}\right)\times EV_{\text{rec-a}}\left(\frac{\text{events}}{\text{day}}\right)\times ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right)}$$

- dermal

FOR INORGANICS:

$$SL_{\text{rec-wat-nc-der-a}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right) \le t^{*}\ (\text{hour})\text{,then } SL_{\text{rec-wat-nc-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{2\times FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right) > t^{*}\ (\text{hour})\text{,then } SL_{\text{rec-wat-nc-der}}\left(\mu g/L\right) = \frac{DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\ \text{cm}^3}{\text{L}}\right)}{FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times\left[\frac{ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right)}{1+B}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{\text{event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) = \frac{THQ\times AT_{\text{rec-a}}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{\text{rec-a}}(20\ \text{years})\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times BW_{\text{rec-a}}(80\ \text{kg})}{\left(\frac{1}{RfD_o\left(\frac{mg}{\text{kg-day}}\right)\times GIABS}\right)\times EV_{\text{rec-a}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-a}}(20\ \text{years})\times EF_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{\text{rec-a}}\left(19652\ \text{cm}^2\right)}$$

- Total

$$SL_{\text{rec-wat-nc-tot-a}}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{\text{rec-wat-nc-ing-a}}}+\frac{1}{SL_{\text{rec-wat-nc-der-a}}}}$$

4.6.2.3 Carcinogenic

The recreator surface water land use equation, presented here, contains the following exposure routes:

- incidental ingestion of water

$$SL_{\text{rec-wat-ca-ing}}\left(\mu g/L\right) = \frac{TR\times AT_{\text{rec}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\ (70\ \text{years})\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{\text{kg-day}}\right)^{-1}\times IFW_{\text{rec-adj}}\left(\frac{L}{kg}\right)}$$

where:

$$IFW_{\text{rec-adj}}\left(\frac{L}{kg}\right) = \left(\begin{array}{c}\frac{EV_{\text{rec-c}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-c}}(6\ \text{years})\times EF_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)\times IRW_{\text{rec-c}}\left(\frac{0.12\ L}{\text{hour}}\right)}{BW_{\text{rec-c}}(15\ \text{kg})}+\\ \frac{EV_{\text{rec-a}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-a}}(20\ \text{years})\times EF_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right)\times IRW_{\text{rec-a}}\left(\frac{0.071\ L}{\text{hour}}\right)}{BW_{\text{rec-a}}(80\ \text{kg})}\end{array}\right)$$

- dermal

FOR INORGANICS:

$$SL_{rec\text{-}wat\text{-}ca\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right)\times ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) \le t^*\ (hour)\text{, then } SL_{rec\text{-}wat\text{-}ca\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) > t^*\ (hour)\text{, then } SL_{rec\text{-}wat\text{-}ca\text{-}der}\,(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right)}$$

where:

$$DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right) = \left(\begin{array}{c}\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right)\times ED_{rec\text{-}c}\,(6\ years)\times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times SA_{rec\text{-}c}\left(6365\ cm^2\right)}{BW_{rec\text{-}c}\,(15\ kg)}+\\ \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}\,(20\ years)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times SA_{rec\text{-}a}\left(19652\ cm^2\right)}{BW_{rec\text{-}a}\,(80\ kg)}\end{array}\right)$$

and:

$$ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) = \left(\frac{\left(ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right)\times ED_{rec\text{-}c}\,(6\ years)+ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right)\times ED_{rec\text{-}a}\,(20\ years)\right)}{ED_{rec\text{-}c}\,(6\ years)+ED_{rec\text{-}a}\,(20\ years)}\right)$$

- Total

$$SL_{rec\text{-}wat\text{-}ca\text{-}tot}\,(\mu g/L) = \frac{1}{\frac{1}{SL_{rec\text{-}wat\text{-}ca\text{-}ing}}+\frac{1}{SL_{rec\text{-}wat\text{-}ca\text{-}der}}}$$

4.6.2.4 Mutagenic

The recreator surface water land use equation, presented here, contains the following exposure routes:

- incidental ingestion of water

$$SL_{\text{rec-wat-mu-ing}}\left(\mu g/L\right) = \frac{TR \times AT_{rec}\left(\frac{365\ \text{days}}{\text{year}} \times LT\left(70\ \text{years}\right)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFWM_{\text{rec-adj}}\left(\frac{L}{kg}\right)}$$

where:

$$IFWM_{\text{rec-adj}}\left(\frac{L}{kg}\right) = \left(\begin{array}{l} \frac{ED_{0\text{-}2}\left(2\ \text{years}\right) \times EF_{0\text{-}2}\left(\frac{\text{days}}{\text{year}}\right) \times IRW_{0\text{-}2}\left(\frac{0.12\ L}{\text{hour}}\right) \times EV_{0\text{-}2}\left(\frac{\text{events}}{\text{day}}\right) \times ET_{0\text{-}2}\left(\frac{\text{hours}}{\text{event}}\right) \times 10}{BW_{0\text{-}2}\left(15\ kg\right)} + \\ \frac{ED_{2\text{-}6}\left(4\ \text{years}\right) \times EF_{2\text{-}6}\left(\frac{\text{days}}{\text{year}}\right) \times IRW_{2\text{-}6}\left(\frac{0.12\ L}{\text{hour}}\right) \times EV_{2\text{-}6}\left(\frac{\text{events}}{\text{day}}\right) \times ET_{2\text{-}6}\left(\frac{\text{hours}}{\text{event}}\right) \times 3}{BW_{2\text{-}6}\left(15\ kg\right)} + \\ \frac{ED_{6\text{-}16}\left(10\ \text{years}\right) \times EF_{6\text{-}16}\left(\frac{\text{days}}{\text{year}}\right) \times IRW_{6\text{-}16}\left(\frac{0.071\ L}{\text{hour}}\right) \times EV_{6\text{-}16}\left(\frac{\text{events}}{\text{day}}\right) \times ET_{6\text{-}16}\left(\frac{\text{hours}}{\text{event}}\right) \times 3}{BW_{6\text{-}16}\left(80\ kg\right)} + \\ \frac{ED_{16\text{-}26}\left(10\ \text{years}\right) \times EF_{16\text{-}26}\left(\frac{\text{days}}{\text{year}}\right) \times IRW_{16\text{-}26}\left(\frac{0.071\ L}{\text{hour}}\right) \times EV_{16\text{-}26}\left(\frac{\text{events}}{\text{day}}\right) \times ET_{16\text{-}26}\left(\frac{\text{hours}}{\text{event}}\right) \times 1}{BW_{16\text{-}26}\left(80\ kg\right)} \end{array}\right)$$

- dermal

FOR INORGANICS:

$$SL_{\text{rec-wat-mu-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hour}\right)\times ET_{\text{event-rec-madj}}\left(\frac{hours}{event}\right)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-rec-madj}}\left(\frac{hours}{event}\right)\le t^{*}\left(hours\right),\text{then } SL_{\text{rec-wat-mu-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{hours}{event}\right)\times ET_{\text{event-rec-madj}}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-rec-madj}}\left(\frac{hours}{event}\right)>t^{*}\left(hours\right),\text{then } SL_{\text{rec-wat-mu-der}}\left(\mu g/L\right)=\frac{DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{\text{event-rec-madj}}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{\text{event}}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{\left(1+B\right)^2}\right)\right]}$$

where:

$$DA_{\text{event}}\left(\frac{ug}{cm^2\text{- event}}\right)=\frac{TR\times AT_{\text{rec}}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFWM_{\text{rec-adj}}\left(\frac{events\text{- }cm^2}{kg}\right)}$$

where:

$$DFWM_{\text{rec-adj}}\left(\frac{events\text{ - }cm^2}{kg}\right)=\left[\begin{array}{l}\left(\frac{EV_{0\text{-}2}\left(\frac{events}{day}\right)\times ED_{0\text{-}2}\left(2\ years\right)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times SA_{0\text{-}2}\left(6365\ cm^2\right)\times 10}{BW_{0\text{-}2}\left(15\ kg\right)}\right)+\\ \left(\frac{EV_{2\text{-}6}\left(\frac{events}{day}\right)\times ED_{2\text{-}6}\left(4\ years\right)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times SA_{2\text{-}6}\left(6365\ cm^2\right)\times 3}{BW_{2\text{-}6}\left(15\ kg\right)}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{events}{day}\right)\times ED_{6\text{-}16}\left(10\ years\right)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times SA_{6\text{-}16}\left(19652\ cm^2\right)\times 3}{BW_{6\text{-}16}\left(80\ kg\right)}\right)+\\ \left(\frac{EV_{16\text{-}26}\left(\frac{events}{day}\right)\times ED_{16\text{-}26}\left(10\ years\right)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times SA_{16\text{-}26}\left(19652\ cm^2\right)\times 1}{BW_{16\text{-}26}\left(80\ kg\right)}\right)\end{array}\right]$$

and:

$$ET_{\text{event-rec-madj}}\left(\frac{hours}{event}\right)=\frac{\left(\begin{array}{l}ET_{\text{event-rec}\left(0\text{-}2\right)}\left(\frac{hours}{event}\right)\times ED_{0\text{-}2}\left(2\ years\right)+ET_{\text{event-rec}\left(2\text{-}6\right)}\left(\frac{hours}{event}\right)\times ED_{2\text{-}6}\left(4\ years\right)+\\ ET_{\text{event-rec}\left(6\text{-}16\right)}\left(\frac{hours}{event}\right)\times ED_{6\text{-}16}\left(10\ years\right)+ET_{\text{event-rec}\left(16\text{-}26\right)}\left(\frac{hours}{event}\right)\times ED_{16\text{-}26}\left(10\ years\right)\end{array}\right)}{ED_{0\text{-}2}\left(2\ years\right)+ED_{2\text{-}6}\left(4\ years\right)+ED_{6\text{-}16}\left(10\ years\right)+ED_{16\text{-}26}\left(10\ years\right)}$$

- Total

$$SL_{\text{rec-wat-mu-tot}}\left(\mu g/L\right)=\frac{1}{\frac{1}{SL_{\text{rec-wat-mu-ing}}}+\frac{1}{SL_{\text{rec-wat-mu-der}}}}$$

4.6.2.5 Vinyl Chloride - Carcinogenic

The recreator surface water land use equation, presented here, contains the following exposure routes:

- incidental ingestion of water

$$SL_{rec\text{-}wat\text{-}ca\text{-}vc\text{-}ing}\left(\mu g/L\right) = \frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right) \times \left(\frac{mg}{1000\ \mu g}\right)}{AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}\right) + \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right) \times IRW_{rec\text{-}c}\ \frac{0.12\ L}{hour} \times \left(\frac{mg}{1000\ \mu g}\right)}{BW_{rec\text{-}c}\ (15\ kg)}\right)}$$

where:

$$IFW_{rec\text{-}adj}\left(\frac{L}{kg}\right) = \left(\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ED_{rec\text{-}c}\ (6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right) \times IRW_{rec\text{-}c}\left(\frac{0.12\ L}{hour}\right)}{BW_{recwc}\ (15\ kg)} + \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right) \times ED_{rec\text{-}a}\ (20\ years) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right) \times IRW_{rec\text{-}a}\left(\frac{0.071\ L}{hour}\right)}{BW_{rec\text{-}a}\ (80\ kg)}\right)$$

- dermal

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) \le t^*\ (hours), \text{then } SL_{rec\text{-}wat\text{-}vc\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hour}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) > t^*\ (hours), \text{then } SL_{rec\text{-}wat\text{-}vc\text{-}der}\left(\mu g/L\right) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hour}\right) \times \left[\frac{ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}\ event}\right) = \frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\left(\frac{DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right)}{AT_{rec}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}\right) + \left(\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times SA_{rec\text{-}c}\left(6365\ cm^2\right)}{BW_{rec\text{-}c}\ (15\ kg)}\right)\right)}$$

where:

$$DFW_{rec\text{-}adj}\left(\frac{events\text{-}cm^2}{kg}\right) = \left(\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right) \times ED_{rec\text{-}c}\ (6\ years) \times EF_{rec\text{-}c}\left(\frac{days}{year}\right) \times SA_{rec\text{-}c}\left(6365\ cm^2\right)}{BW_{rec\text{-}c}\ (15\ kg)} + \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right) \times ED_{rec\text{-}a}\ (20\ years) \times EF_{rec\text{-}a}\left(\frac{days}{year}\right) \times SA_{rec\text{-}a}\left(19652\ cm^2\right)}{BW_{rec\text{-}a}\ (80\ kg)}\right)$$

and:

$$ET_{event\text{-}rec\text{-}adj}\left(\frac{hours}{event}\right) = \left(\frac{\left(ET_{event\text{-}rec\text{-}c}\left(\frac{hours}{event}\right) \times ED_{rec\text{-}c}\ (6\ years)\right) + \left(ET_{event\text{-}rec\text{-}a}\left(\frac{hours}{event}\right) \times ED_{rec\text{-}a}\ (20\ years)\right)}{ED_{rec\text{-}c}\ (6\ years) + ED_{rec\text{-}a}\ (20\ years)}\right)$$

- Total

$$SL_{rec\text{-}wat\text{-}ca\text{-}vc\text{-}tot}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{rec\text{-}wat\text{-}ca\text{-}vc\text{-}ing}} + \frac{1}{SL_{rec\text{-}wat\text{-}ca\text{-}vc\text{-}der}}}$$

4.6.2.6 Trichloroethylene - Carcinogenic and Mutagenic

The recreator surface water land use equation, presented here, contains the following exposure routes:

- incidental ingestion of water

$$SL_{\text{rec-wat-tce-ing}}\left(\mu g/L\right)=\frac{TR\times AT_{\text{rec}}\left(\frac{365\ \text{days}}{\text{year}}\times LT\left(70\ \text{years}\right)\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)}{CSF_{o}\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}\times RBA\times\left(\left(CAF_{o}\left(0.804\right)\times IFW_{\text{rec-adj}}\left(\frac{L}{kg}\right)\right)\right)+\left(MAF_{o}\left(0.202\right)\times IFWM_{\text{rec-adj}}\left(\frac{L}{kg}\right)\right)}$$

where:

$$IFW_{\text{rec-adj}}\left(\frac{L}{kg}\right)=\left(\begin{array}{l}\frac{EV_{\text{rec-c}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-c}}\left(6\ \text{years}\right)\times EF_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times ET_{\text{event-rec-c}}\left(\frac{\text{hours}}{\text{event}}\right)\times IRW_{\text{rec-c}}\left(\frac{0.12\ L}{\text{hour}}\right)}{BW_{\text{rec-c}}\left(15\ kg\right)}+\\ \frac{EV_{\text{rec-a}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-a}}\left(20\ \text{years}\right)\times EF_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times ET_{\text{event-rec-a}}\left(\frac{\text{hours}}{\text{event}}\right)\times IRW_{\text{rec-a}}\left(\frac{0.071\ L}{\text{hour}}\right)}{BW_{\text{rec-a}}\left(80\ kg\right)}\end{array}\right)$$

where:

$$IFWM_{\text{rec-adj}}\left(\frac{L}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0-2}\left(2\ \text{years}\right)\times EF_{0-2}\left(\frac{\text{days}}{\text{year}}\right)\times IRW_{0-2}\left(\frac{0.12\ L}{\text{hour}}\right)\times EV_{0-2}\left(\frac{\text{events}}{\text{day}}\right)\times ET_{0-2}\left(\frac{\text{hours}}{\text{event}}\right)\times 10}{BW_{0-2}\left(15\ kg\right)}+\\ \frac{ED_{2-6}\left(4\ \text{years}\right)\times EF_{2-6}\left(\frac{\text{days}}{\text{year}}\right)\times IRW_{2-6}\left(\frac{0.12\ L}{\text{hour}}\right)\times EV_{2-6}\left(\frac{\text{events}}{\text{day}}\right)\times ET_{2-6}\left(\frac{\text{hours}}{\text{event}}\right)\times 3}{BW_{2-6}\left(15\ kg\right)}+\\ \frac{ED_{6-16}\left(10\ \text{years}\right)\times EF_{6-16}\left(\frac{\text{days}}{\text{year}}\right)\times IRW_{6-16}\left(\frac{0.071\ L}{\text{hour}}\right)\times EV_{6-16}\left(\frac{\text{events}}{\text{day}}\right)\times ET_{6-16}\left(\frac{\text{hours}}{\text{event}}\right)\times 3}{BW_{6-16}\left(80\ kg\right)}+\\ \frac{ED_{16-26}\left(10\ \text{years}\right)\times EF_{16-26}\left(\frac{\text{days}}{\text{year}}\right)\times IRW_{16-26}\left(\frac{0.071\ L}{\text{hour}}\right)\times EV_{16-26}\left(\frac{\text{events}}{\text{day}}\right)\times ET_{16-26}\left(\frac{\text{hours}}{\text{event}}\right)\times 1}{BW_{16-26}\left(80\ kg\right)}\end{array}\right)$$

- dermal

FOR ORGANICS:

$$\text{IF } ET_{event\text{-}rec\text{-}madj}\left(\frac{1\ \text{hour}}{\text{event}}\right) \leq t^{*}\ (\text{hours}), \text{then } SL_{rec\text{-}wat\text{-}tce\text{-}der}\,(\mu g/L) = \frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^{2}\text{- event}}\right)\times\left(\frac{1000\ cm^{3}}{L}\right)}{2\times FA\times K_{p}\left(\frac{cm}{hour}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right) > t^{*}\ (\text{hours}), \text{then } PRG_{rec\text{-}wat\text{-}tce\text{-}der}\,(\mu g/L) = \frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^{2}\text{- event}}\right)\times\left(\frac{1000\ cm^{3}}{L}\right)}{FA\times K_{p}\left(\frac{cm}{hour}\right)\times\left[\frac{ET_{event\text{-}rec\text{-}madj}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^{2}}{(1+B)^{2}}\right)\right]}$$

where:

$$DA_{tce\text{-}event}\left(\frac{ug}{cm^{2}\text{- event}}\right) = \frac{TR\times AT_{rec}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\frac{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\times\left(\left(AF_{o}\,(0.804)\times DFW_{rec\text{-}adj}\left(\frac{events\text{ - }cm^{2}}{kg}\right)\right)+\left(MAF_{o}\,(0.202)\times DFWM_{rec\text{-}adj}\left(\frac{events\text{ - }cm^{2}}{kg}\right)\right)\right)}$$

where:

$$DFW_{rec\text{-}adj}\left(\frac{events\text{ - }cm^{2}}{kg}\right) = \left(\begin{array}{c}\frac{EV_{rec\text{-}c}\left(\frac{events}{day}\right)\times ED_{rec\text{-}c}\,(6\ years)\times EF_{rec\text{-}c}\left(\frac{days}{year}\right)\times SA_{rec\text{-}c}\left(6365\ cm^{2}\right)}{BW_{rec\text{-}c}\,(15\ kg)}+\\ \frac{EV_{rec\text{-}a}\left(\frac{events}{day}\right)\times ED_{rec\text{-}a}\,(20\ years)\times EF_{rec\text{-}a}\left(\frac{days}{year}\right)\times SA_{rec\text{-}a}\left(19652\ cm^{2}\right)}{BW_{rec\text{-}a}\,(80\ kg)}\end{array}\right)$$

where:

$$DFWM_{rec\text{-}adj}\left(\frac{events\text{ - }cm^{2}}{kg}\right) = \left[\begin{array}{l}\left(\frac{EV_{0\text{-}2}\left(\frac{events}{day}\right)\times ED_{0\text{-}2}\,(2\ years)\times EF_{0\text{-}2}\left(\frac{days}{year}\right)\times SA_{0\text{-}2}\left(6365\ cm^{2}\right)\times 10}{BW_{0\text{-}2}\,(15\ kg)}\right)+\\ \left(\frac{EV_{2\text{-}6}\left(\frac{events}{day}\right)\times ED_{2\text{-}6}\,(4\ years)\times EF_{2\text{-}6}\left(\frac{days}{year}\right)\times SA_{2\text{-}6}\left(6365\ cm^{2}\right)\times 3}{BW_{2\text{-}6}\,(15\ kg)}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{events}{day}\right)\times ED_{6\text{-}16}\,(10\ years)\times EF_{6\text{-}16}\left(\frac{days}{year}\right)\times SA_{6\text{-}16}\left(19652\ cm^{2}\right)\times 3}{BW_{6\text{-}16}\,(80\ kg)}\right)+\\ \left(\frac{EV_{16\text{-}26}\left(\frac{events}{day}\right)\times ED_{16\text{-}26}\,(10\ years)\times EF_{16\text{-}26}\left(\frac{days}{year}\right)\times SA_{16\text{-}26}\left(19652\ cm^{2}\right)\times 1}{BW_{16\text{-}26}\,(80\ kg)}\right)\end{array}\right]$$

and:

$$ET_{event\text{-}recw\text{-}madj}\left(\frac{hours}{event}\right) = \frac{\left(\begin{array}{l}ET_{event\text{-}rec\,(0\text{-}2)}\left(\frac{hours}{event}\right)\times ED_{0\text{-}2}\,(2\ years)+ET_{event\text{-}rec\,(2\text{-}6)}\left(\frac{hours}{event}\right)\times ED_{2\text{-}6}\,(4\ years)+\\ ET_{event\text{-}rec\,(6\text{-}16)}\left(\frac{hours}{event}\right)\times ED_{6\text{-}16}\,(10\ years)+ET_{event\text{-}rec\,(16\text{-}26)}\left(\frac{hours}{event}\right)\times ED_{16\text{-}26}\,(10\ years)\end{array}\right)}{ED_{0\text{-}2}\,(2\ years)+ED_{2\text{-}6}\,(4\ years)+ED_{6\text{-}16}\,(10\ years)+ED_{16\text{-}26}\,(10\ years)}$$

FOR ORGANICS:

$$\text{IF } ET_{\text{event-rec-madj}}\left(\frac{1\text{ hour}}{\text{event}}\right) \le t^{*}\ (\text{hours}), \text{then } SL_{\text{rec-wat-tce-der}}\left(\mu g/L\right) = \frac{DA_{\text{tce-event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\text{ cm}^3}{\text{L}}\right)}{2\times FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\sqrt{\frac{6\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times ET_{\text{event-rec-madj}}\left(\frac{\text{hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{\text{event-rec-madj}}\left(\frac{\text{hours}}{\text{event}}\right) > t^{*}\ (\text{hours}), \text{then } PRG_{\text{rec-wat-tce-der}}\left(\mu g/L\right) = \frac{DA_{\text{tce-event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right)\times\left(\frac{1000\text{ cm}^3}{\text{L}}\right)}{FA\times K_p\left(\frac{\text{cm}}{\text{hour}}\right)\times\left[\frac{ET_{\text{event-rec-madj}}\left(\frac{\text{hours}}{\text{event}}\right)}{1+B}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{\text{tce-event}}\left(\frac{\text{ug}}{\text{cm}^2\text{- event}}\right) = \frac{TR\times AT_{\text{rec}}\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)\times\left(\frac{1000\ \mu g}{\text{mg}}\right)}{\frac{CSF_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\times\left(\left(AF_o\,(0.804)\ \times DFW_{\text{rec-adj}}\left(\frac{\text{events - cm}^2}{\text{kg}}\right)\right)+\left(MAF_o\,(0.202)\ \times DFWM_{\text{rec-adj}}\left(\frac{\text{events - cm}^2}{\text{kg}}\right)\right)\right)}$$

where:

$$DFW_{\text{rec-adj}}\left(\frac{\text{events - cm}^2}{\text{kg}}\right) = \left(\begin{gathered}\frac{EV_{\text{rec-c}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-c}}\,(6\text{ years})\ \times EF_{\text{rec-c}}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{\text{rec-c}}\left(6365\text{ cm}^2\right)}{BW_{\text{rec-c}}\,(15\text{ kg})}+\\ \frac{EV_{\text{rec-a}}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{\text{rec-a}}\,(20\text{ years})\ \times EF_{\text{rec-a}}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{\text{rec-a}}\left(19652\text{ cm}^2\right)}{BW_{\text{rec-a}}\,(80\text{ kg})}\end{gathered}\right)$$

where:

$$DFWM_{\text{rec-adj}}\left(\frac{\text{events - cm}^2}{\text{kg}}\right) = \left[\begin{gathered}\left(\frac{EV_{0\text{-}2}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{0\text{-}2}\,(2\text{ years})\ \times EF_{0\text{-}2}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{0\text{-}2}\left(6365\text{ cm}^2\right)\times 10}{BW_{0\text{-}2}\,(15\text{ kg})}\right)+\\ \left(\frac{EV_{2\text{-}6}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{2\text{-}6}\,(4\text{ years})\ \times EF_{2\text{-}6}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{2\text{-}6}\left(6365\text{ cm}^2\right)\times 3}{BW_{2\text{-}6}\,(15\text{ kg})}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{6\text{-}16}\,(10\text{ years})\ \times EF_{6\text{-}16}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{6\text{-}16}\left(19652\text{ cm}^2\right)\times 3}{BW_{6\text{-}16}\,(80\text{ kg})}\right)+\\ \left(\frac{EV_{16\text{-}26}\left(\frac{\text{events}}{\text{day}}\right)\times ED_{16\text{-}26}\,(10\text{ years})\ \times EF_{16\text{-}26}\left(\frac{\text{days}}{\text{year}}\right)\times SA_{16\text{-}26}\left(19652\text{ cm}^2\right)\times 1}{BW_{16\text{-}26}\,(80\text{ kg})}\right)\end{gathered}\right]$$

and:

$$ET_{\text{event-recw-madj}}\left(\frac{\text{hours}}{\text{event}}\right) = \frac{\left(\begin{gathered}ET_{\text{event-rec}\,(0\text{-}2)}\left(\frac{\text{hours}}{\text{event}}\right)\times ED_{0\text{-}2}\,(2\text{ years}) + ET_{\text{event-rec}\,(2\text{-}6)}\left(\frac{\text{hours}}{\text{event}}\right)\times ED_{2\text{-}6}\,(4\text{ years}) +\\ ET_{\text{event-rec}\,(6\text{-}16)}\left(\frac{\text{hours}}{\text{event}}\right)\times ED_{6\text{-}16}\,(10\text{ years}) + ET_{\text{event-rec}\,(16\text{-}26)}\left(\frac{\text{hours}}{\text{event}}\right)\times ED_{16\text{-}26}\,(10\text{ years})\end{gathered}\right)}{ED_{0\text{-}2}\,(2\text{ years})\ + ED_{2\text{-}6}\,(4\text{ years})\ + ED_{6\text{-}16}\,(10\text{ years})\ + ED_{16\text{-}26}\,(10\text{ years})}$$

- Total

$$SL_{\text{rec-wat-tce-tot}}\left(\mu g/L\right) = \frac{1}{\frac{1}{SL_{\text{rec-wat-tce-ing}}}+\frac{1}{SL_{\text{rec-wat-tce-der}}}}$$

4.6.2.7 Supporting Equations

- Child

$$ED_{rec\text{-}c}\left(\text{years}\right) = ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)$$

$$BW_{rec\text{-}c}\left(\text{kg}\right) = \frac{BW_{0\text{-}2}\left(\text{kg}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + BW_{2\text{-}6}\left(\text{kg}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$EV_{rec\text{-}c}\left(\frac{\text{events}}{\text{day}}\right) = \frac{EV_{0\text{-}2}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + EV_{2\text{-}6}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$EF_{rec\text{-}c}\left(\frac{\text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + EF_{2\text{-}6}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$ET_{rec\text{-}c}\left(\frac{\text{hours}}{\text{event}}\right) = \frac{ET_{0\text{-}2}\left(\frac{\text{hours}}{\text{event}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + ET_{2\text{-}6}\left(\frac{\text{hours}}{\text{event}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$SA_{rec\text{-}c}\left(\text{cm}^2\right) = \frac{SA_{0\text{-}2}\left(\text{cm}^2\right) \times ED_{0\text{-}2}\left(\text{years}\right) + SA_{2\text{-}6}\left(\text{cm}^2\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

$$IRW_{rec\text{-}c}\left(\frac{\text{L}}{\text{hour}}\right) = \frac{IRW_{0\text{-}2}\left(\frac{\text{L}}{\text{hour}}\right) \times ED_{0\text{-}2}\left(\text{years}\right) + IRW_{2\text{-}6}\left(\frac{\text{L}}{\text{hour}}\right) \times ED_{2\text{-}6}\left(\text{years}\right)}{ED_{0\text{-}2}\left(\text{years}\right) + ED_{2\text{-}6}\left(\text{years}\right)}$$

- Adult

$$ED_{rec\text{-}a}\left(\text{years}\right) = ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)$$

$$BW_{rec\text{-}a}\left(\text{kg}\right) = \frac{BW_{6\text{-}16}\left(\text{kg}\right) \times ED_{6\text{-}16}\left(\text{years}\right) + BW_{16\text{-}26}\left(\text{kg}\right) \times ED_{16\text{-}26}\left(\text{years}\right)}{ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)}$$

$$EV_{rec\text{-}a}\left(\frac{\text{events}}{\text{day}}\right) = \frac{EV_{6\text{-}16}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{6\text{-}16}\left(\text{years}\right) + EV_{16\text{-}26}\left(\frac{\text{events}}{\text{day}}\right) \times ED_{16\text{-}26}\left(\text{years}\right)}{ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)}$$

$$EF_{rec\text{-}a}\left(\frac{\text{days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\left(\text{years}\right) + EF_{16\text{-}26}\left(\frac{\text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\left(\text{years}\right)}{ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)}$$

$$ET_{rec\text{-}a}\left(\frac{\text{hours}}{\text{event}}\right) = \frac{ET_{6\text{-}16}\left(\frac{\text{hours}}{\text{event}}\right) \times ED_{6\text{-}16}\left(\text{years}\right) + ET_{16\text{-}26}\left(\frac{\text{hours}}{\text{event}}\right) \times ED_{16\text{-}26}\left(\text{years}\right)}{ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)}$$

$$SA_{rec\text{-}a}\left(\text{cm}^2\right) = \frac{SA_{6\text{-}16}\left(\text{cm}^2\right) \times ED_{6\text{-}16}\left(\text{years}\right) + SA_{16\text{-}26}\left(\text{cm}^2\right) \times ED_{16\text{-}30}\left(\text{years}\right)}{ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)}$$

$$IRW_{rec\text{-}a}\left(\frac{\text{L}}{\text{hour}}\right) = \frac{IRW_{6\text{-}16}\left(\frac{\text{L}}{\text{hour}}\right) \times ED_{6\text{-}16}\left(\text{years}\right) + IRW_{16\text{-}26}\left(\frac{\text{L}}{\text{hour}}\right) \times ED_{16\text{-}26}\left(\text{years}\right)}{ED_{6\text{-}16}\left(\text{years}\right) + ED_{16\text{-}26}\left(\text{years}\right)}$$

4.7 Ingestion of Fish

The fish RSL represents the concentration, in the fish, that can be consumed. Note: the consumption rate for fish is not age adjusted for this land use. Also, the SL calculated for fish is not for surface water or soil but is for fish tissue.

The ingestion of fish land use is not provided in the Generic Tables but RSLs can be created by using the Calculator.

4.7.1 Noncarcinogenic

The ingestion of fish equation, presented here, contains the following exposure route:

- consumption of fish.

$$SL_{res\text{-}fsh\text{-}nc\text{-}ing}\left(\text{mg/kg}\right) = \frac{THQ \times AT_{res\text{-}a}\left(\frac{365\ \text{days}}{\text{year}} \times ED_{res}\left(26\ \text{years}\right)\right) \times BW_{res\text{-}a}\left(80\ \text{kg}\right)}{EF_{res\text{-}a}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{res}\left(26\ \text{years}\right) \times \frac{1}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IRF_{res\text{-}a}\left(\frac{\text{mg}}{\text{day}}\right) \times \frac{10^{-6}\text{kg}}{1\,\text{mg}}}$$

4.7.2 Carcinogenic

The ingestion of fish equation, presented here, contains the following exposure route:

- consumption of fish

$$SL_{res\text{-}fsh\text{-}ca\text{-}ing}\left(mg/kg\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right) \times BW_{res\text{-}a}\left(80\ kg\right)}{EF_{res}\left(\frac{350\ days}{year}\right) \times ED_{res}\left(26\ years\right) \times CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times IRF_{res\text{-}a}\left(\frac{mg}{day}\right) \times \frac{10^{-6}kg}{1\ mg}}$$

4.8 Soil to Groundwater

The soil to groundwater scenario was developed to identify concentrations in soil that have the potential to contaminate groundwater above risk based RSLs or MCLs. Migration of contaminants from soil to groundwater can be envisioned as a two-stage process: (1) release of contaminant from soil to soil leachate and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well. The soil to groundwater scenario considers both of these fate and transport mechanisms. First, the acceptable groundwater concentration is multiplied by a dilution factor to obtain a target leachate concentration. For example, if the dilution factor is 10 and the MCL is 0.05 mg/L, the target soil leachate concentration would be 0.5 mg/L. The partition equation (presented in the Soil Screening Guidance documents) is then used to calculate the total soil concentration corresponding to this soil leachate concentration.

These equations are used to calculate screening levels in soil (SSLs) that are protective of groundwater. SSLs are either back-calculated from protective risk-based ground water concentrations or based on MCLs. The SSLs were designed for use during the early stages of a site evaluation when information about subsurface conditions may be limited. Because of this constraint, the equations used are based on conservative, simplifying assumptions about the release and transport of contaminants in the subsurface. Migration of contaminants from soil to groundwater can be envisioned as a two-stage process: (1) release of contaminant in soil leachate and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well. The SSL methodology considers both of these fate and transport mechanisms.

The SSLs protective of groundwater, provided in the generic tables and the calculator, are all risk-based concentrations based on three phases (vapor, soil and water). No substitution for C_{sat} is performed. If the risk-based concentration exceeds C_{sat}, the resulting SSL concentration may be overly protective. This is because the dissolved, absorbed and vapor concentrations cease to rise linearly as soil concentration increases above the C_{sat} level (pure product or nonaqueous phase liquid (NAPL) is present). The SSL model used in the RSL calculator is not a four phase model. If a NAPL is present at your site more sophisticated models may be necessary.

SSLs are provided for metals in the Generic Tables based on Kds from the Soil Screening Guidance Exhibit C-4 . According to Appendix C,

"Exhibit C-4 provides pH-specific soil-water partition coefficients (Kd) for metals. Site-specific soil pH measurements can be used to select appropriate Kd values for these metals. Where site-specific soil pH values are not available, values corresponding to a pH of 6.8 should be used."

If a metal is not listed in Exhibit C-4, Kds were taken from Baes, C. F. 1984 (PDF) (167 pp, 3.0 MB). Kds for organic coumponds are calculated from K_{oc} and the fraction of organic carbon in the soil (f_{oc}). Kds for metals are listed below.

This land use is for developing residential default soil screening levels for the protection of groundwater that are presented in the RSL Generic Tables.

Chemical	CAS	Kd	Reference
Aluminum	7429-90-5	1.50E+03	Baes, C.F. 1984
Antimony (metallic)	7440-36-0	4.50E+01	SSG 9355.4-23 July 1996
Arsenic, Inorganic	7440-38-2	2.90E+01	SSG 9355.4-23 July 1996
Barium	7440-39-3	4.10E+01	SSG 9355.4-23 July 1996
Beryllium and compounds	7440-41-7	7.90E+02	SSG 9355.4-23 July 1996
Boron And Borates Only	7440-42-8	3.00E+00	Baes, C.F. 1984
Bromate	15541-45-4	7.50E+00	Baes, C.F. 1984
Cadmium (Diet)	7440-43-9	7.50E+01	SSG 9355.4-23 July 1996
Cadmium (Water)	7440-43-9	7.50E+01	SSG 9355.4-23 July 1996
Chlorine	7782-50-5	2.50E-01	Baes, C.F. 1984
Chromium (III) (Insoluble Salts)	16065-83-1	1.80E+06	SSG 9355.4-23 July 1996
Chromium Salts	0-00-3	8.50E+02	Baes, C.F. 1984

Chemical	**CAS**	**Kd**	**Reference**
Chromium VI (chromic acid mists)	18540-29-9	1.90E+01	SSG 9355.4-23 July 1996
Chromium VI (particulates)	18540-29-9	1.90E+01	SSG 9355.4-23 July 1996
Chromium, Total (1:6 ratio Cr VI : Cr III)	7440-47-3	1.80E+06	SSG 9355.4-23 July 1996
Cobalt	7440-48-4	4.50E+01	Baes, C.F. 1984
Copper	7440-50-8	3.50E+01	Baes, C.F. 1984
Cyanide (CN-)	57-12-5	9.90E+00	SSG 9355.4-23 July 1996
Fluoride	16984-48-8	1.50E+02	Surrogate Value from Fluorine (Soluble Fluoride)
Fluorine (Soluble Fluoride)	7782-41-4	1.50E+02	Baes, C.F. 1984
Hydrogen Cyanide (HCN)	74-90-8	9.90E+00	Surrogate value from Cyanide
Iron	7439-89-6	2.50E+01	Baes, C.F. 1984
Lead and Compounds	7439-92-1	9.00E+02	Baes, C.F. 1984
Lithium	7439-93-2	3.00E+02	Baes, C.F. 1984
Magnesium	7439-95-4	4.50E+00	Baes, C.F. 1984

Chemical	CAS	Kd	Reference
Manganese (Diet)	7439-96-5	6.50E+01	Baes, C.F. 1984
Manganese (Water)	7439-96-5	6.50E+01	Baes, C.F. 1984
Mercury (elemental)	7439-97-6	5.20E+01	SSG 9355.4-23 July 1996
Mercury, Inorganic Salts	0-01-7	5.20E+01	SSG 9355.4-23 July 1996
Molybdenum	7439-98-7	2.00E+01	Baes, C.F. 1984
Nickel Soluble Salts	7440-02-0	6.50E+01	SSG 9355.4-23 July 1996
Phosphorus, White	7723-14-0	3.50E+00	Baes, C.F. 1984
Selenium	7782-49-2	5.00E+00	SSG 9355.4-23 July 1996
Silver	7440-22-4	8.30E+00	SSG 9355.4-23 July 1996
Sodium	7440-23-5	1.00E+02	Baes, C.F. 1984
Sodium Fluoride	7681-49-4	1.50E+02	Surrogate Value from Fluorine (Soluble Fluoride)
Strontium, Stable	7440-24-6	3.50E+01	Baes, C.F. 1984
Thallium (Soluble Salts)	7440-28-0	7.10E+01	SSG 9355.4-23 July 1996

Chemical	CAS	Kd	Reference
Thorium	0-23-2	1.50E+05	Baes, C.F. 1984
Tin	7440-31-5	2.50E+02	Baes, C.F. 1984
Titanium	7440-32-6	1.00E+03	Baes, C.F. 1984
Uranium (Soluble Salts)	0-23-8	4.50E+02	Baes, C.F. 1984
Vanadium and Compounds	0-06-6	1.00E+03	SSG 9355.4-23 July 1996
Vanadium, Metallic	7440-62-2	1.00E+03	SSG 9355.4-23 July 1996
Zinc (Metallic)	7440-66-6	6.20E+01	SSG 9355.4-23 July 1996
Zirconium	7440-67-7	3.00E+03	Baes, C.F. 1984

Because Kds vary greatly by soil type, it is highly recommended that site-specific Kds be determined and used to develop SSLs.

The more protective of the carcinogenic and noncarcinogenic SLs is selected to calculate the SSL.

4.8.1 Noncarcinogenic Tapwater Equations for SSLs

The tapwater equations, presented in Section 4.1.2.1, are used to calculate the noncarcinogenic SSLs for volatiles and nonvolatiles. If the contaminant is a volatile, ingestion, dermal and inhalation exposure routes are considered. If the contaminant is not a volatile, only ingestion and dermal are considered.

4.8.2 Carcinogenic Tapwater Equations for SSLs

The tapwater equations, presented in Section 4.1.2.3, are used to calculate the carcinogenic SSLs for volatiles and nonvolatiles. Sections 4.1.2.4 and 4.1.2.5 present the mutagenic and vinyl chloride equations, respectively. If the contaminant is a volatile, ingestion, dermal and inhalation exposure routes are considered. If the contaminant is not a volatile, only ingestion and dermal are considered.

4.8.3 Method 1 for SSL Determination

Method 1 employs a partitioning equation for migration to groundwater and defaults are provided. This method is used to generate the download default tables. If H' is not available, SSL can still be calculated. H' changes when groundwater temperature changes. Please see section 4.9.9 of this user guide for H' determination at temperature other than 25°C.

- method 1.

$$\mathrm{SSL(mg/kg)} = C_{\mathrm{water}}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \left[K_d\left(\frac{\mathrm{L}}{\mathrm{kg}}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{\mathrm{water}}}{L_{\mathrm{soil}}}\right) + \theta_a\left(\frac{L_{\mathrm{air}}}{L_{\mathrm{soil}}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ \mathrm{kg}}{\mathrm{L}}\right)}\right)\right]$$

where:

$$C_{\mathrm{water}}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) = \mathrm{MCL}\left(\frac{\mathrm{ug}}{\mathrm{L}}\right) \times \left(\frac{1\ \mathrm{mg}}{1000\ \mathrm{ug}}\right) \times \mathrm{DAF}$$

or:

$$C_{\mathrm{water}}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) = \mathrm{PRG}\left(\frac{\mathrm{ug}}{\mathrm{L}}\right) \times \left(\frac{1\ \mathrm{mg}}{1000\ \mathrm{ug}}\right) \times \mathrm{DAF}$$

and:

$$\theta_a\left(\frac{L_{\mathrm{air}}}{L_{\mathrm{soil}}}\right) = n\left(\frac{L_{\mathrm{water}}}{L_{\mathrm{soil}}}\right) - \theta_w\left(\frac{0.3\ L_{\mathrm{water}}}{L_{\mathrm{soil}}}\right);$$

$$n\left(\frac{L_{\mathrm{pore}}}{L_{\mathrm{soil}}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ \mathrm{kg}}{\mathrm{L}}\right)}{\rho_s\left(\frac{2.65\ \mathrm{kg}}{\mathrm{L}}\right)}\right)$$

$$K_d\left(\frac{\mathrm{L}}{\mathrm{kg}}\right) = K_{oc}\left(\frac{\mathrm{L}}{\mathrm{kg}}\right) \times f_{oc}\left(\frac{0.002\ \text{g-carbon}}{\text{g-soil}}\right), \text{for organic compounds;}$$

K_d values for inorganic compounds are listed in the user guide.

The fraction of organic carbon (f_{oc}) selected for this equation is 0.002. This is the default for subsurface soil identified in U.S. EPA 1996b, Sections 2.5.2 and 2.5.7. According to this source, soil organic carbon decreases rapidly with depth. Note that the default f_{oc} in section “4.9.4 Infinite Source Chronic Volatilization Factor (VF_{ulim})” is 0.006, which is the default for surface soil from the same study.

4.8.4 Method 2 for SSL Determination

Method 2 employs a mass-limit equation for migration to groundwater and site-specific information is required. This method can be used in the calculator portion of this website.

- method 2.

$$SSL(mg/kg) = \frac{C_w\left(\frac{mg}{L}\right) \times I\left(\frac{0.18\ m}{year}\right) \times ED\left(70\ years\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right) \times d_s\left(m\right)}$$

where:

$$C_w\left(\frac{mg}{L}\right) = MCL\left(\frac{ug}{L}\right) \times \left(\frac{1\ mg}{1000\ ug}\right) \times DAF$$

or:

$$C_w\left(\frac{mg}{L}\right) = PRG\left(\frac{ug}{L}\right) \times \left(\frac{1\ mg}{1000\ ug}\right) \times DAF$$

4.8.5 Determination of the Dilution Factor

The SSL values in the download tables are based on a dilution factor of 1. If one wishes to use the calculator to calculate screening levels using the SSL guidance for a source up to 0.5 acres, then a dilution factor of 20 can be used. If all of the parameters needed to calculate a site-specific dilution factor are known, they may be entered.

- Dilution Attenuation Factor.

$$\text{Dilution Attenuation Factor (DAF)} = 1 + \frac{K\left(\frac{m}{year}\right) \times i\left(\frac{m}{m}\right) \times d\left(m\right)}{I\left(\frac{0.18\ m}{year}\right) \times L\left(m\right)}$$

where:

$$d\left(m\right) = \left(0.0112 \times L^2\left(m\right)\right)^{0.5} + d_a \times \left[1\text{-}\exp\left(\frac{-L\left(m\right) \times I\left(\frac{m}{year}\right)}{K\left(\frac{m}{year}\right) \times i\left(\frac{m}{m}\right) \times d_a\left(m\right)}\right)\right]$$

4.9 Supporting Equations and Parameter Discussion

There are two parts of the above land use equations that require further explanation. They are the inhalation variables: the particulate emission factor (PEF) and the volatilization factor (VF).

4.9.1 Wind-driven Particulate Emission Factor (PEF)

Inhalation of contaminants adsorbed to respirable particles (PM10) was assessed using a default PEF equal to $1.36 \times 10^9\ m^3/kg$. This equation relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. The generic PEF was derived using default values that correspond to a receptor point concentration of approximately $0.76\ \mu g/m^3$. The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site, where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g., years). This represents an annual average emission rate based on wind erosion that should be compared with chronic health criteria; it is not appropriate for evaluating the potential for more acute exposures. Definitions of the input variables are in Table 1.

With the exception of specific heavy metals, the PEF does not appear to significantly affect most soil screening levels. The equation forms the basis for deriving a generic PEF for the inhalation pathway. For more details regarding specific parameters used in the PEF model, refer to Appendix D of the Supplemental Soil Screening Guidance. The use of alternate values on a specific site should be justified and presented in an Administrative Record if considered in CERCLA remedy selection.

$$\text{PEF}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{wind}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{3{,}600\left(\frac{s}{hour}\right)}{0.036\times(1 - V)\times\left(\frac{U_m\left(\frac{m}{s}\right)}{U_t\left(\frac{m}{s}\right)}\right)^3\times F(x)}$$

where:

$$\frac{Q}{C_{wind}} = A\times\exp\left[\frac{\left(\ln A_s\,(\text{acre}) - B\right)^2}{C}\right]$$

and:

$$\text{if } x < 2,\ F(x) = 1.91207 - 0.0278085\ x + 0.48113\ x^2 - 1.09871\ x^3 + 0.335341\ x^4$$

$$\text{if } x \geq 2,\ F(x) = 0.18\left(8x^3 + 12x\right)e^{\left(-x^2\right)}$$

where:

$$x = 0.886\times\left(\frac{U_t}{U_m}\right)$$

Note: the generic PEF evaluates wind-borne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbance that could lead to greater emissions than assumed here.

4.9.2 Vehicle traffic-driven Particulate Emission Factor (PEF_{sc})

The equation to calculate the subchronic particulate emission factor (PEF_{sc}) is significantly different from the residential and non-residential PEF equations. The PEF_{sc} focuses exclusively on emissions from truck traffic on unpaved roads, which typically contribute the majority of dust emissions during construction. This equation requires estimates of parameters such as the number of days with at least 0.01 inches of rainfall, the mean vehicle weight, and the sum of fleet vehicle distance traveled during construction.

The number of days with at least 0.01 inches of rainfall can be estimated using Exhibit 5-2 in the supplemental soil screening guidance (PDF) (187 pp, 2.2 MB). Mean vehicle weight (W) can be estimated by assuming the numbers and weights of different types of vehicles. For example, assuming that the daily unpaved road traffic consists of 20 two-ton cars and 10 twenty-ton trucks, the mean vehicle weight would be:

W = [(20 cars x 2 tons/car) + (10 trucks x 20 tons/truck)]/30 vehicles = 8 tons

The sum of the fleet vehicle kilometers traveled during construction (∑ VKT) can be estimated based on the size of the area of surface soil contamination, assuming the configuration of the unpaved road, and the amount of vehicle traffic on the road. For example, if the area of surface soil contamination is 0.5 acres (or 2,024 m^2), and one assumes that this area is configured as a square with the unpaved road segment dividing the square evenly, the road length would be equal to the square root of 2,024 m^2, 45 m (or 0.045 km). Assuming that each vehicle travels the length of the road once per day, 5 days per week for a total of 6 months, the total fleet vehicle kilometers traveled would be:

∑ VKT = 30 vehicles x 0.045 km/day x (52 weeks/year ÷ 2) x 5 days/wk = 175.5 km

$$PEF_{sc}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{sr}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{1}{F_D} \times \left[\frac{T_t\,(s) \times A_R\left(m^2\right)}{\frac{2.6 \text{ x } \left(\frac{s}{12}\right)^{0.8} \times \left(\frac{W(\text{tons})}{3}\right)^{0.4}}{\left(\frac{M_{dry}}{0.2}\right)^{0.3}} \times \frac{\left(365\left(\frac{\text{days}}{\text{year}}\right) - p\left(\frac{\text{days}}{\text{year}}\right)\right)}{365\left(\frac{\text{days}}{\text{year}}\right)} \times 281.9 \times \Sigma\,\mathrm{VKT}}\right.$$

$$\frac{Q}{C_{sr}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_s\,(\text{acre}) - B\right)^2}{C}\right]$$

$$A_R\left(m^2\right) = L_R\,(\text{ft}) \times W_R\,(20 \text{ feet}) \times 0.092903\left(\frac{m^2}{\text{feet}^2}\right)$$

$$W\,(\text{tons}) = \frac{\left(\text{number of cars} \times \frac{\text{tons}}{\text{car}} + \text{number of trucks} \times \frac{\text{tons}}{\text{truck}}\right)}{\text{total vehicles}}$$

$$\Sigma\,\mathrm{VKT}\,(\text{km}) = \text{total vehicles} \times \text{distance}\left(\frac{\text{km}}{\text{day}}\right) \times EW_{cw}\left(\frac{\text{weeks}}{\text{year}}\right) \times DW_{cw}\left(\frac{\text{days}}{\text{week}}\right)$$

$$T_t\ (7200000\text{ s}) = ED_{cw}\,(1 \text{ years}) \times EF_{cw}\left(\frac{250 \text{ days}}{\text{year}}\right) \times ET_{cw}\left(\frac{8 \text{ hours}}{\text{day}}\right) \times \left(\frac{3600 \text{ s}}{\text{hour}}\right)$$

$$F_D\,(0.18584) = 0.1852 + \left(5.3537 / t_c\right) + \left(-9.6318 / t_c{}^2\right)$$

$$t_c\,(8400 \text{ hours}) = ED_{cw}\,(1 \text{ years}) \times EW_{cw}\left(\frac{50 \text{ weeks}}{\text{year}}\right) \times \left(\frac{7 \text{ days}}{\text{week}}\right) \times \left(\frac{24 \text{ hours}}{\text{day}}\right)$$

4.9.3 Other than vehicle traffic-driven Particulate Emission Factor (PEF'_{sc})

Other than emissions from unpaved road traffic, the construction worker may also be exposed to particulate matter emissions from wind erosion, excavation soil dumping, dozing, grading, and tilling or similar operations PEF'_{sc}. These operations may occur separately or concurrently and the duration of each operation may be different. For these reasons, the total unit mass emitted from each operation is calculated separately and the sum is normalized over the entire area of contamination and over the entire time during which construction activities take place. Equation E-26 in the supplemental soil screening guidance (PDF) (187 pp, 2.2 MB) was used.

$$PEF'_{sc}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{1}{F_D} \times \frac{1}{<J'_T>\left(\frac{g}{m^2-s}\right)}$$

where:

$$\frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_c\,(acre)\text{-}B\right)^2}{C}\right]$$

$$<J'_T>\left(\frac{g}{m^2-s}\right) = \frac{M^{pc}_{wind}(g) + M_{excav}(g) + M_{doz}(g) + M_{grade}(g) + M_{till}(g)}{A_{surf}\left(m^2\right) \times T_t(s)}$$

$$M^{pc}_{wind}(g) = 0.036 \times (1\text{-}V) \times \left(\frac{U_m\left(\frac{m}{s}\right)}{U_t\left(\frac{m}{s}\right)}\right)^3 \times F(x) \times A_{surf}\left(m^2\right) \times ED\ (years) \times 8760\left(\frac{hours}{year}\right)$$

$$M_{excav}(g) = 0.35 \times 0.0016 \times \frac{\left(\frac{U_m\left(\frac{m}{s}\right)}{2.2}\right)^{1.3}}{\left(\frac{M_{m\text{-}excav}(\%)}{2}\right)^{1.4}} \times \rho_{soil}\left(\frac{Mg}{m^3}\right) \times A_{excav}\left(m^2\right) \times d_{excav}(m) \times N_{A\text{-}dump} \times 1000$$

$$M_{doz}(g) = 0.75 \times \frac{0.45 \times s_{doz}(\%)^{1.5}}{\left(M_{m\text{-}doz}(\%)\right)^{1.4}} \times \frac{\Sigma VKT_{doz}(km)}{S_{doz}\left(\frac{km}{hr}\right)} \times 1000\left(\frac{g}{kg}\right)$$

$$M_{grade}(g) = 0.60 \times 0.0056 \times S_{grade}\left(\frac{km}{hour}\right)^{2.0} \times \Sigma VKT_{grade}(km) \times 1000\left(\frac{g}{kg}\right)$$

and:

$$M_{till}(g) = 1.1 \times s_{till}(\%)^{0.6} \times A_{c\text{-}till}(acres) \times 4047\left(\frac{m^2}{acre}\right) \times 10^{-4}\left(\frac{ha}{m^2}\right) \times 1000\left(\frac{g}{kg}\right) \times N_{A\text{-}till}$$

where:

$$\Sigma VKT_{grade}(km) = A_{c\text{-}grade}(acres) \times 4047\left(\frac{m^2}{acre}\right) \times \frac{1}{B_g(m)} \times \frac{1}{1000\left(\frac{m}{km}\right)} \times N_{A\text{-}grade}$$

where:

$$\Sigma VKT_{doz}(km) = A_{c\text{-}doz}(acres) \times 4047\left(\frac{m^2}{acre}\right) \times \frac{1}{B_g(m)} \times \frac{1}{1000\left(\frac{m}{km}\right)} \times N_{A\text{-}doz}$$

$$T_t\ (7200000\ s) = ED_{cw}\,(1\ years) \times EF_{cw}\left(\frac{250\ days}{year}\right) \times ET_{cw}\left(\frac{8\ hours}{day}\right) \times \left(\frac{3600\ s}{hour}\right)$$

$$F_D\,(0.18584) = 0.1852 + \left(5.3537 / t_c\right) + \left(-9.6318 / t_c{}^2\right)$$

$$t_c\left(8400\text{ hours}\right) = ED_{cw}\left(1\text{ years}\right) \times EW_{cw}\left(\frac{50\text{ weeks}}{\text{year}}\right) \times \left(\frac{7\text{ days}}{\text{week}}\right) \times \left(\frac{24\text{ hours}}{\text{day}}\right)$$

and:

$$\text{if } x < 2,\ F\left(x\right) = 1.91207 - 0.0278085\ x + 0.48113\ x^2 - 1.09871\ x^3 + 0.335341\ x^4$$

$$\text{if } x \geq 2,\ F\left(x\right) = 0.18\left(8x^3 + 12x\right)e^{\left(-x^2\right)}$$

where:

$$x = 0.886 \times \left(\frac{U_t}{U_m}\right)$$

4.9.4 Infinite Source Chronic Volatilization Factor (VF_{ulim})

The soil-to-air VF is used to define the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to air. VF is calculated from the equation below using chemical-specific properties and either site-measured or default values for soil moisture, dry bulk density, and fraction of organic carbon in soil. The Soil Screening Guidance: User's Guide (PDF) (89 pp, 863 K) describes how to develop site measured values for these parameters.

VF is only calculated for volatile compounds. Volatiles, for the purpose of this guidance, are chemicals with a Henry's Law constant greater than or equal to 1 x 10^{-5} atm-m^3/mole or a vapor pressure greater than or equal to 1 mm Hg. The volatile status of a chemical is important for some exposure routes. According to RAGS Part E, dermal absorption to soil is not assessed for volatiles. For the purposes of this guidance, dermal exposure to soil is only quantified if RAGS Part E provides a dermal absorption value in Exhibit 3-4 or the website, regardless of volatility status. The rationale for this is that in the considered soil exposure scenarios, volatile organic compounds would tend to be volatilized from the soil on skin and should be accounted for via inhalation routes in the combined exposure pathway analysis. Further, a chemical must be volatile in order to be included in the calculation of tapwater inhalation. H' changes when groundwater temperature changes. Please see section 4.9.9 of this user guide for H' determination at temperature other than 25°C.

unlimited source model for chronic exposure

$$VF_{ulim}\left(\frac{m^3_{air}}{kg_{soil}}\right)=\frac{\frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right)\times\left(3.14\times D_A\left(\frac{cm^2}{s}\right)\times T\left(s\right)\right)^{1/2}\times 10^{-4}\left(\frac{m^2}{cm^2}\right)}{2\times\rho_b\left(\frac{g}{cm^3}\right)\times D_A\left(\frac{cm^2}{s}\right)}$$

where:

$$\frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right)=A\times\exp\left[\frac{\left(\ln A_s\left(acre\right)-B\right)^2}{C}\right]$$

where:

$$D_A\left(\frac{cm^2}{s}\right)=\frac{\left(\theta_a\left(\frac{L_{air}}{L_{soil}}\right)^{10/3}\times D_{ia}\left(\frac{cm^2}{s}\right)\times H'+\theta_w\left(\frac{0.15\ L_{water}}{L_{soil}}\right)^{10/3}\times D_{iw}\left(\frac{cm^2}{s}\right)\right)\Big/ n^2\left(\frac{L_{pore}}{L_{soil}}\right)}{\rho_b\left(\frac{1.5g}{cm^3}\right)\times K_d\left(\frac{cm^3}{g}\right)+\theta_w\left(\frac{0.15\ L_{water}}{L_{soil}}\right)+\theta_a\left(\frac{L_{air}}{L_{soil}}\right)\times H'}$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right)=n\left(\frac{L_{pore}}{L_{soil}}\right)-\theta_w\left(\frac{0.15\ L_{water}}{L_{soil}}\right)\text{and } n\left(\frac{L_{pore}}{L_{soil}}\right)=1-\left(\rho_b\left(\frac{1.5g}{cm^3}\right)\Big/\rho_s\left(\frac{2.65\ g}{cm^3}\right)\right)$$

where:

$$K_d\left(\frac{L}{kg}\right)=K_{oc}\left(\frac{L}{kg}\right)\times f_{oc}\left(\frac{0.006\text{ g-carbon}}{\text{g-soil}}\right)\text{, for organic compounds;}$$

K_d values for inorganic compounds are listed in the user guide.

The fraction of organic carbon (f_{oc}) selected for this equation is 0.006. This is the default for surface soil identified in U.S. EPA 1996b, Sections 2.4.2 and 2.5.7, and represents the mean value for the top 0.3m of Class B soils. According to this source, soil organic carbon decreases rapidly with depth. Note that the default f_{oc} in section “4.8.3 Method 1 for SSL Determination” is 0.002, which is the default for subsurface soil from the same study.

Diffusivity in Water (cm^2/s)

Diffusivity in water can be calculated from the chemical's molecular weight and density, using the following correlation equation based on WATER9 (U.S. EPA, 2001 (PDF) (38 pp, 185 K)):

$$D_{iw}\left(\frac{cm^2}{s}\right) = 0.0001518 \times \left(\frac{T\,^{0}C + 273.16}{298.16}\right) \times \left(\frac{MW\left(\frac{g}{mol}\right)}{\rho\left(\frac{g}{cm^3}\right)}\right)^{-0.6}$$

where:

$$T \text{ typically} = 25^{0}C$$

If density is not available,

$$D_{iw}\left(\frac{cm^2}{s}\right) = 0.000222 \times (MW)^{-\left(\frac{2}{3}\right)}$$

If density is not available, diffusivity in water can be calculated using the correlation equation based on U.S. EPA (1987). The value for diffusivity in water must be greater than zero. No maximum limit is enforced.

Diffusivity in Air (cm^2/s).

Diffusivity in air can be calculated from the chemical's molecular weight and density, using the following correlation equation based on WATER9 (U.S. EPA, 2001 (PDF) (38 pp, 185 K)). If density is not available, an alternate equation is provided.:

$$D_{ia}\left(\frac{cm^2}{s}\right) = \frac{0.00229 \times \left(T^0C+273.16\right)^{1.5} \times \sqrt{0.034+\left(\frac{1}{MW\left(\frac{g}{mol}\right)}\right)} \times MW_{cor}}{\left(\left(\frac{MW\left(\frac{g}{mol}\right)}{2.5\times p\left(\frac{g}{cm^3}\right)}\right)^{0.333}+1.8\right)^2}$$

where:

T typically = 25 ^{0}C

$MW_{cor} = \left(1\text{-}0.000015\times MW^2\right)$ If MW_{cor} is less than 0.4, then MW_{cor} is set to 0.4.

If density is not available use,

$$D_{ia}\left(\frac{cm^2}{s}\right) = 1.9 \times \left(MW\left(\frac{g}{mol}\right)^{-\left(\frac{2}{3}\right)}\right)$$

For dioxins, furans, and dioxin-like PCBs always use,

$$D_{ia}\left(\frac{cm^2}{s}\right) = \left(\frac{154\left(\frac{g}{mol}\right)}{MW\left(\frac{g}{mol}\right)}\right)^{0.5} \times 0.068\left(\frac{cm^2}{s}\right)$$

For dioxins, furans, and dioxin-like PCBs, diffusivity in air should always be calculated from the molecular weight using the Graham's Law correlation equation based on December 2003 NAS Review Draft Part I: Volume 3 (pg 4-38)(PDF) (148 pp, 1.9 MB). In this equation, the unknown diffusivity is solved by correlation to the known diphenyl diffusivity of 0.068 cm^2/s and MW of 154 g/mol.

4.9.5 Mass-limit Chronic Volatilization Factor (VF_{mlim})

This Equation presents a model for calculating mass-limit SSLs for the outdoor inhalation of volatiles. This model can be used only if the depth and area of contamination are known or can be estimated with confidence. This equation is presented in the Soil Screening Guidance: User's Guide (PDF) (89 pp, 863 KF) and the Supplemental Soil Screening Guidance (PDF) (187 pp, 2.2 MB).

Use of infinite source models to estimate volatilization can violate mass balance considerations, especially for small sources. To address this concern, the Soil Screening Guidance includes a model for calculating a mass-limit SSL that provides a lower limit to the SSL **when the area and depth (i.e., volume) of the source are known or can be estimated reliably.**

A mass-limit SSL represents the level of contaminant in the subsurface that is still protective when the entire volume of contamination volatilizes over the 26-year exposure duration and the level of contaminant at the receptor does not exceed the health-based limit.

To use mass-limit SSLs, determine the area and depth of the source, calculate both standard and mass-limit SSLs, compare them for each chemical of concern and select the higher of the two values.

Note that the equation requires a site-specific determination of the average depth of contamination in the source. Step 3, in the SSG, provides guidance for conducting subsurface sampling to determine source depth. Where the actual average depth of contamination is uncertain, a conservative estimate should be used (e.g., the maximum possible depth in the unsaturated zone). At many sites, the average water table depth may be used unless there is reason to believe that contamination extends below the water table. In this case SSLs do not apply and further investigation of the source in question is needed.

mass limit model for chronic exposure

$$VF_{mlim}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{\left[T\,(year) \times \left(3.15 \times 10^7\left(\frac{s}{year}\right)\right)\right]}{\rho_b\left(\frac{mg}{m^3}\right) \times d_s\,(m) \times 10^6\left(\frac{g}{mg}\right)}$$

where:

$$\frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2\text{- }s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_s\,(acre) - B\right)^2}{C}\right]$$

4.9.6 Unlimited Source Subchronic Volatilization Factor for Construction Worker ($VF_{ulim\text{-}sc}$)

Equation 5-14 of the supplemental soil screening guidance (PDF) (187 pp, 2.2 MB) is appropriate for calculating the soil-to-air volatilization factor ($VF_{ulim\text{-}sc}$) that relates the concentration of a contaminant in soil to the concentration in air resulting from volatilization. The equation for the subchronic dispersion factor for volatiles, Q/C_{sa}, is presented in Equation 5-15 of the supplemental soil screening guidance (PDF) (187 pp, 2.2 MB). Q/C_{sa} was derived using EPA's SCREEN3 dispersion model for a hypothetical site under a wide range of meteorological conditions. Unlike the Q/C values for the other scenarios, the Q/C_{sa} for the construction scenario's simple site-specific approach can be modified only to reflect different site sizes between 0.5 and 500 acres; it cannot be modified for climatic zone. Site managers conducting a detailed site-specific analysis for the construction scenario can develop a site-specific Q/C value by running the SCREEN3 model. Further details on the derivation of Q/C_{sa} can be found in Appendix E (PDF) (42 pp, 779 K) of the supplemental soil screening guidance (PDF) (187 pp, 2.2 MB). If H' is not available, D_A can still be calculated. H' changes when groundwater temperature changes. Please see section 4.9.9 of this user guide for H' determination at temperature other than 25°C.

unlimited source model for subchronic exposure

$$VF_{ulim\text{-}sc}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{1}{F_D} \times \left[\frac{\left(3.14 \times D_A\left(\frac{cm^2}{s}\right) \times T_c\left(s\right)\right)^{1/2}}{2 \times \rho_b\left(\frac{1.5g}{cm^3}\right) \times D_A\left(\frac{cm^2}{s}\right)}\right] \times 10^{-4}\left(\frac{m^2}{cm^2}\right)$$

where:

$$\frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_s\left(acre\right) - B\right)^2}{C}\right]$$

$$T_c\ \left(30240000\ s\right) = ED_{cw}\left(1\ year\right) \times EW_{cw}\left(\frac{50\ weeks}{year}\right) \times \left(\frac{7\ days}{week}\right) \times \left(\frac{24\ hours}{day}\right) \times \left(\frac{3600\ s}{hour}\right)$$

$$F_D\left(0.18584\right) = 0.1852 + \left(5.3537 / t_c\right) + \left(-9.6318 / t_c^2\right)$$

$$t_c\left(8400\ hours\right) = ED_{cw}\left(1\ year\right) \times EW_{cw}\left(\frac{50\ weeks}{year}\right) \times \left(\frac{7\ days}{week}\right) \times \left(\frac{24\ hours}{day}\right)$$

$$D_A\left(\frac{cm^2}{s}\right) = \frac{\left(\theta_a\left(\frac{L_{air}}{L_{soil}}\right)^{10/3} \times D_{ia}\left(\frac{cm^2}{s}\right) \times H' + \theta_w\left(\frac{0.15\ L_{water}}{L_{soil}}\right)^{10/3} \times D_{iw}\left(\frac{cm^2}{s}\right)\right) \Big/ n^2\left(\frac{L_{pore}}{L_{soil}}\right)}{\rho_b\left(\frac{1.5g}{cm^3}\right) \times K_d\left(\frac{cm^3}{g}\right) + \theta_w\left(\frac{0.15\ L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'}$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{pore}}{L_{soil}}\right) - \theta_w\left(\frac{0.15\ L_{water}}{L_{soil}}\right) \text{and } n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\rho_b\left(\frac{1.5\ g}{cm^3}\right) \Big/ \rho_s\left(\frac{2.65\ g}{cm^3}\right)\right)$$

and:

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\left(\frac{0.006\ g\text{-}carbon}{g\text{-}soil}\right), \text{for organic compounds;}$$

K_d values for inorganic compounds are listed in the user guide.

4.9.7 Mass-limit Subchronic Volatilization Factor for Construction Worker ($VF_{mlim\text{-}sc}$)

Because the equations developed to calculate SSLs for the inhalation of volatiles outdoors assume an infinite source, they can violate mass-balance considerations, especially for small sources. To address this concern, a mass-limit SSL equation for this pathway may be used (Equation 5-17 of the supplemental soils screening guidance (PDF) (187 pp, 2.2 MB)). This equation can be used only when the volume (i.e., area and depth) of the contaminated soil source is known or can be estimated with confidence. As discussed above, the simple site-specific approach for calculating construction scenario SSLs uses the same emission model for volatiles as that used in the residential and non-residential scenarios. However, the conservative nature of this model (i.e., it assumes all contamination is at the surface) makes it sufficiently protective of construction worker exposures to volatiles.

mass limit model for subchronic exposure

$$VF_{mlim\text{-}sc}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{1}{F_D} \times \frac{T_c\,(s)}{\rho_b\left(\frac{1.5\ Mg}{m^3}\right) \times d_s\,(m) \times 10^6\left(\frac{g}{mg}\right)}$$

where:

$$\frac{Q}{C_{sa}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_s\,(acre) - B\right)^2}{C}\right]$$

$$T_c\ (30240000\ s) = ED_{cw}\,(1\ year) \times EW_{cw}\left(\frac{50\ weeks}{year}\right) \times \left(\frac{7\ days}{week}\right) \times \left(\frac{24\ hours}{day}\right) \times \left(\frac{3600\ s}{hour}\right)$$

$$F_D\ (0.18584) = 0.1852 + \left(5.3537 / t_c\right) + \left(-9.6318 / t_c^{\ 2}\right)$$

$$t_c\ (8400\ hours) = ED_{cw}\,(1\ year) \times EW_{cw}\left(\frac{50\ weeks}{year}\right) \times \left(\frac{7\ days}{week}\right) \times \left(\frac{24\ hours}{day}\right)$$

4.9.8 Dermal Contact with Water Supporting Equations

- EPD = Effective Predictive Domain. The EPD is an area on a X/Y plot that symbolizes 95% statistical confidence levels of a regression equation to accurately estimate a dermal permeability constant (K_p). Only if a chemical is within the EPD, will a K_p be estimated and the dermal exposure to water exposure route quantified. The EPD is determined by investigating the predictive power of a regression equation using MW and log Kow values for a compound. If the intersection of the values falls within the designated plotted area, the chemical is determined to be in the EPD and a K_p is estimated. The boundaries of MW and log K_{ow} for the regression equation are presented below. The EPD is depicted in RAGS Part E in Appendix A; Exhibit A-1.

  $-0.06831 \leq 5.103 \times 10^{-4}$ MW + 0.5616 log $K_{ow} \leq 0.5577$ and
  $-0.3010 \leq -5.103 \times 10^{-4}$ MW + 0.05616 log $K_{ow} \leq 0.1758$

- FA = fraction absorbed water. The FA is described in RAGS Part E in Appendix A. The FA term should be applied to account for the loss of chemical due to the desquamation of the outer skin layer and a corresponding reduction in the absorbed dermal dose. To determine FA vales for the RSLs, the following regression analysis was performed. This analysis builds on the RAGS Part E data.

  ```
  logds=(-2.805063-0.0056118*mw) ;
  dsclc=10**logds ;
  dsc = dsclc*&lsc ;
  B = kp*(mw**0.5)/2.6 ;
  tau = &lsc**2/(6*dsc) ;
  logB=log10(B) ;
  ```

```
logtau = log10(tau) ;
if B<=0.1 then FAcalc = 0.9589849087 -.0163393790*logB -.1451565908*logtau
-.0534664095*logB*logtau ;
else if B>0.1 and B<=1 then FAcalc = 1.051232292 + 0.091016187*logB -0.286735467*logtau
-0.180504367*logB*logtau ;
else if B>1 then FAcalc = 0.992336792 + 0.479643809*logB -0.114381522*logtau
-1.263647642*logB*logtau ;
FA = ifn(FAcalc>=1,1,round(FAcalc,0.1));
if FA<0 then FA=0 ;
```

- B = Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (ve)

$$B = \frac{K_p\left(\frac{cm}{hour}\right)}{K_{p,ve}\left(\frac{cm}{hour}\right)} \approx K_p\left(\frac{cm}{hour}\right) \times \frac{\sqrt{MW\left(\frac{g}{mole}\right)}}{2.6} \text{ (as an approximation)}$$

where:

$$K_{p,ve}\left(\frac{cm}{hour}\right) = \frac{K_{ew} \times D_e\left(\frac{cm^2}{hour}\right)}{L_e\,(cm)}$$

where:

$K_{ew} = 1$ (assuming epidermis behaves essentially as water);

$L_e = 10^{-2}\,(cm)$;

$$D_e = \frac{7.1\times10^{-6}\left(\frac{cm^2}{sec}\right)}{\sqrt{MW\left(\frac{g}{mole}\right)}} \text{ (assumes } D_e = 10^{-6}\left(\frac{cm^2}{sec}\right) \text{ when MW = 50)}$$

- t^* = Time to reach steady-state (hours) = 2.4 τ_{event}

$$\text{If } B \le 0.6\text{, then } t^*\,(hours) = 2.4 \times \tau_{event}\left(\frac{hours}{event}\right)$$

or,

$$\text{If } B > 0.6\text{, then } t^*\,(hours) = 6 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(b-\sqrt{b^2-c^2}\right)$$

where:

$$b = \frac{2\times(1+B)^2}{\pi} - c \quad \text{and} \quad c = \frac{1+3\times B+3\times B^2}{3\times(1+B)}$$

- τ_{event} = Lag time per event (hours/event)

$$\tau_{event}\left(\frac{\text{hours}}{\text{event}}\right) = \frac{l_{sc}^{2}\,(\text{cm})}{6 \times D_{sc}\left(\frac{\text{cm}^2}{\text{hour}}\right)}$$

where:

$$\log \frac{D_{sc}\left(\frac{\text{cm}^2}{\text{hour}}\right)}{l_{sc}\,(\text{cm})} = -2.80 - 0.0056 \times \text{MW}\left(\frac{\text{g}}{\text{mole}}\right) \text{ or } \frac{D_{sc}\left(\frac{\text{cm}^2}{\text{hr}}\right)}{l_{sc}\,(\text{cm})} = 10^{\left(-2.80 - 0.0056 \times \text{MW}\left(\frac{\text{g}}{\text{mole}}\right)\right)}$$

thus:

$$l_{sc}\,(\text{cm}) = \frac{10^{\left(-2.80 - 0.0056 \times \text{MW}\left(\frac{\text{g}}{\text{mole}}\right)\right)}}{D_{sc}\left(\frac{\text{cm}^2}{\text{hour}}\right)} \text{ and } D_{sc}\left(\frac{\text{cm}^2}{\text{hour}}\right) = l_{sc}\,(\text{cm}) \times 10^{\left(-2.80 - 0.0056 \times \text{MW}\left(\frac{\text{g}}{\text{mole}}\right)\right)}$$

4.9.9 H' Determination at Temperature Other Than 25°C

In site-specific mode for soil and soil to groundwater land uses, users are given the option to the change groundwater temperature from the default of 25°C to a site-specific value. Since the unitless Henry's Law Constant (H') is derived based on the partial pressure of a gas in equilibrium with a liquid and the equilibrium changes when temperature changes, H' is changed to reflect the equilibrium at the given temperature. The equation below illustrates how H' is derived when groundwater temperature is changed. An EPA Fact Sheet describing the process can be found at https://www.epa.gov/vaporintrusion/fact-sheet-correcting-henrys-law-constant-temperature.

$$H' = \left(\frac{\exp\left[- \frac{\Delta H_{v,w}\left(\frac{cal}{mol}\right)}{R_c\left(1.9872\ cal/mol\text{-}K\right)} \times \left(\frac{1}{T_w\ (K)} - \frac{1}{T_R\ (298.15\ K)} \right) \right] \times HLC\left(atm\text{-}m^3/mol\right)}{R\left(8.205E\text{-}05\ atm\text{-}m^3/mol\text{-}K\right) \times T_w\ (K)} \right)$$

where:

$$T_w\ (K) = T_w\left({}^{o}C\right) + 273.15$$

and:

$$\Delta H_{v,w}\left(\frac{cal}{mol}\right) = \Delta H_{v,b}\left(\frac{cal}{mol}\right) \times \left[\frac{1 - T_w\ (K)/T_c\ (K)}{1 - T_b\ (K)/T_c\ (K)} \right]^{\eta}$$

where:

$$\text{IF} \left(\frac{T_b}{T_c}\right) < 0.57\ \text{, then: } \eta = 0.3;$$

$$\text{IF} \left(\frac{T_b}{T_c}\right) > 0.71\ \text{, then: } \eta = 0.41;$$

$$\text{IF } 0.57 < \left(\frac{T_b}{T_c}\right) \leq 0.71\ \text{, then: } \eta = \left(0.74 \times \left(\frac{T_b}{T_c}\right) - 0.116\right)$$

5. Special Considerations

Most of the SLs are readily derived by referring to the above equations. However, there are some cases for which the standard equations do not apply and/or external adjustments to the SLs are recommended. These special case chemicals are discussed below.

5.1 Cadmium

IRIS presents an oral "water" RfD for cadmium for use in assessment of risks to water of 0.0005 mg/kg-day. IRIS also presents an oral "food" RfD for cadmium for use in assessment of risks to soil and biota of 0.001 mg/kg-day. The SLs for Cadmium are based on the appropriate oral RfD based on the media. The "water" RfD is slightly more conservative (by a factor of 2) than the RfD for "food" and it could be argued that the more conservative RfD should be used to develop screening levels. RAGS Part E, in Exhibit 4-1, presents a GIABS for soil of 2.5% and for water of 5%.

5.2 Lead

EPA has no consensus RfD or SFO for inorganic lead, so it is not possible to calculate SLs as we have done for other chemicals. EPA considers lead to be a special case because of the difficulty in identifying the classic "threshold" needed to develop an RfD.

EPA therefore evaluates lead exposure by using blood-lead modeling, such as the Integrated Exposure-Uptake Biokinetic Model (IEUBK). The EPA Office of Solid Waste has also released a detailed directive on risk assessment and cleanup of residential soil lead. The directive recommends that soil lead levels less than 400 mg/kg are generally safe for residential use. Above that level, the document suggests collecting data and modeling blood-lead levels with the IEUBK model. For the purposes of screening, therefore, 400 mg/kg is recommended for residential soils. For water, we suggest 15 µg/L (the EPA Action Level in water), and for air, the National Ambient Air Quality Standard of 0.15 $\mu g/m^3$. An updated screening level for soil lead at commercial/industrial (i.e., non-residential) sites of 800 part per million (ppm) is based on a recent analysis of the combined phases of the National Health and Nutrition Examination Survey (NHANES III) that choose a cleanup goal protective for all subpopulations. More information can be found here.

However, caution should be used when both water and soil are being assessed. The IEUBK model shows that if the average soil concentration is 400 mg/kg, an average tap water concentration above 5 µg/L would yield more than 5% of the population above a 10 µg/dL blood-lead level. If the average tap water concentration is 15 µg/L, an average soil concentration greater than 250 mg/kg would yield more than 5% of the population above a 10 µg/dL blood-lead level.

EPA uses a second Adult Lead Model to estimate SLs for an industrial setting. This SL is intended to protect a fetus that may be carried by a pregnant female worker. It is assumed that a cleanup goal that is protective of a fetus will also afford protection for male or female adult workers. The model equations were developed to calculate cleanup goals such that the fetus of a pregnant female worker would not likely have an unsafe concentration of lead in blood.

For lead in soil, the default values for absolute bioavailability (ABA) in the IEUBK Model for Lead in Children are 0.3 for soil and dust and 0.5 for food and water. This corresponds to an RBA for soil of 0.6 (ABA_soil / ABA_water = 0.6). It's important to note that the ABA values in the IEUBK model are central estimates and the oral RBA at any given site may be higher or lower than the default oral RBA for lead. For this reason, and because it provides a more comprehensive characterization of exposure at a site, the TRW recommends using EPA SW846 Method 1340 to estimate site-specific RBA. Guidance related to these topics can be found in the Soil Bioavailability at Superfund Site Guidance. Documents OSWER 9200.3-51 and OSWER 9285.7-77 both contain the value for lead.

For more information on EPA's lead models and other lead-related topics, please go to Addressing Lead at Superfund Sites.

5.3 Manganese

The IRIS RfD (0.14 mg/kg-day) includes manganese from all sources, including diet. The author of the IRIS assessment for manganese recommended that the dietary contribution from the normal U.S. diet (an upper limit of 5 mg/day) be subtracted when evaluating non-food (e.g., drinking water or soil) exposures to manganese, leading to a RfD of 0.071 mg/kg-day for non-food items. The explanatory text in IRIS further recommends using a modifying factor of 3 when calculating risks associated with non-food sources due to a number of uncertainties that are discussed in the IRIS file for manganese, leading to a RfD of 0.024 mg/kg-day. This modified RfD has been used in the derivation of some manganese screening levels for soil and water. For more information regarding the Manganese RfD, users are advised to contact the author of the IRIS assessment on Manganese.

5.4 Vanadium Compounds

The oral RfD toxicity value for Vanadium, used in this website, is derived from the IRIS oral RfD for Vanadium Pentoxide by factoring out the molecular weight (MW) of the oxide ion. Vanadium Pentoxide (V_20_5) has a molecular weight of 181.88. The two atoms of Vanadium contribute 56% of the MW. Vanadium Pentoxide's oral RfD of 9E-03 mg/kg-day multiplied by 56% gives a Vanadium oral RfD of 5.04E-03 mg/kg-day.

5.5 Uranium

The "Uranium Soluble Salts" RSL uses the ATSDR intermediate MRL of 2E-04 mg/kg-day instead of the IRIS oral RfD of 3E-03 mg/kg-day. This is a deviation from the typical RSL toxicity hierarchy. This deviation was justified by the 2003 hierarchy memo (PDF) (4 pp, 25 K) that acknowledges and "recognizes that EPA should use the best science available on which to base risk assessments." In December 2016, the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) announced its determination that the ATSDR intermediate MRL generally reflects a better scientific basis for assessing the chronic health risks of soluble uranium than the RfD currently available in IRIS." The rationale for this determination is summarized in an accompanying memorandum (PDF) (11 pp, 2.5 MB), which recommends use of the ATSDR intermediate MRL for assessing chronic and subchronic human exposures at Superfund sites nationwide.

5.6 Chromium (VI)

It is recommended that valence-specific data for chromium be collected whenever possible when chromium is likely to be an important contaminant at a site, and when hexavalent chromium (Cr (VI)) may exist. For Cr (VI), IRIS shows an air inhalation unit risk (IUR) of 1.2E-2 per (μg/m^3). While the exact ratio of Cr(VI) to Cr(III) in the data used to derive the IRIS IUR value is not known, it is likely that both Cr(VI) and Cr(III) were present. The RSLs, calculated using the IRIS IUR, assume that the Cr(VI) to Cr(III) ratio is 1:6. Because of various sources of uncertainty, this assumption may overestimate or underestimate the risk calculated. Users are invited to review the document "Toxicological Review of Hexavalent Chromium" in support of the summary information on Cr(VI) on IRIS to determine whether they believe this ratio applies to their site and to consider consulting with an EPA regional risk assessor. The uncertainty section of the risk assessment may want to address the potential for overestimating or underestimating the risk and provide quantitative analysis by deriving different IUR values based on different Cr(VI) to Cr(III) ratios from more recent studies.

In the RSL Table, the Cr(VI) specific value (assuming 100% Cr(VI)) is derived by multiplying the IRIS Cr (VI) value by 7. This is considered to be a health-protective assumption, and is also consistent with the State of California's interpretation of the Mancuso study that forms the basis for their estimated cancer potency of Cr(VI).

If you are working on a chromium site, you may want to contact the appropriate regulatory officials in your region to determine what their position is on this issue.

The Maximum Contaminant Level (MCL) of 100 μg/L for "Chromium (total)", from the EPA's MCL listing is applied to the "Chromium, Total" analyte on this website.

The State of California Environmental Protection Agency (CalEPA) determined that Cr(VI) by ingestion is likely to be carcinogenic in humans. CalEPA derived an oral cancer slope factor, based on a dose-related increase of tumors of the small intestine in male mice conducted by the National Toxicology Program (PDF) (162 pp, 1.9 MB). CalEPA determined that Cr(VI) was carcinogenic by mutagenic by mode of action.

EPA's Office of Pesticide Programs (OPP) (PDF) (23 pp, 414 K) made a determination that Cr(VI) has a mutagenic mode of action for carcinogenesis in all cells regardless of type, following administration via drinking water. OPP recommended that Age-Dependent Adjustment Factors (ADAFs) be applied when assessing cancer risks from early-life exposure (< 16 years of age). This determination was reviewed by OPP's Cancer Assessment Review Committee and published in a peer review journal (PDF) (23 pp, 414 K)).

Therefore, the RSL workgroup adopted the Tier III CalEPA value and the OPP recommendation with respect to mutagenicity. More recently, in 2011, external peer reviewers provided input on the EPA's Office of Research and Development Integrated Risk Information System draft Toxicological Review of Hexavalent Chromium. The majority of reviewers questioned the evidence used to support a mutagenic mode of action for carcinogenesis for Cr(VI). Furthermore, in 2011 California Environmental Protection Agency finalized its drinking water Public Health Goal for Cr(VI). CalEPA's Technical Support Document concluded in numerous studies that Cr(VI) is both genotoxic and mutagenic.

Therefore, the RSL workgroup acknowledges that there is uncertainty associated with the assessment of hexavalent chromium. However, no updated consensus IRIS assessment (Tier I) has yet appeared, and chromium is still under review by the IRIS program. With respect to RSLs, the more health-protective approach of applying ADAFs for early life exposure via ingestion, dermal and inhalation was used to calculate screening levels for all exposure pathways. Application of ADAFs for all exposure pathways results in more health-protective screening levels.

As always, consult EPA toxicologists in the Superfund program of the regional office when developing site specific screening levels.

5.7 Aminodinitrotoluenes

The IRIS oral RfD of 2E-03 mg/kg-day for 2,4-Dinitrotoluene is used as a surrogate for 2-Amino-4,6-Dinitrotoluene and 4-Amino-2,6-Dinitrotoluene.

5.8 PCBs

Aroclor 1016 is considered "lowest risk" and assigned appropriate toxicity values. All other Aroclors are assigned the high risk toxicity values.

5.9 Xylenes

The IRIS oral RfD of 2E-01 mg/kg-day for xylene, mixture is used as a surrogate for the 3 xylene congeners. The earlier RfD values for some xylene isomers were withdrawn from our electronic version of HEAST. Also, the IRIS inhalation RfC of 1E-01 mg/m^3 for xylene, mixture is used as a surrogate for the 3 xylene congeners.

5.10 Arsenic

Arsenic screening levels for ingestion of soil are now calculated with the default relative bioavailability factor (RBA) of 0.6. The RBA can be adjusted using the calculator in site-specific/user-provided mode the same way toxicity values can be changed. The RBA for soil ingestion is shown in the calculator output. The 2012 document, Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil (PDF) (58 pp, 474 K) provides supporting information.

In 2017, the EPA has released a standard operating procedure for an in vitro bioaccessibility assay for arsenic in soil. The in vitro method for predicting oral RBA of arsenic in soil (EPA SW846 Method 1340) has been validated, and it is now recommended that the in vitro method be used to estimate site-specific RBA, when site-specific RBA is needed. This method can provide a more comprehensive characterization of RBA variability at the site. The default value represents the 95th percentile of many arsenic soil samples, and it is expected that the site-specific RBA will be less than 0.6 at most sites, which means that the default should be protective for screening. Site-specific RBAs derived with the in vitro method should be verified with your Regional Risk Assessor. Guidance related to these topics can be found in the Soil Bioavailability at Superfund Sites: Guidance.

Absolute bioavailability can be thought of as the absorption fraction (PDF) (20 pp, 133 K). Relative bioavailability accounts for differences in the bioavailability of a contaminant between the medium of exposure (e.g., soil) and the media associated with the toxicity value (e.g., the arsenic RfD and SFO are derived from drinking water studies). The 60% oral RBA for arsenic in soil is empirically-based. It represents an upper-bound estimate from numerous studies where the oral RBA of soil-borne arsenic in samples collected from across the U.S. was experimentally determined against the water-soluble form. This RBA does not apply to dermal exposures to arsenic in soil for which the absorbed dose is calculated using a dermal absorption fraction (ABS_d) of 0.03 (Exhibit 3-4 of USEPA, 2004).

5.11 Total Petroleum Hydrocarbons (TPHs)

The six TPH fractions were assigned representative compounds for determination of toxicity values and chemical-specific parameters to calculate RSLs. The PPRTV (PDF) (60 pp, 678 K) paper was the principal source for the derivation of these values.

The carbon ranges and representative compounds are listed in the table below. An average of the chemical-specific parameters for 2-methylnaphthalene and naphthalene was calculated for the medium aromatic fraction.

TPH Fractions	**Number of Carbons**	**Equivalent Carbon Number Index**	**Representative Compound (RfD/RfC)**
Low aliphatic	C5-C8	EC5-EC8	n-hexane
Medium aliphatic	C9-C18	EC>8-EC16	hydrocarbon streams*
High aliphatic	C19-C32	EC>16-EC35	white mineral oil
Low aromatic	C6-C8	EC6-EC<9	benzene
Medium aromatic	C9-C16	EC9-EC<22	2-methylnaphthalene/naphthalene

TPH Fractions	**Number of Carbons**	**Equivalent Carbon Number Index**	**Representative Compound (RfD/RfC)**
High aromatic	C17-C32	EC>22-EC35	fluoranthene

*Medium aliphatic representative compound was not listed in the PPRTV paper so n-nonane was selected by the RSL work-group to represent the chemical-specific parameters.

5.12 Soil Saturation Limit (C_{sat})

The soil saturation concentration, C_{sat}, corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil contaminant may be present in free phase (i.e., nonaqueous phase liquids (NAPLs) for contaminants that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures). C_{sat} is not calculated for chemicals that are solid at ambient soil temperatures. The following decision criteria was established from SSL guidance, Table C-3: if melting point is less than 20 °C, chemical is a liquid; if melting point is above 20 °C, chemical is solid.

Equation 4-10 is used to calculate C_{sat} for each volatile contaminant. As an update to RAGS HHEM, Part B (USEPA 1991a), this equation takes into account the amount of contaminant that is in the vapor phase in soil in addition to the amount dissolved in the soil's pore water and sorbed to soil particles. If H' is not available, C_{sat} can still be calculated.

Chemical-specific C_{sat} concentrations must be compared with each VF-based inhalation SL because a basic principle of the SL volatilization model is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminants that have a VF-based inhalation SL that exceeds the C_{sa}t concentration are set equal to C_{sat}. For organic compounds that are solids (e.g., PAHs), soil screening decisions are based on the appropriate SLs for other pathways of concern at the site (e.g., ingestion). Note, that the SLs presented for soil inhalation in the RSL tool combine the VF and the PEF components. If the C_{sat} substitution is performed, the whole SL is replaced and not just the VF component.

The RSL tables and the default calculator settings do not substitute C_{sat} for risk-based calculations. If the risk-based concentration exceeds C_{sat}, the resulting SSL concentration may be overly protective. This is because the dissolved, absorbed and vapor concentrations cease to rise linearly as soil concentration increases above the C_{sat} level (pure product or nonaqueous phase liquid (NAPL) is present). The SSL model used in the RSL calculator is not a four phase model. If a NAPL is present at your site more sophisticated models may be necessary. The calculator, if operated in site-specific mode, will give the option to apply the C_{sat} substitution rule. H' changes when groundwater temperature changes. Please see section 4.9.9 of this user guide for H' determination at temperature other than 25°C.

$$C_{sat}\left(\frac{mg}{kg}\right)=\frac{S\left(\frac{mg}{L}\right)}{\rho_b\left(\frac{kg}{L}\right)}\times\left(K_d\left(\frac{L}{kg}\right)\times\rho_b\left(\frac{kg}{L}\right)+\theta_w\left(\frac{L_{water}}{L_{soil}}\right)+H'\times\theta_a\left(\frac{L_{air}}{L_{soil}}\right)\right)$$

where:

$$K_d\left(\frac{L}{kg}\right)=K_{oc}\left(\frac{L}{kg}\right)\times f_{oc}\left(\frac{0.006\text{ g-carbon}}{\text{g-soil}}\right)\text{, for organic compounds;}$$

K_d values for inorganic compounds are listed in the user guide,

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right)=n\left(\frac{L_{pore}}{L_{soil}}\right)-\theta_w\left(\frac{L_{water}}{L_{soil}}\right)$$

and:

$$n=1-\left(\frac{\rho_b\left(\frac{kg}{L}\right)}{\rho_s\left(\frac{kg}{L}\right)}\right)$$

5.13 SL Theoretical Ceiling Limit

The ceiling limit of 10^{+5} mg/kg is equivalent to a chemical representing 10% by weight of the soil sample. At this contaminant concentration (and higher), the assumptions for soil contact may be violated (for example, soil adherence and wind-borne dispersion assumptions) due to the presence of the foreign substance itself.

The RSL tables and the default calculator settings do not substitute the theoretical ceiling limit for risk-based calculations but they do indicate if the resulting RSL has exceeded the theoretical ceiling limit in the key. The calculator, if operated in site-specific mode, will give the option to apply the theoretical ceiling limit.

5.14 Target Risk

With the exceptions described previously, SLs are chemical concentrations that correspond to fixed levels of risk (i.e., either a one-in-one million [10^{-6}] for cancer risk or a noncarcinogenic hazard quotient of 1) in soil, air, and water. In noncarcinogenic equations, THQ represents the target hazard quotient and is used for individual substances or exposure routes like: ingestion, dermal, and inhalation. The target hazard index (THI), is the target across multiple substances or exposure routes. In most cases, where a substance causes both cancer and noncancer (systemic) effects, the 10^{-6} cancer risk will result in a more stringent criteria and consequently this value is presented in the printed copy of the Table. SL concentrations that equate to a 10^{-6} cancer risk are indicated by 'ca' in the calculator and 'c' in the generic tables. SL concentrations that equate to a hazard quotient (HQ) of 1 for noncarcinogenic concerns are indicated by 'nc' in the calculator and 'n' in the generic tables.

If the SLs are to be used for site screening, it is recommended that both cancer and noncancer-based SLs be used. Both carcinogenic and noncarcinogenic values may be obtained in the Supporting Tables.

Some users of this SL Table may plan to multiply the cancer SL concentrations by 10 or 100 to set 'action levels' for triggering remediation or to set less stringent cleanup levels for a specific site after considering non-risk-based factors such as ambient levels, detection limits, or technological feasibility. This risk management practice recognizes that there may be a range of values that may be 'acceptable' for carcinogenic risk (EPA's risk management range is one-in-a-million [10^{-6}] to one-in-ten thousand [10^{-4}]). However, this practice could lead one to overlook serious noncancer health threats and it is strongly recommended that the user consult with a toxicologist or regional risk assessor before doing this. Carcinogens are indicated by an asterisk ('*') in the SL Table where the noncancer SLs would be exceeded if the cancer value that is displayed is multiplied by 100. ('**') indicate that the noncancer values would be exceeded if the cancer SL were multiplied by 10. There is no range of 'acceptable' noncarcinogenic 'risk' for CERCLA sites. Therefore, the noncancer SLs should not be multiplied by 10 or 100 when setting final cleanup criteria. In the rare case where noncancer SLs are more stringent than cancer SLs set at one-in-one-million risk, a similar approach has been applied (e.g. 'max').

SL concentrations in the printed Table are risk-based, but for soil there are two important exceptions: (1) for several volatile chemicals, SLs may exceed the soil saturation level ('sat') and (2) SLs may exceed a non-risk based 'ceiling limit' concentration of 10^{+5} mg/kg ('max') for relatively less toxic inorganic and semivolatile contaminants. For more information on the 'sat' value in the SL Table, please see the discussion in Section 5.11. For more information on the 'max' value in the SL Table, please see the discussion in Section 5.13.

With respect to applying a 'ceiling limit' for chemicals other than volatiles, it is recognized that this is not a universally accepted approach. Some within the agency argue that all values should be risk-based to allow for scaling (for example, if the risk-based SL is set at a hazard quotient = 1.0, and the user would like to set the hazard quotient to 0.1 to take into account multiple chemicals, then this is as simple as multiplying the risk-based SL by 1/10th). If scaling is necessary, SL users can do this simply by referring to the Supporting Tables at this website where risk-based soil concentrations are presented for all chemicals.

In spite of the fact that applying a ceiling limit is not a universally accepted approach, this table applies a 'max' soil concentration to the SL Table for the following reasons:

- Risk-based SLs for some chemicals in soil exceed unity (>1,000,000 mg/kg), which is not possible.
- The ceiling limit of 10^{+5} mg/kg is equivalent to a chemical representing 10% by weight of the soil sample. At this contaminant concentration (and higher), the assumptions for soil contact may be violated (for example, soil adherence and wind-borne dispersion assumptions) due to the presence of the foreign substance itself.
- SLs currently do not address short-term exposures (e.g., pica children and construction workers). Although extremely high soil SLs are likely to represent relatively non-toxic chemicals, such high values may not be justified if in fact more toxicological data were available for evaluating short-term and/or acute exposures.

5.15 Screening Sites with Multiple Contaminants

The screening levels in the tables are calculated under the assumption that only one contaminant is present. Users needing to screen sites with multiple contaminants should consult with their regional risk assessors. The following sections describe how target risks can be changed to screen against multiple contaminants and how the ratio of concentration to RSL can be used to estimate total risk.

5.15.1 Adjusting Target Risk and Target Hazard Quotient

When multiple contaminants are present at a site the target hazard quotient (THQ) may be modified. The following options are among the commonly used methods to modify the THQ:

The calculator on this website can be used to generate SLs based on any THQ or target cancer risk (TR) deemed appropriate by the user. The THQ input to the calculator can be modified from the default of 1. How much it should be modified is a user decision, but it could be based upon the number of contaminants being screened together. For example, if one is screening two contaminants together, then the THQ could be modified to 0.5. If ten contaminants are being screened together, then the THQ could be modified to 0.1. The above example weights each chemical equally; it is also possible to weight the chemicals unequally, as long as the total risk meets the desired goal. The decision of how to weight the chemicals is likely to be site-specific, and it is recommended that this decision be made in consultation with the regional risk assessor.

Note that when the TR or THQ is altered, the relationship between cancer-based and noncancer-based SLs may change. At certain risk levels, the cancer-based number may be more conservative; at different risk levels, the noncancer-based number may be more conservative. The data user needs to consider both cancer and noncancer endpoints.

Similar to the above approach of using the calculator to recalculate SLs based on non-default target levels, the values in the screening tables themselves can be addressed directly. Consistent with the above logic, although the EPA Superfund Program has not developed guidance on this, it is not uncommon that Superfund sites are screened at a THQ of 0.1. (The cancer-based SLs are already at a target risk of 1E-6 and are usually not adjusted further in this scenario.) SLs based on a THQ of 0.1 can be derived by dividing a default SL by 10. Again, note that altering the target HQ can change the relationship between cancer-based and noncancer-based screening levels; the data user needs to consider both endpoints. Additional approaches or alternatives may exist. When screening actual or potential Superfund sites, users are encouraged to consult with risk assessors in that EPA Regional Office when evaluating or screening contamination at a site with multiple contaminants to see if they may know of another approach or if they have a preference.

5.15.2 Using RSLs to Sum Risk from Multiple Contaminants

RSLs can be used to estimate the total risk from multiple contaminants at a site as part of a screening procedure used by some regions. This methodology, which does not substitute for a baseline risk assessment, is often called the "sum of the ratios" approach. A step-wise approach follows:

1. Perform an extensive records search and compile existing data.
2. Identify site contaminants in the SL Table. Record the SL concentrations for various media and note whether SL is based on cancer risk (indicated by 'c') or noncancer hazard (indicated by 'n'). Segregate cancer SLs from non-cancer SLs and exclude (but don't eliminate) non-risk based SLs 's' or 'm'.
3. For cancer risk estimates, take the site-specific concentration (maximum or 95th percent of the upper confidence limit on the mean (UCL)) and divide by the SL concentrations that are designated for cancer evaluation 'c'. Multiply this ratio by 10-6 to estimate chemical-specific risk for a reasonable maximum exposure (RME). For multiple pollutants, simply add the risk for each chemical. See

equation below.

$$\text{Total Cancer Risk} = \left[\left(\frac{C_x}{SL_x}\right)+\left(\frac{C_y}{SL_y}\right)+\left(\frac{C_z}{SL_z}\right)\right] \times TR$$

where:

TR = target cancer risk
C = site contaminant concentration

4. For non-cancer hazard estimates, divide the concentration term by its respective non-cancer SL designated as 'n' and sum the ratios for multiple contaminants. The cumulative ratio represents a non-carcinogenic hazard index (HI). A hazard index of 1 or less is generally considered 'safe'. A ratio greater than 1 suggests further evaluation. Note that carcinogens may also have an associated non-cancer SL that is not listed in the SL Table. To obtain these values, the user should view the Supporting Tables. See equation below

$$\text{Total Hazard Index} = \left[\left(\frac{C_x}{SL_x}\right)+\left(\frac{C_y}{SL_y}\right)+\left(\frac{C_z}{SL_z}\right)\right] \times THQ$$

where:

THQ = target hazard quotient
C = site contaminant concentration

5.16 Deriving Soil Gas SLs

The air SLs could apply to indoor air from, e.g., a vapor intrusion scenario. To model indoor air concentrations from other media (e.g., soil gas, groundwater), consult with regional experts in vapor intrusion.

For more information on EPA's current understanding of this emerging exposure pathway, please refer to EPA's recent draft guidance Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (USEPA 2002).

5.17 Mutagens

Some of the cancer causing analytes in this tool operate by a mutagenic mode of action for carcinogenesis. There is reason to surmise that some chemicals with a mutagenic mode of action, which would be expected to cause irreversible changes to DNA, would exhibit a greater effect in early-life versus later-life exposure. Cancer risk to children in the context of the U.S. Environmental Protection Agency's cancer guidelines (U.S. EPA, 2005 (PDF) (166 pp, 468 K)) includes both early-life exposures that may result in the occurrence of cancer during childhood and early-life exposures that may contribute to cancers later in life. In keeping with this guidance, separate cancer risk equations are presented for mutagens. The mutagen vinyl chloride has a unique set of equations. Consult Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F, March 2005 (PDF) (126 pp, 1.78 MB) for further information.

The below table lists the chemicals considered to be carcinogenic by mutagenic mode of action for the purposes of the RSLs. Also provided in the table is a link to the source as to why the chemical is considered to be a mutagen.

Chemical	CASRN	Reference
	79-06-1	IRIS
Benz[a]anthracene	56-55-3	Benzo[a]pyrene*
Benzidine	92-87-5	Supplemental Guidance
Benzo[a]pyrene	50-32-8	Supplemental Guidance
Benzo[b]fluoranthene	205-99-2	Benzo[a]pyrene*
Benzo[k]fluoranthene	207-08-9	Benzo[a]pyrene*
Chromium(VI)	18540-29-9	CalEPA and OPP
Chrysene	218-01-9	Benzo[a]pyrene*
Coke Oven Emissions	8007-45-2	70 Federal Register 19992
Dibenz[a,h]anthracene	53-70-3	Supplemental Guidance
Dibromo-3-chloropropane, 1,2-	96-12-8	PPRTV
Dimethylbenz(a)anthracene, 7,12-	57-97-6	Supplemental Guidance
Ethylene Oxide	75-21-8	IRIS
Indeno[1,2,3-cd]pyrene	193-39-5	Benzo[a]pyrene*
Methylcholanthrene, 3-	56-49-5	Supplemental Guidance
Methylene Chloride	75-09-2	IRIS
Methylene-bis(2-chloroaniline), 4,4'-	101-14-4	PPRTV
Nitrosodiethylamine, N-	55-18-5	Supplemental Guidance

Nitrosodimethylamine, N-	62-75-9	Supplemental Guidance
Nitroso-N-ethylurea, N-	759-73-9	Supplemental Guidance
Nitroso-N-methylurea, N-	684-93-5	Supplemental Guidance
Safrole	94-59-7	Supplemental Guidance
Trichloroethylene	79-01-6	IRIS
Trichloropropane, 1,2,3-	96-18-4	IRIS
Urethane	51-79-6	Supplemental Guidance
Vinyl Chloride	75-01-4	Supplemental Guidance

* Please see section 2.3.6 of this user guide regarding Relative Potency Factors (RPFs).

5.18 Trichloroethylene (TCE)

It is recommended that a regional risk assessor be consulted when evaluating TCE in any medium especially when less than chronic exposure scenarios are considered. The Superfund program issued a Compilation of Information Relating of Early/Interim Actions at Superfund Sites and the TCE IRIS Assessment (PDF) (3 pp, 929 K) memo in August 2014. Several regions have issued their own guidance as well.

In order to make the calculator display the correct results for TCE, the standard cancer and mutagen equations needed to be combined. Since TCE requires the use of different toxicity values for cancer and mutagen equations, it was decided to make a toxicity value adjustment factor for cancer (CAF) and mutagens (MAF). The adjustments were done for oral (o) and inhalation (i). These adjustment factors are used in the TCE equation images presented in section 4. The equations used are presented below. The adjustment factors are based on the adult-based toxicity values and these are the cancer toxicity values presented in the Generic Tables.

$$\text{CAF}_o\,(0.804) = \frac{\text{CSF}_o\left(\frac{3.7\times10^{-2}\,\text{mg}}{\text{kg - day}}\right)^{-1}\ \text{NHL+Liver oral slope factor}}{\text{CSF}_o\left(\frac{4.6\times10^{-2}\,\text{mg}}{\text{kg - day}}\right)^{-1}\ \text{Adult – based oral slope factor}}\qquad \text{MAF}_o\,(0.202) = \frac{\text{CSF}_o\left(\frac{9.3\times10^{-3}\,\text{mg}}{\text{kg - day}}\right)^{-1}\ \text{Kidney oral slope fact}}{\text{CSF}_o\left(\frac{4.6\times10^{-2}\,\text{mg}}{\text{kg - day}}\right)^{-1}\ \text{Adult – based oral slope f}}$$

$$\text{CAF}_i\,(0.756) = \frac{\text{IUR}\left(3.1\times10^{-6}\,\mu\text{g}/\text{m}^3\right)^{-1}\ \text{NHL+Liver unit risk estimate}}{\text{IUR}\left(4.1\times10^{-6}\,\mu\text{g}/\text{m}^3\right)^{-1}\ \text{Adult – based unit risk estimate}}\qquad \text{MAF}_i\,(0.244) = \frac{\text{IUR}\left(1\times10^{-6}\,\mu\text{g}/\text{m}^3\right)^{-1}\ \text{Kidney unit risk esti}}{\text{IUR}\left(4.1\times10^{-6}\,\mu\text{g}/\text{m}^3\right)^{-1}\ \text{Adult – based unit risk}}$$

5.19 Mercuric Chloride (and other Mercury salts)

The IRIS RfC for "Mercury (elemental)" is used as a surrogate for "Mercuric Chloride (and other Mercury salts)". Note, that the VF for "Mercury (elemental)" is not used as a surrogate for "Mercuric Chloride (and other Mercury salts)". The use of the surrogate RfC would appear to be a violation of the RSL toxicity hierarchy because Cal EPA offers a RfC for Mercuric Chloride. However, the actual form of mercury evaluated for the Cal EPA RfC was elemental mercury. Since IRIS already had a RfC for "Mercury (elemental)", it was decided to use the tier 1 source over a tier 3 source.

5.20 Cyanide (CN-)

The IRIS RfC for "Hydrogen Cyanide" is used as a surrogate for "Cyanide (CN-)".

5.21 Thallic Oxide and Thallium Selenite

The oral RfD for thallic oxide, used in this website, is derived from the PPRTV oral RfD for thallium sulfate by molecular weight (MW) adjustments and stoichiometric calculations. Thallic oxide (Tl_2O_3) has a MW of 456.765 and thallium sulfate (Tl_2SO_4) has a MW of 504.82. To derive the oral RfD of 2E-05 mg/kg-day for thallic oxide, the thallium sulfate RfD of 2E-05 mg/kg-day is multiplied by the MW of thallic oxide (456.765) divided by the MW of thallium sulfate (504.82). The oral RfD for thallium selenite, used in this website, is derived from the PPRTV oral RfD for thallium by molecular weight (MW) adjustments and stoichiometric calculations. Thallium selenite (TlSe) has a MW of 283.34 and thallium (Tl) has a MW of 204.38. To derive the oral RfD of 1E-05 mg/kg-day for thallium selenite, the thallium RfD of 1E-05 mg/kg-day is multiplied by the MW of thallium selenite (283.34) divided by the MW of thallium (204.38).

5.22 Polycyclic Aromatic Hydrocarbons (PAHs)

For PAHs in soil, we have not made any recommendations on a default value, which is to say that the default assumption remains that these are 100% bioavailable. There is also no available in vitro method to estimate the oral RBA of PAHs. A small number of sites have elected to run swine or rat models to assess oral RBA, and the TRW has reviewed them before the RBA was accepted for use at the site. Guidance related to these topics can be found in the Soil Bioavailability at Superfund Sites Guidance.

5.23 Refractory Ceramic Fibers

The ATSDR chronic RfC for refractory ceramic fibers is presented in units of fibers/cm^3. The RfC presented in the tables and calculator is 0.03 fibers/cm^3, which differs from all other chemicals where the RfC unit is mg/m^3. When the chronic RfC is used in the standard RSL air inhalation equations, the resulting units are not in µg/m^3 like all the other chemicals. RSLs are only calculated for air as the medium. The air values in the RSL table are calculated using the equations below to give RSLs in fibers/m$^{3.}$

Resident Air Noncancer Equation

$$SL_{res\text{-}air\text{-}rcf}\left(\frac{f}{m^3}\right)=\frac{THQ\times AT_{res\text{-}a}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{res}\left(26\ \text{years}\right)\right)\times\left(\frac{1.0\times10^{6}\ \text{cm}^3}{\text{m}^3}\right)}{EF_{res}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{res}\left(26\ \text{years}\right)\times ET_{res}\left(\frac{24\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times\frac{1}{RfC\left(\frac{f}{cm^3}\right)}}$$

Composite Worker Air Noncancer Equation

$$SL_{w\text{-}air\text{-}rcf}\left(\frac{f}{m^3}\right)=\frac{THQ\times AT_{w}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{w}\left(25\ \text{years}\right)\right)\times\left(\frac{1.0\times10^{6}\ \text{cm}^3}{\text{m}^3}\right)}{EF_{w}\left(\frac{250\ \text{days}}{\text{year}}\right)\times ED_{w}\left(25\ \text{years}\right)\times ET_{w}\left(\frac{8\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times\frac{1}{RfC\left(\frac{f}{cm^3}\right)}}$$

Indoor Worker Air Noncancer Equation

$$SL_{iw\text{-}air\text{-}rcf}\left(\frac{f}{m^3}\right)=\frac{THQ\times AT_{iw}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{iw}\left(25\ \text{years}\right)\right)\times\left(\frac{1.0\times10^{6}\ \text{cm}^3}{\text{m}^3}\right)}{EF_{iw}\left(\frac{250\ \text{days}}{\text{year}}\right)\times ED_{iw}\left(25\ \text{years}\right)\times ET_{iw}\left(\frac{8\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times\frac{1}{RfC\left(\frac{f}{cm^3}\right)}}$$

Outdoor Worker Air Noncancer Equation

$$SL_{ow\text{-}air\text{-}rcf}\left(\frac{f}{m^3}\right)=\frac{THQ\times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}}\times ED_{ow}\left(25\ \text{years}\right)\right)\times\left(\frac{1.0\times10^{6}\ \text{cm}^3}{\text{m}^3}\right)}{EF_{ow}\left(\frac{225\ \text{days}}{\text{year}}\right)\times ED_{ow}\left(25\ \text{years}\right)\times ET_{ow}\left(\frac{8\ \text{hours}}{\text{day}}\right)\times\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\times\frac{1}{RfC\left(\frac{f}{cm^3}\right)}}$$

Refractory Ceramic Fibers Air RSLs (fibers/m^3)

Land Use	**THI = 0.1**	**THI = 1.0**
Resident	3128	31286
Composite Worker	13140	131400
Indoor Worker	13140	131400
Outdoor Worker	14600	146000

5.24 Lanthanum Salts

The oral chronic RfDs for lanthanum salts, used in this website, are derived from the PPRTV oral chronic RfD for lanthanum by molecular weight (MW) adjustments and stoichiometric calculations. Lanthanum chloride, anhydrous ($LaCl_3$) has a MW of 245.27, and lanthanum (La) has a MW of 138.91. To derive the chronic oral RfD of 2.83E-05 mg/kg-day for lanthanum chloride, anhydrous, the lanthanum RfD of 5E-05 mg/kg-day is multiplied by the MW of lanthanum (138.91) divided by the MW of lanthanum chloride, anhydrous (245.27). To derive the chronic oral RfD of 1.87E-05 mg/kg-day for lanthanum chloride heptahydrate, the lanthanum RfD of 5E-05 mg/kg-day is multiplied by the MW of lanthanum (138.91) divided by the MW of lanthanum chloride heptahydrate (371.37). To derive the chronic oral RfD of 1.60E-05 mg/kg-day for lanthanum nitrate hexahydrate, the lanthanum RfD of 5E-05 mg/kg-day is multiplied by the MW of lanthanum (138.91) divided by the MW of lanthanum nitrate hexahydrate (433.01). To derive the chronic oral RfD of 2.08E-05 mg/kg-day for lanthanum acetate hydrate, the lanthanum RfD of 5E-05 mg/kg-day is multiplied by the MW of lanthanum (138.91) divided by the MW of lanthanum acetate hydrate (334.05).

6. Using the Calculator

The Calculator can be used to generate site-specific SLs or PRGs. The calculator requires the user to make some simple selections. To use the calculator Select a land use. Next, select whether you want Default or Site-specific SLs. Selecting default screening levels will reproduce the results in the generic Generic Tables. Selecting Site-Specific will allow you to change exposure parameters. Now pick your analytes. To pick several in a row, depress the left mouse button and drag, then release. Or hold the Ctrl key down and select multiple analytes that are not in a row. Select the output option. Hit the retrieve button. If you selected Site-Specific, the next page allows you to change exposure parameters. Hit the retrieve button. SLs are being calculated. The first table presents the input parameters that were selected. The next table contains the screening levels. This table can be too big to print. The easiest way to manage this table is to move it to a spreadsheet or a database. To copy this table, hold the left mouse key down and drag across the entire table. when done, press Ctrl c to copy. Switch to a spreadsheet and press Ctrl v to paste.

- **Table 1. Standard Default Factors**

Symbol	Definition (units)	Default	Reference
SLs			
Resident SLs			
$SL_{res\text{-}sol\text{-}nc\text{-}ing}$	Resident Soil Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res\text{-}sol\text{-}nc\text{-}der}$	Resident Soil Noncarcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator

$SL_{res-sol-nc-inh}$	Resident Soil Noncarcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res-sol-nc-tot}$	Resident Soil Noncarcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res-sol-ca-ing}$	Resident Soil Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res-sol-ca-der}$	Resident Soil Carcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res-sol-ca-inh}$	Resident Soil Carcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res-sol-ca-tot}$	Resident Soil Carcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res-sol-mu-ing}$	Resident Soil Mutagenic Ingestion (mg/kg)	Mutagen-specific	Determined in this calculator
$SL_{res-sol-mu-der}$	Resident Soil Mutagenic Dermal (mg/kg)	Mutagen-specific	Determined in this calculator
$SL_{res-sol-mu-inh}$	Resident Soil Mutagenic Inhalation (mg/kg)	Mutagen-specific	Determined in this calculator
$SL_{res-sol-mu-tot}$	Resident Soil Mutagenic Total (mg/kg)	Mutagen-specific	Determined in this calculator
$SL_{res-sol-ca-vc-ing}$	Resident Soil Carcinogenic Vinyl Chloride Ingestion (mg/kg)	Vinyl Chloride -specific	Determined in this calculator

$SL_{res-sol-ca-vc-der}$	Resident Soil Carcinogenic Vinyl Chloride Dermal (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{res-sol-ca-vc-inh}$	Resident Soil Carcinogenic Vinyl Chloride Inhalation (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{res-sol-ca-vc-tot}$	Resident Soil Carcinogenic Vinyl Chloride Total (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{res-sol-tce-ing}$	Resident Soil Trichloroethylene Ingestion (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{res-sol-tce-der}$	Resident Soil Trichloroethylene Dermal (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{res-sol-tce-inh}$	Resident Soil Trichloroethylene Inhalation (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{res-sol-tce-tot}$	Resident Soil Trichloroethylene Total (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{water-nc-ing}$	Resident Tapwater Noncarcinogenic Ingestion (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-nc-der}$	Resident Tapwater Noncarcinogenic Dermal (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-nc-inh}$	Resident Tapwater Noncarcinogenic Inhalation (µg/L)	Contaminant-specific	Determined in this calculator

$SL_{water-nc-tot}$	Resident Tapwater Noncarcinogenic Total (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-ca-ing}$	Resident Tapwater Carcinogenic Ingestion (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-ca-der}$	Resident Tapwater Carcinogenic Dermal (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-ca-inh}$	Resident Tapwater Carcinogenic Inhalation (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-ca-tot}$	Resident Tapwater Carcinogenic Total (µg/L)	Contaminant-specific	Determined in this calculator
$SL_{water-mu-ing}$	Resident Tapwater Mutagenic Ingestion (µg/L)	Mutagen-specific	Determined in this calculator
$SL_{water-mu-der}$	Resident Tapwater Mutagenic Dermal (µg/L)	Mutagen-specific	Determined in this calculator
$SL_{water-mu-inh}$	Resident Tapwater Mutagenic Inhalation (µg/L)	Mutagen-specific	Determined in this calculator
$SL_{water-mu-tot}$	Resident Tapwater Mutagenic Total (µg/L)	Mutagen-specific	Determined in this calculator
$SL_{res-water-ca-vc-ing}$	Resident Tapwater Carcinogenic Vinyl Chloride Ingestion (µg/L)	Vinyl Chloride-specific	Determined in this calculator
$SL_{res-water-ca-vc-der}$	Resident Tapwater Carcinogenic Vinyl Chloride Dermal (µg/L)	Vinyl Chloride-specific	Determined in this calculator

$SL_{res\text{-}water\text{-}ca\text{-}vc\text{-}inh}$	Resident Tapwater Carcinogenic Vinyl Chloride Inhalation (µg/L)	Vinyl Chloride-specific	Determined in this calculator
$SL_{res\text{-}water\text{-}ca\text{-}vc\text{-}tot}$	Resident Tapwater Carcinogenic Vinyl Chloride Total (µg/L)	Vinyl Chloride-specific	Determined in this calculator
$SL_{water\text{-}tce\text{-}ing}$	Resident Tapwater Trichloroethylene Ingestion (µg/L)	Trichloroethylene-specific	Determined in this calculator
$SL_{water\text{-}tce\text{-}der}$	Resident Tapwater Trichloroethylene Dermal (µg/L)	Trichloroethylene-specific	Determined in this calculator
$SL_{water\text{-}tce\text{-}inh}$	Resident Tapwater Trichloroethylene Inhalation (µg/L)	Trichloroethylene-specific	Determined in this calculator
$SL_{water\text{-}tce\text{-}tot}$	Resident Tapwater Trichloroethylene Total (µg/L)	Trichloroethylene-specific	Determined in this calculator
$SL_{res\text{-}air\text{-}nc}$	Resident Air Noncarcinogenic (µg/m^3)	Contaminant-specific	Determined in this calculator
$SL_{res\text{-}air\text{-}ca}$	Resident Air Carcinogenic (µg/m^3)	Contaminant-specific	Determined in this calculator
$SL_{res\text{-}air\text{-}mu}$	Resident Air Mutagenic (µg/m^3)	Mutagen-specific	Determined in this calculator
$SL_{res\text{-}air\text{-}ca\text{-}vinyl\ chloride}$	Resident Air Carcinogenic Vinyl Chloride (µg/m^3)	Vinyl Chloride-specific	Determined in this calculator
$SL_{res\text{-}air\text{-}tce}$	Resident Air Trichloroethylene (µg/m^3)	Trichloroethylene-specific	Determined in this calculator

Worker SLs			
$SL_{w\text{-}sol\text{-}nc\text{-}ing}$	Composite Worker Soil Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}nc\text{-}der}$	Composite Worker Soil Noncarcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}nc\text{-}inh}$	Composite Worker Soil Noncarcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}nc\text{-}tot}$	Composite Worker Soil Noncarcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}ca\text{-}ing}$	Composite Worker Soil Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}ca\text{-}der}$	Composite Worker Soil Carcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}ca\text{-}inh}$	Composite Worker Soil Carcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}sol\text{-}ca\text{-}tot}$	Composite Worker Soil Carcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}air\text{-}nc}$	Composite Worker Air Noncarcinogenic ($\mu g/m^3$)	Contaminant-specific	Determined in this calculator
$SL_{w\text{-}air\text{-}ca}$	Composite Worker Air Carcinogenic ($\mu g/m^3$)	Contaminant-specific	Determined in this calculator

$SL_{ow\text{-}sol\text{-}nc\text{-}ing}$	Outdoor Worker Soil Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}nc\text{-}der}$	Outdoor Worker Soil Noncarcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}nc\text{-}inh}$	Outdoor Worker Soil Noncarcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}nc\text{-}tot}$	Outdoor Worker Soil Noncarcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}ca\text{-}ing}$	Outdoor Worker Soil Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}ca\text{-}der}$	Outdoor Worker Soil Carcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}ca\text{-}inh}$	Outdoor Worker Soil Carcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}sol\text{-}ca\text{-}tot}$	Outdoor Worker Soil Carcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}air\text{-}nc}$	Outdoor Worker Air Noncarcinogenic (μg/m^3)	Contaminant-specific	Determined in this calculator
$SL_{ow\text{-}air\text{-}ca}$	Outdoor Worker Air Carcinogenic (μg/m^3)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}sol\text{-}nc\text{-}ing}$	Indoor Worker Soil Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator

$SL_{iw\text{-}sol\text{-}nc\text{-}inh}$	Indoor Worker Soil Noncarcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}sol\text{-}nc\text{-}tot}$	Indoor Worker Soil Noncarcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}sol\text{-}ca\text{-}ing}$	Indoor Worker Soil Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}sol\text{-}ca\text{-}inh}$	Indoor Worker Soil Carcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}sol\text{-}ca\text{-}tot}$	Indoor Worker Soil Carcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}air\text{-}nc}$	Indoor Worker Air Noncarcinogenic (μg/m^3)	Contaminant-specific	Determined in this calculator
$SL_{iw\text{-}air\text{-}ca}$	Indoor Worker Air Carcinogenic (μg/m^3)	Contaminant-specific	Determined in this calculator
$SL_{cw\text{-}sol\text{-}nc\text{-}ing}$	Construction Worker Soil Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{cw\text{-}sol\text{-}nc\text{-}der}$	Construction Worker Soil Noncarcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{cw\text{-}sol\text{-}nc\text{-}inh}$	Construction Worker Soil Noncarcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{cw\text{-}sol\text{-}nc\text{-}tot}$	Construction Worker Soil Noncarcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator

$SL_{cw-sol-ca-ing}$	Construction Worker Soil Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{cw-sol-ca-der}$	Construction Worker Soil Carcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{cw-sol-ca-inh}$	Construction Worker Soil Carcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{cw-sol-ca-tot}$	Construction Worker Soil Carcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
Recreator SLs			
$SL_{rec-sol-nc-ing}$	Recreator Soil Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec-sol-nc-der}$	Recreator Soil Noncarcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec-sol-nc-inh}$	Recreator Soil Noncarcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec-sol-nc-tot}$	Recreator Soil Noncarcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec-sol-ca-ing}$	Recreator Soil Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec-sol-ca-der}$	Recreator Soil Carcinogenic Dermal (mg/kg)	Contaminant-specific	Determined in this calculator

$SL_{rec\text{-}sol\text{-}ca\text{-}inh}$	Recreator Soil Carcinogenic Inhalation (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}ca\text{-}tot}$	Recreator Soil Carcinogenic Total (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}mu\text{-}ing}$	Recreator Soil Mutagenic Ingestion (mg/kg)	Mutagenic-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}mu\text{-}der}$	Recreator Soil Mutagenic Dermal (mg/kg)	Mutagenic-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}mu\text{-}inh}$	Recreator Soil Mutagenic Inhalation (mg/kg)	Mutagenic-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}mu\text{-}tot}$	Recreator Soil Mutagenic Total (mg/kg)	Mutagenic-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}ca\text{-}vc\text{-}ing}$	Recreator Soil Carcinogenic Vinyl Chloride Ingestion (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}ca\text{-}vc\text{-}der}$	Recreator Soil Carcinogenic Vinyl Chloride Dermal (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}ca\text{-}vc\text{-}inh}$	Recreator Soil Carcinogenic Vinyl Chloride Inhalation (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}ca\text{-}vc\text{-}tot}$	Recreator Soil Carcinogenic Vinyl Chloride Total (mg/kg)	Vinyl Chloride-specific	Determined in this calculator
$SL_{rec\text{-}sol\text{-}tce\text{-}ing}$	Recreator Soil Trichloroethylene Ingestion (mg/kg)	Trichloroethylene-specific	Determined in this calculator

$SL_{rec-sol-tce-der}$	Recreator Soil Trichloroethylene Dermal (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{rec-sol-tce-inh}$	Recreator Soil Trichloroethylene Inhalation (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{rec-sol-tce-tot}$	Recreator Soil Trichloroethylene Total (mg/kg)	Trichloroethylene-specific	Determined in this calculator
$SL_{rec-water-nc-ing}$	Recreator Surface Water Non-Carcinogenic Ingestion (μg/L)	Contaminant-specific	Determined in this calculator
$SL_{rec-water-nc-der}$	Recreator Surface Water Non-Carcinogenic Dermal (μg/L)	Contaminant-specific	Determined in this calculator
$SL_{rec-water-nc-tot}$	Recreator Surface Water Non-Carcinogenic Total (μg/L)	Contaminant-specific	Determined in this calculator
$SL_{rec-water-ca-ing}$	Recreator Surface Water Carcinogenic Ingestion (μg/L)	Contaminant-specific	Determined in this calculator
$SL_{rec-water-ca-der}$	Recreator Surface Water Carcinogenic Dermal (μg/L)	Contaminant-specific	Determined in this calculator
$SL_{rec-water-ca-tot}$	Recreator Surface Water Carcinogenic Total (μg/L)	Contaminant-specific	Determined in this calculator
$SL_{rec-water-mu-ing}$	Recreator Surface Water Mutagenic Ingestion (μg/L)	Mutagen-specific	Determined in this calculator
$SL_{rec-water-mu-der}$	Recreator Surface Water Mutagenic Dermal (μg/L)	Mutagen-specific	Determined in this calculator

$SL_{rec\text{-}water\text{-}mu\text{-}tot}$	Recreator Surface Water Mutagenic Total (µg/L)	Mutagen-specific	Determined in this calculator
$SL_{rec\text{-}water\text{-}vc\text{-}ing}$	Recreator Surface Water Carcinogenic Vinyl Chloride Ingestion (µg/L)	Vinyl Chloride-specific	Determined in this calculator
$S_{rec\text{-}water\text{-}vc\text{-}der}$	Recreator Surface Water Carcinogenic Vinyl Chloride Dermal (µg/L)	Vinyl Chloride-specific	Determined in this calculator
$SL_{rec\text{-}water\text{-}vc\text{-}tot}$	Recreator Surface Water Carcinogenic Vinyl Chloride Total (µg/L)	Vinyl Chloride-specific	Determined in this calculator
$SL_{rec\text{-}water\text{-}tce\text{-}ing}$	Recreator Surface Water Trichlroethylene Ingestion (µg/L)	Trichlroethylene-specific	Determined in this calculator
$SL_{rec\text{-}water\text{-}tce\text{-}der}$	Recreator Surface Water Trichlroethylene Dermal (µg/L)	Trichlroethylene-specific	Determined in this calculator
$SL_{rec\text{-}water\text{-}tce\text{-}tot}$	Recreator Surface Water Trichlroethylene Total (µg/L)	Trichlroethylene-specific	Determined in this calculator
Fish SLs			
$SL_{res\text{-}fsh\text{-}nc\text{-}ing}$	Resident Fish Noncarcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
$SL_{res\text{-}fsh\text{-}ca\text{-}ing}$	Resident Fish Carcinogenic Ingestion (mg/kg)	Contaminant-specific	Determined in this calculator
Toxicity Values			
RfD_o or RFDOC	Chronic Oral Reference Dose (mg/kg-day)	Contaminant-specific	EPA Superfund hierarchy

RfC or RFCIC	Chronic Inhalation Reference Concentration (mg/m^3)	Contaminant-specific	EPA Superfund hierarchy
CSF_o or SFO	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Contaminant-specific	EPA Superfund hierarchy
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Contaminant-specific	EPA Superfund hierarchy
Miscellaneous Variables			
TR	target risk	1×10^{-6}	Selected by user
THQ	target hazard quotient	0.1	Selected by user
THI	target hazard index	0.1	Selected by user
RBA	relative bioavailability factor	Arsenic = 0.6 All Others = 1	U.S. EPA 2012
K	Andelman Volatilization Factor (L/m^3)	0.5	U.S. EPA 1991b (pg. 20)
K_p	Dermal Permeability Constant (cm/hour)	Contaminant-specific Inorganic default = 0.001	U.S. EPA 2004 Exhibit 3-1 and Section 3.1.2.1
$K_{p,ve}$	Steady-state Permeability Coefficient (cm/hour)	Contaminant-specific	U.S. EPA 2004
K_{ew}	Equillibrium Partition Coefficient between epidermis and water (unitless)	1 - assuming epidermis behaves essentially as water	U.S. EPA 2004

D_e	Effective Diffusivity of absorbing chemical in the epidermis (cm^2/sec)	(7.1×10^{-6}) / $(\sqrt{MW})$	U.S. EPA 2004
L_e	Effective Thickness of the Epidermis (cm)	10^{-2}	U.S. EPA 2004
$AT_{res\text{-}c}$	Averaging time - resident child (days)	365 x $ED_{res\text{-}c}$ = 2190	U.S. EPA 1989 (pg. 6-23)
$AT_{res\text{-}a}$	Averaging time - resident adult (days)	365 x ED_{res} = 9490	U.S. EPA 1989 (pg. 6-23)
AT_{res}	Averaging time - resident age adjusted (days)	365 x LT = 25550	U.S. EPA 1989 (pg. 6-23)
$AT_{w\text{-}a}$	Averaging time - composite worker (days)	365 x ED_w = 9125 (non-carcinogenic)	U.S. EPA 1989 (pg. 6-23)
AT_w	Averaging time - composite worker (days)	365 x LT = 25550 (carcinogenic)	U.S. EPA 1989 (pg. 6-23)
$AT_{iw\text{-}a}$	Averaging time - indoor worker (days)	365 x ED_{iw} = 9125 (non-carcinogenic)	U.S. EPA 1989 (pg. 6-23)
AT_{iw}	Averaging time - indoor worker soil (days)	365 x LT = 25550 (carcinogenic)	U.S. EPA 1989 (pg. 6-23)
$AT_{ow\text{-}a}$	Averaging time - outdoor worker (days)	365 x ED_{ow} = 9125 (non-carcinogenic)	U.S. EPA 1989 (pg. 6-23)
AT_{ow}	Averaging time - outdoor worker (days)	365 x LT = 25550 (carcinogenic)	U.S. EPA 1989 (pg. 6-23)
$AT_{cw\text{-}a}$	Averaging time - construction worker (days)	EWcw x 7 (d/wk) x EDcw = 350 (non-carcinogenic)	U.S. EPA 1989 (pg. 6-23)

AT_{cw}	Averaging time - construction worker (days)	365 x LT = 25550 (carcinogenic)	U.S. EPA 1989 (pg. 6-23)
$AT_{rec\text{-}c}$	Averaging time - recreator child (days)	365 x $ED_{rec\text{-}c}$	U.S. EPA 1989 (pg. 6-23)
$AT_{rec\text{-}a}$	Averaging time - recreator adult (days)	365 x $ED_{rec\text{-}a}$	U.S. EPA 1989 (pg. 6-23)
AT_{rec}	Averaging time - recreator (days)	365 x LT	U.S. EPA 1989 (pg. 6-23)
LT	Lifetime (years)	70	U.S. EPA 1989 (pg. 6-22)
$\Delta H_{v,b}$	Enthalpy of vaporization at the normal boiling point (cal/mol)	Contaminant-specific	See Chemical-specific hierarchy
$\Delta H_{v,gw}$	Enthalpy of vaporization at temperature of groundwater (cal/mol)	Contaminant-specific	Determined in this calculator
HLC	Henry's Law Constant at specified groundwater temperature (atm-m^3/mol)	Contaminant-specific	See Chemical-specific hierarchy
T_w	Groundwater Temperatures (Kelvin)	Site-specific	Site-specific
T_C	Critical Temperatures (Kelvin)	Contaminant-specific	See Chemical-specific hierarchy

T_b	Normal Boiling Point (Kelvin)	Contaminant-specific	See Chemical-specific hierarchy

n	If ($T_b/T_C < 0.57$)
	If ($T_b/T_C > 0.71$)
	If ($0.57 < T_b/T_C \leq 0.71$)
		n = 0.3
		n = 0.41
		n = (0.74 x T_b/T_C - 0.116)
			U.S. EPA Fact Sheet Unitless exponent values used to determine ΔHv,gw

Ingestion and Dermal Contact Rates			
IRW_{res-c}	Resident Drinking Water Ingestion Rate - Child (L/day)	0.78	U.S. EPA 2011, Tables 3-15 and 3-33; weighted average of 90th percentile consumer-only ingestion of drinking water (birth to <6 years)
IRW_{res-a}	Resident Drinking Water Ingestion Rate - Adult (L/day)	2.5	U.S. EPA 2011, Table 3-33; 90th percentile of consumer-only ingestion of drinking water (>= 21 years)
$IFW_{res-adj}$	Resident Drinking Water Ingestion Rate - Age-adjusted (L/kg)	327.95	Calculated using the age adjusted intake factors equation
$IFWM_{res-adj}$	Resident Mutagenic Drinking Water Ingestion Rate - Age-adjusted (L/kg)	1019.9	Calculated using the age adjusted intake factors equation
IRS_{res-c}	Resident Soil Ingestion Rate - Child (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{res-a}	Resident Soil Ingestion Rate - Adult (mg/day)	100	U.S. EPA 1991a (pg. 15)
$IFS_{res-adj}$	Resident Soil Ingestion Rate - Age-adjusted (mg/kg)	36750	Calculated using the age adjusted intake factors equation

$IFSM_{res\text{-}adj}$	Resident Mutagenic Soil Ingestion Rate - Age-adjusted (mg/kg)	166833.33	Calculated using the age adjusted intake factors equation
IR_{iw}	Indoor Worker Soil Ingestion Rate (mg/day)	50	U.S. EPA 1991a (pg. 15)
IR_{ow}	Outdoor Worker Soil Ingestion Rate (mg/day)	100	U.S. EPA 1991a (pg. 15)
IR_{cw}	Construction Worker Soil Ingestion Rate (mg/day)	330	U.S. EPA 2002 Exhibit 5-1
IR_{w}	Composite Worker Soil Ingestion Rate (mg/day)	100	U.S. EPA 1991a (pg. 15)
$IRW_{rec\text{-}c}$	Recreator Surface Water Ingestion Rate - Child (L/hour)	0.12	U.S. EPA 2011, Table 3.5
$IRW_{rec\text{-}a}$	Recreator Surface Water Ingestion Rate - Adult (L/hour)	0.071	U.S. EPA 2011, Table 3.5
$IFW_{rec\text{-}adj}$	Recreator Surface Water Ingestion Rate - Age-adjusted (L/kg)	Site-specific	Calculated using the age adjusted intake factors equation
$IRW_{0\text{-}2}$	Surface Water Ingestion Rate - Age Segment 0-2 (L/hour)	0.12	U.S. EPA 2011, Table 3.5
$IRW_{2\text{-}6}$	Surface Water Ingestion Rate - Age Segment 2-6 (L/hour)	0.12	U.S. EPA 2011, Table 3.5
$IRW_{6\text{-}16}$	Surface Water Ingestion Rate - Age Segment 6-16 (L/hour)	0.071	U.S. EPA 2011, Table 3.5

IRW_{16-26}	Surface Water Ingestion Rate - Age Segment 16-26 (L/hour)	0.071	U.S. EPA 2011, Table 3.5
$IFWM_{rec-adj}$	Recreator Mutagenic Surface Water Ingestion Rate - Age-adjusted (L/kg)	Site-specific	Calculated using the age adjusted intake factors equation
IRS_{rec-c}	Recreator Soil Ingestion Rate - Child (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{rec-a}	Recreator Soil Ingestion Rate - Adult (mg/day)	100	U.S. EPA 1991a (pg. 15)
$IFS_{rec-adj}$	Recreator Soil Ingestion Rate - Age-adjusted (mg/kg)	Site-specific	Calculated using the age adjusted intake factors equation
IRS_{0-2}	Soil Ingestion Rate - Age-segment 0-2 (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{2-6}	Soil Ingestion Rate - Age-segment 2-6 (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{6-16}	Soil Ingestion Rate - Age-segment 6-16 (mg/day)	100	U.S. EPA 1991a (pg. 15)
IRS_{16-26}	Soil Ingestion Rate - Age-segment 16-26 (mg/day)	100	U.S. EPA 1991a (pg. 15)
$IFSM_{rec-adj}$	Recreator Mutagenic Soil Ingestion Rate - Age-adjusted (mg/kg)	Site-specific	Calculated using the age adjusted intake factors equation
$DFS_{res-adj}$	Resident soil dermal contact factor- age-adjusted (mg/kg)	103390	Calculated using the age adjusted intake factors equation
$DFSM_{res-adj}$	Resident Mutagenic soil dermal contact factor- age-adjusted (mg/kg)	428260	Calculated using the age adjusted intake factors equation

$DFS_{rec\text{-}adj}$	Recreator soil dermal contact factor- age-adjusted (mg/kg)	Site-specific	Calculated using the age adjusted intake factors equation
$DFSM_{rec\text{-}adj}$	Recreator Mutagenic soil dermal contact factor- age-adjusted (mg/kg)	Site-specific	Calculated using the age adjusted intake factors equation
$DFW_{res\text{-}adj}$	Resident water dermal contact factor- age-adjusted (cm^2 - event/kg)	2610650	Calculated using the age adjusted intake factors equation
$DFWM_{res\text{-}adj}$	Resident Mutagenic water dermal contact factor- age-adjusted (cm^2 - event/kg)	8191633	Calculated using the age adjusted intake factors equation
$DFW_{rec\text{-}adj}$	Recreator water dermal contact factor- age-adjusted (cm^2 - event/kg)	Site-specific	Calculated using the age adjusted intake factors equation
$DFWM_{rec\text{-}adj}$	Recreator Mutagenic water dermal contact factor- age-adjusted (cm^2 - event/kg)	Site-specific	Calculated using the age adjusted intake factors equation
$IRF_{res\text{-}a}$	Fish Ingestion Rate (mg/day)	Site-specific	Recommend using site-specific values
$SA_{res\text{-}c}$	Resident surface area soil - child (cm^2/day)	2373	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years)(forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)

$SA_{res\text{-}a}$	Resident surface area soil - adult (cm^2/day)	6032	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years) (forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.
$SA_{res\text{-}c}$	Resident surface area water - child (cm^2)	6365	U.S. EPA 2014, weighted average of mean values for children <6 years.
$SA_{res\text{-}a}$	Resident surface area water - adult (cm^2)	19652	U.S. EPA 2014, weighted average of mean values for adults, male and female 21+.
SA_{ow}	Outdoor Worker soil surface area - adult (cm^2/day)	3527	US EPA 2011a, Table 7-2; weighted average of mean values for head, hands, and forearms (male and female, 21+years)
SA_{cw}	Construction Worker soil surface area - adult (cm^2/day)	3527	US EPA 2011a, Table 7-2; weighted average of mean values for head, hands, and forearms (male and female, 21+years)
SA_{w}	Composite Worker soil surface area - adult (cm^2/day)	3527	US EPA 2011a, Table 7-2; weighted average of mean values for head, hands, and forearms (male and female, 21+years)

SA_{rec-c}	Recreator surface area soil - child (cm^2/day)	2373	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years)(forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)
SA_{rec-a}	Recreator surface area soil - adult (cm^2/day)	6032	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years)(forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.
SA_{rec-c}	Recreator surface area water - child (cm^2)	6365	U.S. EPA 2014, weighted average of mean values for children <6 years.
SA_{rec-a}	Recreator surface area water - adult (cm^2)	19652	U.S. EPA 2014, weighted average of mean values for adults, male and female 21+.
SA_{0-2}	Resident/Recreator surface area soil - age segment 0-2 (cm^2/day)	2373	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years)(forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)

SA_{2-6}	Resident/Recreator surface area soil - age segment 2-6 (cm^2/day)	2373	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years)(forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)
SA_{6-16}	Resident/Recreator surface area soil - age segment 6-16 (cm^2/day)	6032	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years) (forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.
SA_{16-26}	Resident/Recreator surface area soil - age segment 16-26 (cm^2/day)	6032	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years) (forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.
SA_{0-2}	Resident/Recreator surface area water - age segment 0-2 (cm^2)	6365	U.S. EPA 2014, weighted average of mean values for children <6 years.
SA_{2-6}	Resident/Recreator surface area water - age segment 2-6 (cm^2)	6365	U.S. EPA 2014, weighted average of mean values for children <6 years.

$SA_{6\text{-}16}$	Resident/Recreator surface area water - age segment 6-16 (cm^2)	19652	U.S. EPA 2014, weighted average of mean values for adults, male and female 21+.
$SA_{16\text{-}26}$	Resident/Recreator surface area water - age segment 16-26 (cm^2)	19652	U.S. EPA 2014, weighted average of mean values for adults, male and female 21+.
$AF_{res\text{-}c}$	Resident soil adherence factor - child (mg/cm^2)	0.2	U.S. EPA 2002 (Exhibit 1-2)
$AF_{res\text{-}a}$	Resident soil adherence factor - adult (mg/cm^2)	0.07	U.S. EPA 2002 (Exhibit 1-2)
AF_{ow}	Outdoor Worker soil adherence factor (mg/cm^2)	0.12	U.S. EPA 2011, Table 7-20 and Section 7.2.2; arithmetic mean of weighted average of body part- specific (hands, forearms, and face) mean adherence factors for adult commercial/industrial activities
AF_w	Composite Worker soil adherence factor (mg/cm^2)	0.12	U.S. EPA 2011, Table 7-20 and Section 7.2.2; arithmetic mean of weighted average of body part- specific (hands, forearms, and face) mean adherence factors for adult commercial/industrial activities
AF_{cw}	Construction Worker soil adherence factor (mg/cm^2)	0.3	U.S. EPA 2002 (Exhibit 5-1)
$AF_{rec\text{-}c}$	Recreator soil adherence factor - child (mg/cm^2)	0.2	U.S. EPA 2002 (Exhibit 1-2)

$AF_{rec\text{-}a}$	Recreator soil adherence factor - adult (mg/cm^2)	0.07	U.S. EPA 2002 (Exhibit 1-2)
$AF_{0\text{-}2}$	Resident/Recreator soil adherence factor - age segment 0-2 (mg/cm^2)	0.2	U.S. EPA 2002 (Exhibit 1-2)
$AF_{2\text{-}6}$	Resident/Recreator soil adherence factor - age segment 2-6 (mg/cm^2)	0.2	U.S. EPA 2002 (Exhibit 1-2)
$AF_{6\text{-}16}$	Resident/Recreator soil adherence factor - age segment 6-16 (mg/cm^2)	0.07	U.S. EPA 2002 (Exhibit 1-2)
$AF_{16\text{-}26}$	Resident/Recreator soil adherence factor - age segment 16-26 (mg/cm^2)	0.07	U.S. EPA 2002 (Exhibit 1-2)
$BW_{res\text{-}c}$	Resident Body Weight - child (kg)	15	U.S. EPA 1991a (pg. 15)
$BW_{res\text{-}a}$	Resident Body Weight - adult (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
$BW_{rec\text{-}c}$	Recreator Body Weight - child (kg)	15	U.S. EPA 1991a (pg. 15)
$BW_{rec\text{-}a}$	Recreator Body Weight - adult (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
$BW_{0\text{-}2}$	Resident/Recreator Body Weight - age segment 0-2 (kg)	15	U.S. EPA 1991a (pg. 15)
$BW_{2\text{-}6}$	Resident/Recreator Body Weight - age segment 2-6 (kg)	15	U.S. EPA 1991a (pg. 15)

BW_{6-16}	Resident/Recreator Body Weight - age segment 6-16 (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
BW_{16-26}	Resident/Recreator Body Weight - age segment 16-26 (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
BW_{ow}	Outdoor Worker Body Weight (kg)	80	U.S. EPA 1991a (pg. 15)
BW_{cw}	Construction Worker Body Weight (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
BW_{iw}	Indoor Worker Body Weight (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
BW_{w}	Composite Worker Body Weight (kg)	80	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78
ABS_{d}	Fraction of contaminant absorbed dermally from soil (unitless)	Contaminant-specific Inorganic default = none VOC default = none SVOC default = 0.1	U.S. EPA 2004 (Exhibit 3-4 and section 3.2.2.4)
GIABS	Fraction of contaminant absorbed in gastrointestinal tract (unitless) Note: if the GIABS is >50% then it is set to 100% for the calculation of dermal toxicity values.	Contaminant-specific Inorganic default = 1.0 VOC default = 1.0 SVOC default = 1.0	U.S. EPA 2004 (Exhibit 4-1 and section 4.2)
DA_{event}	Absorbed dose per event ($\mu g/cm^2$ - event)	Contaminant-specific	U.S. EPA 2004 (Equation 3.2 and 3.3)

Exposure Frequency, Exposure Duration, and Exposure Time Variables

EF_{res}	Resident Exposure Frequency (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{res-a}	Resident Exposure Frequency - adult (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{res-c}	Resident Exposure Frequency - child (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{w}	Composite Worker Exposure Frequency (days/year)	250	U.S. EPA 1991a (pg. 15)
EF_{iw}	Indoor Worker Exposure Frequency (days/year)	250	U.S. EPA 1991a (pg. 15)
EF_{ow}	Outdoor Worker Exposure Frequency (days/year)	225	U.S. EPA 2002 (Exhibit 1-2)
EF_{cw}	Construction Worker Exposure Frequency (days/year)	250	U.S. EPA 2002 Exhibit 5-1
EF_{rec}	Recreator Exposure Frequency (days/year)	Site-specific	Site-specific
EF_{rec-c}	Recreator Exposure Frequency - child (days/year)	Site-specific	Site-specific
EF_{rec-a}	Recreator Exposure Frequency - adult (days/year)	Site-specific	Site-specific
EF_{0-2}	Resident/Recreator Exposure Frequency - age segment 0-2 (days/year)	Resident - 350 Recreator - Site-specific	Resident - U.S. EPA 1991a (pg. 15) Recreator - Site-specific

EF_{2-6}	Resident/Recreator Exposure Frequency - age segment 2-6 (days/year)	Resident - 350 Recreator - Site-specific	Resident - U.S. EPA 1991a (pg. 15) Recreator - Site-specific
EF_{6-16}	Resident/Recreator Exposure Frequency - age segment 6-16 (days/year)	Resident - 350 Recreator - Site-specific	Resident - U.S. EPA 1991a (pg. 15) Recreator - Site-specific
EF_{16-26}	Resident/Recreator Exposure Frequency - age segment 16-26 (days/year)	Resident - 350 Recreator - Site-specific	Resident - U.S. EPA 1991a (pg. 15) Recreator - Site-specific
ED_{res}	Resident Exposure Duration (years)	26	EPA 2011, Table 16-108; 90th percentile for current residence time.
ED_{res-c}	Resident Exposure Duration - child (years)	6	U.S. EPA 1991a (pg. 15)
ED_{res-a}	Resident Exposure Duration - adult (years)	20	ED_{res} (26 years) - ED_{res-c} (6 years)
ED_{w}	Composite Worker Exposure Duration - (years)	25	U.S. EPA 1991a (pg. 15)
ED_{iw}	Indoor Worker Exposure Duration - (years)	25	U.S. EPA 1991a (pg. 15)
ED_{ow}	Outdoor Worker Exposure Duration (years)	25	U.S. EPA 1991a (pg. 15)
ED_{cw}	Construction Worker Exposure Duration (years)	1	U.S. EPA 2002 Exhibit 5-1
ED_{rec}	Recreator Exposure Duration (years)	26	EPA 2011, Table 16-108; 90th percentile for current residence time.

$ED_{rec\text{-}c}$	Recreator Exposure Duration - child (years)	6	U.S. EPA 1991a (pg. 15)
$ED_{rec\text{-}a}$	Recreator Exposure Duration - adult (years)	20	ED_{rec} (26 years) - $ED_{rec\text{-}c}$ (6 years)
$ED_{0\text{-}2}$	Resident/Recreator Exposure Duration - age segment 0-2 (years)	2	U.S. EPA 2005 (pg. 37)
$ED_{2\text{-}6}$	Resident/Recreator Exposure Duration - age segment 2-6 (years)	4	U.S. EPA 2005 (pg. 37)
$ED_{6\text{-}16}$	Resident/Recreator Exposure Duration - age segment 6-16 (years)	10	U.S. EPA 2005 (pg. 37)
$ED_{16\text{-}26}$	Resident/Recreator Exposure Duration - age segment 16-26 (years)	10	U.S. EPA 2005 (pg. 37)
$ET_{res\text{-}a}$	Resident Exposure Time (hours/day)	24	The whole day
$ET_{res\text{-}c}$	Resident Exposure Time (hours/day)	24	The whole day
ET_{res}	Resident Exposure Time (hours/day)	24	The whole day
ET_{w}	Composite Worker Exposure Time (hours/day)	8	The work day
ET_{iw}	Indoor Worker Exposure Time (hours/day)	8	The work day
ET_{ow}	Outdoor Worker Exposure Time (hours/day)	8	The work day

ET_{cw}	Construction Worker Exposure Time (hours/day)	8	The work day
ET_{rec}	Recreator Exposure Time (hours/day)	Site-specific	Site-specific
ET_{rec-c}	Recreator Exposure Time - child (hours/day)	Site-specific	Site-specific
ET_{rec-a}	Recreator Exposure Time - adult (hours/day)	Site-specific	Site-specific
$ET_{event-res-c}$	Resident Water Exposure Time - child (hours/event)	0.54	U.S. EPA 2011, Table 16-28; weighted average of 90th percentile time spent bathing (birth to <6 years)
$ET_{event-res-a}$	Resident Water Exposure Time - adult (hours/event)	0.71	U.S. EPA 2011, Tables 16-30 and 16-31; weighted average of adult (21 to 78) 90th percentile of time spent bathing/ showering in a day, divided by mean number of baths/showers taken in a day.
$ET_{event-res-adj}$	Resident Water Exposure Time - age-adjusted (hours/event)	0.6708	Calculated using the age adjusted intake factors equation
$ET_{event-res-madj}$	Resident Exposure Time - age-adjusted (hours/event)	0.6708	Calculated using the age adjusted intake factors equation
$ET_{event-rec-c}$	Recreator Surface Water Exposure Time - child (hours/event)	Site-specific	Site-specific
$ET_{event-rec-a}$	Recreator Surface Water Exposure Time - adult (hours/event)	Site-specific	Site-specific

ET_{0-2}	Resident/Recreator Exposure Time - age segment 0-2 (hours/day)	Resident - 24 Recreator - Site-specific	Resident - The whole day Recreator - Site-specific
ET_{2-6}	Resident/Recreator Exposure Time - age segment 2-6 (hours/day)	Resident - 24 Recreator - Site-specific	Resident - The whole day Recreator - Site-specific
ET_{6-16}	Resident/Recreator Exposure Time - age segment 6-16 (hours/day)	Resident - 24 Recreator - Site-specific	Resident - The whole day Recreator - Site-specific
ET_{16-26}	Resident/Recreator Exposure Time - age segment 16-26 (hours/day)	Resident - 24 Recreator - Site-specific	Resident - The whole day Recreator - Site-specific
$ET_{event-rec-adj}$	Recreator Exposure Time - age-adjusted (hours/event)	Site-specific	Calculated using the age adjusted intake factors equation
$ET_{event-rec (0-2)}$	Recreator Exposure Time - age segment 0-2 (hours/event)	Site-specific	Site-specific
$ET_{event-rec (2-6)}$	Recreator Exposure Time - age segment 2-6 (hours/event)	Site-specific	Site-specific
$ET_{event-rec (6-16)}$	Recreator Exposure Time - age segment 6-16 (hours/event)	Site-specific	Site-specific
$ET_{event-rec (16-26)}$	Recreator Exposure Time - age segment 16-26 (hours/event)	Site-specific	Site-specific
$ET_{event-res (0-2)}$	Resident Exposure Time - age segment 0-2 (hours/event)	0.54	Calculated based on the ET given for ETevent-res-c

$ET_{event\text{-}res\ (2\text{-}6)}$	Resident Exposure Time - age segment 2-6 (hours/event)	0.54	Calculated based on the ET given for ETevent-res-c
$ET_{event\text{-}res\ (6\text{-}16)}$	Resident Exposure Time - age segment 6-16 (hours/event)	0.71	Calculated based on the ET given for ETevent-res-a
$ET_{event\text{-}res\ (16\text{-}26)}$	Resident Exposure Time - age segment 16-26 (hours/event)	0.71	Calculated based on the ET given for ETevent-res-a
$ET_{event\text{-}rec\text{-}madj}$	Recreator Exposure Time - age-adjusted (hours/event)	Site-specific	Calculated using the age adjusted intake factors equation
$EV_{rec\text{-}c}$	Recreator Events - child (events/day)	Site-specific	Site-specific
$EV_{rec\text{-}a}$	Recreator Events - adult (events/day)	Site-specific	Site-specific
$EV_{res\text{-}c}$	Resident Events - child (events/day)	1	U.S. EPA 2004; Exhibit 3-2
$EV_{res\text{-}a}$	Resident Events - adult (events/day)	1	U.S. EPA 2004; Exhibit 3-2
$EV_{0\text{-}2}$	Resident/Recreator Events - age segment 0-2 (events/day)	Resident - 1 Recreator - Site-specific	U.S. EPA 2004; Exhibit 3-2
$EV_{2\text{-}6}$	Resident/Recreator Events - age segment 2-6 (events/day)	Resident - 1 Recreator - Site-specific	U.S. EPA 2004; Exhibit 3-2
$EV_{6\text{-}16}$	Resident/Recreator Events - age segment 6-16 (events/day)	Resident - 1 Recreator - Site-specific	U.S. EPA 2004; Exhibit 3-2

EV_{16-26}	Resident/Recreator Events - age segment 16-26 (events/day)	Resident - 1 Recreator - Site-specific	U.S. EPA 2004; Exhibit 3-2
Soil to Groundwater SSL Factor Variables			
C_w	Target soil leachate concentration (mg/L)	nonzero MCL or RSL × DAF	U.S. EPA. 2002 Equation 4-14
DAF	Dilution attenuation factor (unitless)	1 (or site-specific)	U.S. EPA. 2002 Equation 4-11
ED	Exposure duration	70	U.S. EPA. 2002 Equation 4-14
I	Infiltration Rate (m/year)	0.18	U.S. EPA. 2002 Equation 4-11
L	source length parallel to ground water flow (m)	site-specific	U.S. EPA. 2002 Equation 4-11
i	hydraulic gradient (m/m)	site-specific	U.S. EPA. 2002 Equation 4-11
K	aquifer hydraulic conductivity (m/year)	site-specific	U.S. EPA. 2002 Equation 4-11
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.3	U.S. EPA. 2002 Equation 4-10
θ_a	air-filled soil porosity (L_{air}/L_{soil})	$= n-\theta_w$	U.S. EPA. 2002 Equation 4-10
n	total soil porosity (L_{pore}/L_{soil})	$= 1-(\rho_b/\rho_s)$	U.S. EPA. 2002 Equation 4-10
ρ_s	soil particle density (Kg/L)	2.65	U.S. EPA. 2002 Equation 4-10
ρ_b	dry soil bulk density (kg/L)	1.5	U.S. EPA. 2002 Equation 4-10

H'	Dimensionless Henry Law Constant (unitless)	Contaminant-specific	See Chemical-specific hierarchy
K_d	soil-water partition coefficient (L/kg)	= K_{oc}*f_{oc} for organics	U.S. EPA. 2002 Equation 4-10
K_{oc}	soil organic carbon/water partition coefficient (L/kg)	Contaminant-specific	See Chemical-specific hierarchy
f_{oc}	fraction organic carbon in soil (g/g)	0.002	U.S. EPA. 2002 Equation 4-10
d_a	aquifer thickness (m)	site-specific	U.S. EPA. 2002 Equation 4-10
d_s	depth of source (m)	site-specific	U.S. EPA. 2002 Equation 4-10
d	mixing zone depth (m)	site-specific	U.S. EPA. 2002 Equation 4-12
Wind Particulate Emission Factor Variables			
PEF	Particulate Emission Factor - Minneapolis (m^3/kg)	1.36 x 10^9(region-specific)	U.S. EPA 2002 Exhibit D-2
Q/C_{wind}	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	93.77 (region-specific)	U.S. EPA 2002 Exhibit D-2
V	Fraction of Vegetative Cover (unitless)	0.5	U.S. EPA. 2002 Equation 4-5
U_m	Mean Annual Wind Speed (m/s)	4.69	U.S. EPA. 2002 Equation 4-5

U_t	Equivalent Threshold Value of Wind Speed at 7m (m/s)	11.32	U.S. EPA. 2002 Equation 4-5
F(x)	Function Dependent on U_m /U_t (unitless)	0.194	U.S. EPA. 2002 Equation 4-5
A	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 Exhibit D-2
A_s	Areal extent of the site or contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 Exhibit D-2
B	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 Exhibit D-2
C	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 Exhibit D-2
Mechanical Particulate Emission Factor Variables from Vehicle Traffic			
PEF_{sc}	Particulate Emission Factor - subchronic (m^3/kg)	(site-specific)	U.S. EPA 2002 Equation 5-5
Q/C_{sr}	Inverse of the ratio of the 1-h geometric mean concentration to the emission flux along a straight road segment bisecting a square site (g/m^2-s per kg/m^3)	23.02 (for 0.5 acre site)	U.S. EPA 2002 Equation 5-5
F_D	Dispersion correction factor (unitless)	0.185	U.S. EPA 2002 Equation E-16
T	Total time over which construction occurs (s)	site-specific	U.S. EPA 2002 Equation 5-5
A_R	Surface area of contaminated road segment (m^2)	($A_R = L_R * W_R * 0.092903m^2/ft^2$)	U.S. EPA 2002 Equation 5-5

L_R	Length of road segment (ft)	Site-specific	U.S. EPA 2002 Equation 5-5
W_R	Width of road segment (ft)	20	U.S. EPA 2002 Equation E-18
W	Mean vehicle weight (tons)	(number of cars x tons/car + number of trucks x tons/truck) / total vehicles)	U.S. EPA 2002 Equation 5-5
p	Number of days with at least 0.01 inches of precipitation (days/year)	Site-specific	U.S. EPA 2002 Exhibit 5-2
∑VKT	Sum of fleet vehicle kilometers traveled during the exposure duration (km)	∑VKT = total vehicles x distance (km/day) x frequency (weeks/year) x (days/year)	U.S. EPA 2002 Equation 5-5
A	Dispersion constant unitless	12.9351	U.S. EPA 2002 Equation 5-6
A_s	Areal extent of site surface soil contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 Equation 5-6
B	Dispersion constant unitless	5.7383	U.S. EPA 2002 Equation 5-6
C	Dispersion constant unitless	71.7711	U.S. EPA 2002 Equation 5-6
Mechanical Particulate Emission Factor Variables from other than Vehicle Traffic			
PEF'_{sc}	Particulate Emission Factor - subchronic (m^3/kg)	(site-specific)	U.S. EPA 2002 Equation E-26

Q/C_{sa}	Inverse of the ratio of the 1-h. geometric mean air concentration and the emission flux at the center of the square emission source (g/m^2-s per kg/m^3)	Site-specific	U.S. EPA 2002 Equation E-15
F_D	Dispersion correction factor (unitless)	Site-specific	U.S. EPA 2002 Equation E-16
A	Dispersion constant unitless	2.4538	U.S. EPA 2002 Equation E-15
B	Dispersion constant unitless	17.5660	U.S. EPA 2002 Equation E-15
C	Dispersion constant unitless	189.0426	U.S. EPA 2002 Equation E-15
A_s	Areal extent of site surface soil contamination (acres)	(range 0.5 to 500)	U.S. EPA 2002 Equation E-15
J'_T	Total time-averaged PM_{10} unit emission flux for construction activities other than traffic on unpaved roads (g/m^2-s)	Site-specific	U.S. EPA 2002 Equation E-25
M^{PC}_{wind}	Unit mass emitted from wind erosion (g)	site-specific	U.S. EPA 2002 Equation E-20
V	Fraction of Vegetative Cover (unitless)	0	U.S. EPA 2002 Equation E-20
U_m	Mean Annual Wind Speed (m/s)	4.69	U.S. EPA 2002 Equation E-20
U_t	Equivalent Threshold Value of Wind Speed at 7m (m/s)	11.32	U.S. EPA 2002 Equation E-20

F(x)	Function Dependent on U_m /U_t (unitless)	0.194	U.S. EPA 2002 Equation E-20
A_{surf}	Areal extent of site surface soil contamination (m^2)	(range 0.5 to 500)	U.S. EPA 2002 Equation E-20
ED	Exposure duration (years)	Site-specific	U.S. EPA 2002 Equation E-20
M_{excav}	Unit mass emitted from excavation soil dumping (g)	site-specific	U.S. EPA 2002 Equation E-21
0.35	PM_{10} particle size multiplier (unitless)	0.35	U.S. EPA 2002 Equation E-21
U_m	Mean annual wind speed during construction (m/s)	4.69	U.S. EPA 2002 Equation E-21
$M_{m-excav}$	Gravimetric soil moisture content (%)	12 (mean value for municipal landfill cover)	U.S. EPA 2002 Equation E-21
ρ_{soil}	In situ soil density (includes water) (mg/m^3)	1.68	U.S. EPA 2002 Equation E-21
A_{excav}	Areal extent of excavation (m^2)	(range 0.5 to 500)	U.S. EPA 2002 Equation E-21
d_{excav}	Average depth of excavation (m)	Site-specific	U.S. EPA 2002 Equation E-21
N_{A-dump}	Number of times soil is dumped (unitless)	2	U.S. EPA 2002 Equation E-21
M_{doz}	Unit mass emitted from dozing operations (g)	site-specific	U.S. EPA 2002 Equation E-22
0.75	PM_{10} scaling factor (unitless)	0.75	U.S. EPA 2002 Equation E-22

s_{doz}	Soil silt content (%)	6.9	U.S. EPA 2002 Equation E-22
$M_{m\text{-}doz}$	Gravimetric soil moisture content (%)	7.9 (mean value for overburden)	U.S. EPA 2002 Equation E-22
$\sum VKT_{doz}$	Sum of dozing kilometers traveled (km)	Site-specific	U.S. EPA 2002 Equation E-22
S_{doz}	Average dozing speed (kph)	11.4 (mean value for graders)	U.S. EPA 2002 Equation E-22
$N_{A\text{-}doz}$	Number of times site is dozed (unitless)	Site-specific	U.S. EPA 2002 Equation E-22
B_d	Dozer blade length (m)	Site-specific	U.S. EPA 2002 Page E-28
M_{grade}	Unit mass emitted from grading operations (g)	site-specific	U.S. EPA 2002 Equation E-23
0.60	PM10 scaling factor (unitless)	0.60	U.S. EPA 2002 Equation E-23
$\sum VKT_{grade}$	Sum of grading kilometers traveled (km)		U.S. EPA 2002 Equation E-23
S_{grade}	Average grading speed (kph)	11.4 (mean value for graders)	U.S. EPA 2002 Equation E-23
$N_{A\text{-}grade}$	Number of times site is graded (unitless)	Site-specific	U.S. EPA 2002 Equation E-23
B_g	Grader blade length (m)	Site-specific	U.S. EPA 2002 Page E-28
M_{till}	Unit mass emitted from tilling operations (g)	site-specific	U.S. EPA 2002 Equation E-24
s_{till}	Soil silt content (%)	18	U.S. EPA 2002 Equation E-24

$A_{c\text{-}till}$	Areal extent of tilling (acres)	Site-specific	U.S. EPA 2002 Equation E-24
$A_{c\text{-}grade}$	Areal extent of grading (acres)	Site-specific	Necessary to solve $\sum VKT_{grade}$ in U.S. EPA 2002 Equation E-23
$A_{c\text{-}doz}$	Areal extent of dozinging (acres)	Site-specific	Necessary to solve $\sum VKT_{grade}$ in U.S. EPA 2002 Equation E-22
$N_{A\text{-}till}$	Number of times soil is tilled (unitless)	2	U.S. EPA 2002 Equation E-24
Chronic Volatilization Factor and Soil Saturation Limit Variables			
VF_{ulim}	Volatilization Factor - Los Angeles (m^3/kg)	Contaminant-specific	U.S. EPA. 2002 Equation 4-8
C_{sat}	Soil saturation concentration (mg/kg)	Contaminant-specific	U.S. EPA. 2002 Equation 4-9
Q/C_{vol}	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	68.18	U.S. EPA. 2002 Equation 4-8
A	Dispersion constant unitless	11.9110 (region-specific)	U.S. EPA 2002 Exhibit D-3
A_s	Areal extent of the site contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 Equation 4-8
B	Dispersion constant unitless	18.4385 (region-specific)	U.S. EPA 2002 Exhibit D-3
C	Dispersion constant unitless	209.7845 (region-specific)	U.S. EPA 2002 Exhibit D-3

D_A	Apparent Diffusivity (cm^2/s)	Contaminant-specific	U.S. EPA. 2002 Equation 4-8
T	Exposure interval (s)	8.2×108 (used for unlimited source model)	U.S. EPA. 2002 Equation 4-8
T	Exposure interval (years)	26 (used for mass-limit model)	U.S. EPA. 2002 Equation 4-13
ρ_b	Dry soil bulk density (g/cm^3)	1.5	U.S. EPA. 2002 Equation 4-8
θ_a	Air-filled soil porosity (L_{air}/L_{soil}) (n-θ_w)	0.28	U.S. EPA. 2002 Equation 4-8
n	Total soil porosity (L_{pore}/L_{soi}l) (1-(ρ_b/ρ_s)	0.43	U.S. EPA. 2002 Equation 4-8
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15	U.S. EPA. 2002 Equation 4-8
ρ_s	Soil particle density (g/cm^3)	2.65	U.S. EPA. 2002 Equation 4-8
S	Water Solubility Limit (mg/L)	Contaminant-specific	See Chemical-specific hierarchy
R	Universal Gas Constant (L-atm/mole-K)	0.082057	U.S. EPAFact Sheet
R_c	Universal Gas Constant (cal/mole-K)	1.9872	U.S. EPA Fact Sheet
D_{ia}	Diffusivity in air (cm^2/s)	Contaminant-specific	U.S. EPA. 2001
H'	Dimensionless Henry's Law Constant	Contaminant-specific	See Chemical-specific hierarchy

D_{iw}	Diffusivity in water (cm^2/s)	Contaminant-specific	U.S. EPA. 2001
K_d	Soil-water partition coefficient (L/Kg) ($K_{oc} \times f_{oc}$)	Contaminant-specific	U.S. EPA. 2002 Equation 4-8
K_{oc}	Soil organic carbon-water partition coefficient (L/Kg)	$= K_{oc} * f_{oc}$ for organics	See Chemical-specific hierarchy
f_{oc}	Organic carbon content of soil (g/g)	0.006	U.S. EPA. 2002 Equation 4-8
ds	Average source depth (m)	Site-specific	U.S. EPA 2002 Equation 4-13
Subchronic Volatilization Factor for Unlimited Source and Mass-limit Equations			
$VF_{ulim\text{-}sc}$	Subchronic Volatilization Factor (m^3/kg)	Contaminant-specific	U.S. EPA 2002 Equation 5-14
Q/C_{sa}	Inverse of the ratio of the 1-h geometric mean air concentration to the volatilization flux at the center of a square source (g/m^2-s per kg/m^3)	14.31 (for 0.5 acre site)	U.S. EPA 2002 Equation 5-14
A	Dispersion constant unitless	2.4538	U.S. EPA 2002 Equation 5-15
A_c	Areal extent of the site soil contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 Equation 5-15
B	Dispersion constant unitless	17.5660	U.S. EPA 2002 Equation 5-15
C	Dispersion constant unitless	189.0426	U.S. EPA 2002 Equation 5-15

D_A	Apparent Diffusivity (cm^2/s)	Contaminant-specific	U.S. EPA 2002 Equation 5-14
T	Total time over which construction occurs (s)	site-specific	U.S. EPA 2002 Equation 5-14
ρ_b	Dry soil bulk density (g/cm^3)	1.5	U.S. EPA 2002 Equation 5-14
F_D	Dispersion correction factor (unitless)	0.185	U.S. EPA 2002 Equation 5-14
θ_a	Air-filled soil porosity (L_{air}/L_{soil}) ($n-\theta_w$)	0.28	U.S. EPA 2002 Equation 5-14
n	Total soil porosity (L_{pore}/L_{soil}) ($1-(\rho_b/\rho_s$)	0.43	U.S. EPA 2002 Equation 5-14
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15	U.S. EPA 2002 Equation 5-14
ρ_s	Soil particle density (g/cm^3)	2.65	U.S. EPA 2002 Equation 5-14
D_{ia}	Diffusivity in air (cm^2/s)	Contaminant-specific	U.S. EPA 2001
H'	Dimensionless Henry's Law Constant	Contaminant-specific	See Chemical-specific hierarchy
D_{iw}	Diffusivity in water (cm^2/s)	Contaminant-specific	U.S. EPA 2001
K_d	Soil-water partition coefficient (L/Kg) ($K_{oc} \times f_{oc}$)	$= K_{oc}*f_{oc}$ for organics	See Chemical-specific hierarchy
K_{oc}	Soil organic carbon-water partition coefficient (L/Kg)	Contaminant-specific	See Chemical-specific hierarchy

f_{oc}	Organic carbon content of soil (g/g)	0.006 (0.6%)	U.S. EPA 2002 Equation 5-14
T	Total time over which construction occurs (year)	site-specific (T=ED)	U.S. EPA 2002 Equation 5-17
d_s	Average source depth (m)	Site-specific	U.S. EPA 2002 Equation 5-17

7. References

U.S. EPA (Environmental Protection Agency). 1987. Processes, Coefficients, and Models for Simulation Toxic Organics and Heavy Metals in Surface Waters. EPA/600/3-87/015. Office of Research and Development, Athens, GA.

U.S. EPA 1989. Risk assessment guidance for Superfund. Volume I: Human health evaluation manual (Part A)(PDF) (289 pp, 6.9 MB). Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002.

U.S. EPA 1991a. Human health evaluation manual, supplemental guidance: "Standard default exposure factors (PDF) (28 pp, 248 K)". OSWER Directive 9285.6-03.

U.S. EPA 1991b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals) (PDF) (68 pp, 721 K). Office of Emergency and Remedial Response. EPA/540/R-92/003. December 1991

U.S. EPA. 1996a. Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-23

U.S. EPA. 1996b. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-17A

U.S. EPA. 1997a. Exposure Factors Handbook (PDF) (854 pp, 7.7 MB). Office of Research and Development, Washington, DC. EPA/600/P-95/002Fa.

U.S. EPA 2000. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Part I: Estimating Exposure to Dioxin-Like Compounds. Volume 3--Properties, Environmental Levels, and Background Exposures. Draft Final Report. EPA/600/P- 00/001. Office of Research and Development, Washington, DC. September.

U.S. EPA, 2000b. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (PDF) (185 pp, 790 K).

U.S. EPA, 2001 (PDF) (38 pp, 185 K). WATER9. Version 1.0.0. Office of Air Quality Planning and Standards, Research Triangle Park, NC. Web site.

U.S. EPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. December 2002.

U.S. EPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP.July 2004. Document (PDF) (186 pp, 4.2 MB) and website.

U.S. EPA 2005. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. March 2005. Document (PDF) (166 pp, 468 K)

U.S. EPA 2009. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment) Final. OSWER 9285.7-82. January 2009. Document (PDF) (68 pp, 724 K), memo (PDF) (3 pp, 487 K) and website.

U.S. EPA 2011. Exposure Factors Handbook 2011 Edition (Final). National Center for Environmental Assessment, Office of Research and Development. Washington D.C. Currently available online at http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252 or download here (PDF) (1436 pp, 21.3 MB).

U.S. EPA 2012. OSWER Directive 9200.1-113: Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil . Washington, DC.

U.S. EPA 2014. OSWER Directive 9200.1-120 (PDF) (7 pp, 1.1 MB). Washington, DC.

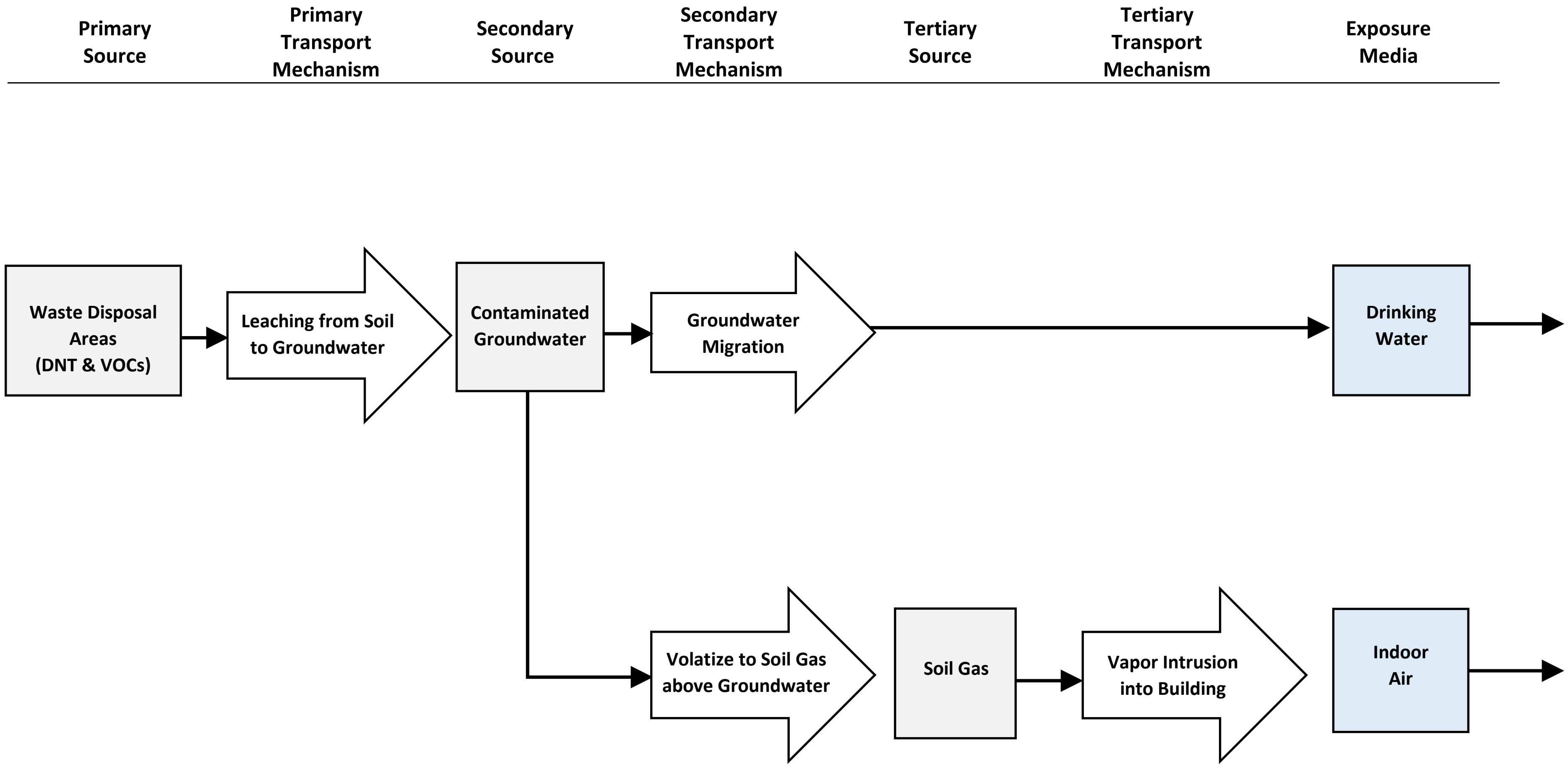
For assistance/questions please use the Regional Screening Levels (RSLs) contact us page. For general risk assessment questions, separate from the RSLs, please use the link below.

LAST UPDATED ON NOVEMBER 19, 2018

Appendix H

Groundwater Conceptual Site Models – Exposure Routes

Groundwater Conceptual Site Model – PBG Plume
Badger Army Ammunition Plant



Exposure Route	Human Receptor	
	Off-site Use	On-site Use
	Residential	Hypothetical Future Residential
Ingestion	●	⊙
Inhalation	●	⊙
Dermal	●	⊙
Inhalation	○	○

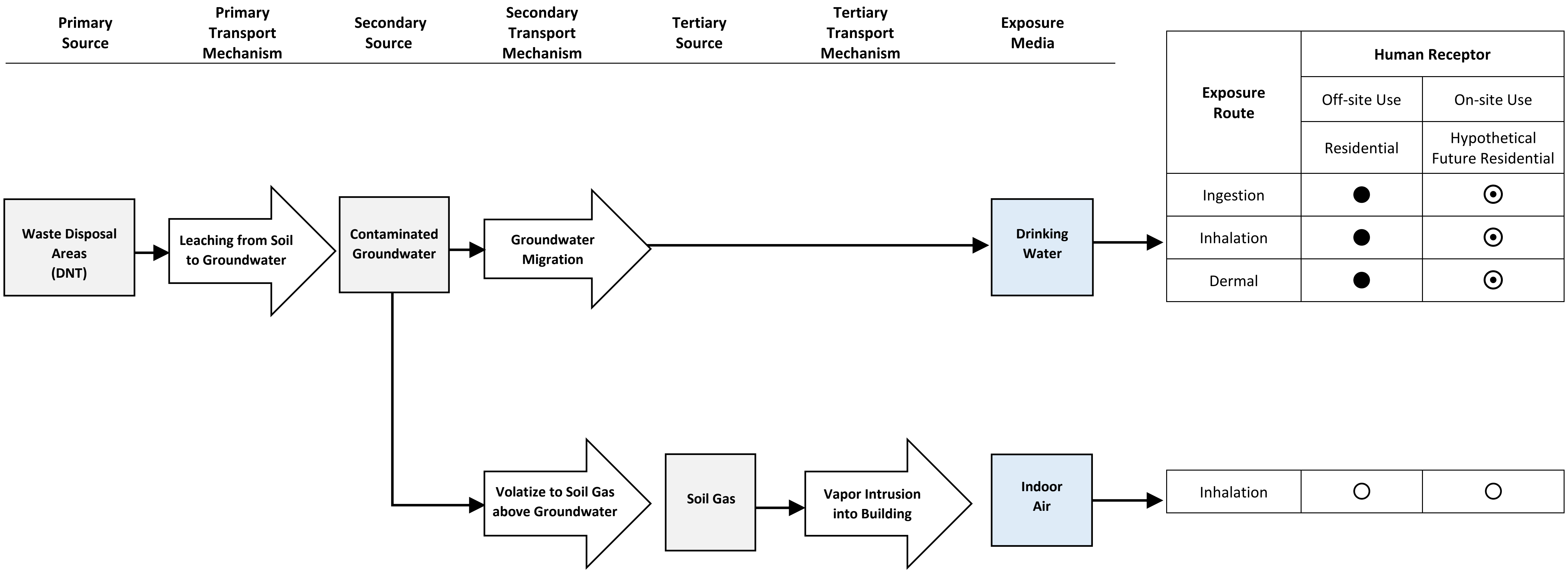
LEGEND:

● Pathway potentially complete under current land use conditions and warrants further evaluation.

⊙ Pathway incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future onsite groundwater usage.

○ Pathway incomplete or considered insignificant; no further evaluation is warranted.

Groundwater Conceptual Site Model – DBG Plume
Badger Army Ammunition Plant



Exposure Route	Human Receptor	
	Off-site Use	On-site Use
	Residential	Hypothetical Future Residential
Ingestion	●	⊙
Inhalation	●	⊙
Dermal	●	⊙
Inhalation	○	○

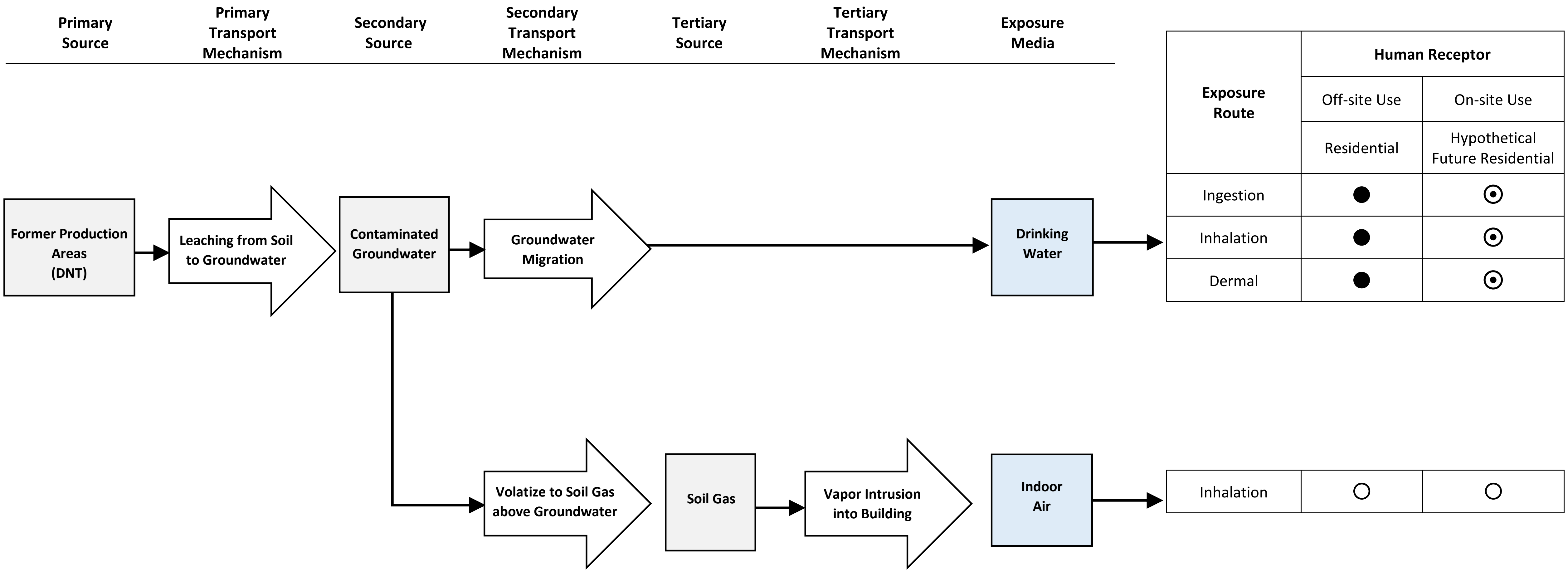
LEGEND:

● Pathway potentially complete under current land use conditions and warrants further evaluation.

⊙ Pathway incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future onsite groundwater usage.

○ Pathway incomplete or considered insignificant; no further evaluation is warranted.

Groundwater Conceptual Site Model – Central Plume
Badger Army Ammunition Plant



Exposure Route	Human Receptor	
	Off-site Use	On-site Use
	Residential	Hypothetical Future Residential
Ingestion	●	⊙
Inhalation	●	⊙
Dermal	●	⊙
Inhalation	○	○

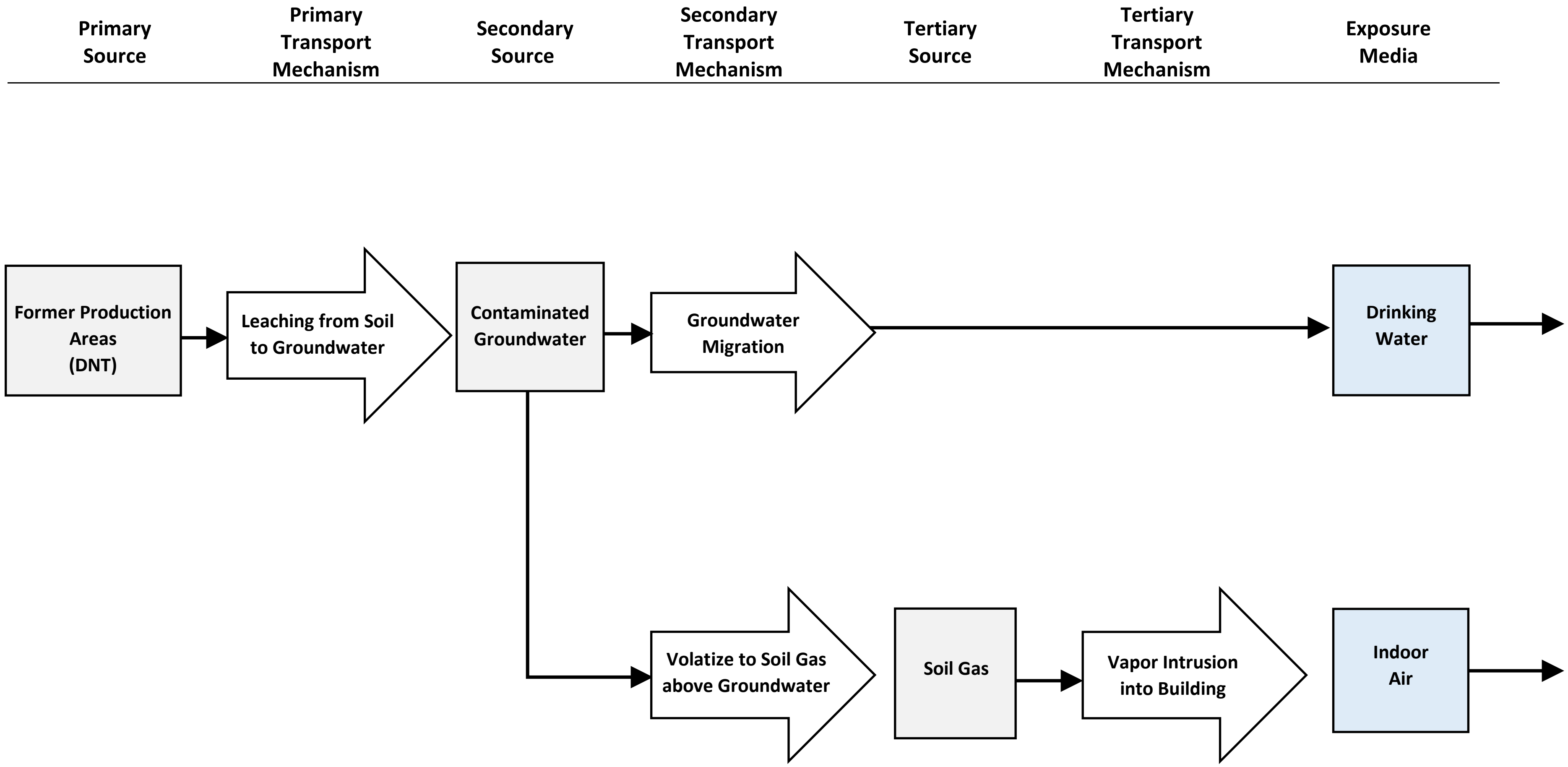
LEGEND:

● Pathway potentially complete under current land use conditions and warrants further evaluation.

⊙ Pathway incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future onsite groundwater usage.

○ Pathway incomplete or considered insignificant; no further evaluation is warranted.

Groundwater Conceptual Site Model – NC Area Plume
Badger Army Ammunition Plant



Exposure Route	Human Receptor	
	Off-site Use	On-site Use
	Residential	Hypothetical Future Residential
Ingestion	○	⊙
Inhalation	○	⊙
Dermal	○	⊙
Inhalation	○	○

LEGEND:

● Pathway potentially complete under current land use conditions and warrants further evaluation.

⊙ Pathway incomplete or considered insignificant under current land use conditions but potentially complete under hypothetical future onsite groundwater usage.

○ Pathway incomplete or considered insignificant; no further evaluation is warranted.

Appendix I

Remedial Alternative Cost Summaries

PBG Plume Alternative 2 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Monitored Natural Attenuation and Alternate Water Supply	**Direct Capital Cost**	No design cost to implement alternative	$ -	$0
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ -	$0
		Legal/License/Permit (5% of Direct Capital Cost)	$ -	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ -	
		Contingency (20% of Direct Capital Cost)	$ -	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 4,511,746	$4,913,113
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
				$4,913,113

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

PBG Plume Alternative 3 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Active Groundwater Remediation - Pump & Treat	**Direct Capital Cost**	Four groundwater extraction wells	$ 520,573	$3,633,573
		Four mobile treatment units	$ 2,460,000	
		Treatment area preparation, piping, utilities, SCADA System, buoy system, restoration	$ 653,000	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 363,357	$1,635,108
		Legal/License/Permit (5% of Direct Capital Cost)	$ 181,679	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 363,357	
		Contingency (20% of Direct Capital Cost)	$ 726,715	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 4,511,746	$7,433,131
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
		Mobile treatment units - 8 years of O&M (2 for 8 years, 1 for 6 years, 1 for 2 years)	$ 2,520,018	
				$12,701,812

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

PBG Plume Alternative 4 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Active Groundwater Remediation - Anaerobic Bioremediation	**Direct Capital Cost**	Biochemical product (59 tankers)	$ 2,754,328	$3,254,729
		Drilling, well installation & development, direct push, injection, abandonment & decontamination (9 wells, 150 DPTs)	$ 500,402	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 325,473	$1,464,628
		Legal/License/Permit (5% of Direct Capital Cost)	$ 162,736	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 325,473	
		Contingency (20% of Direct Capital Cost)	$ 650,946	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 4,511,746	$4,913,113
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
				$9,632,470

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

PBG Plume Alternative 5 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Well Replacement - Plume Area	**Direct Capital Cost**	Replacement of 47 residential wells	$ 2,350,000	$2,350,000
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 235,000	$1,057,500
		Legal/License/Permit (5% of Direct Capital Cost)	$ 117,500	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 235,000	
		Contingency (20% of Direct Capital Cost)	$ 470,000	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 4,511,746	$4,511,746
				$7,919,246

Notes:

Costs are based on current monitoring plans and engineering estimates.

O&M - Operations and Maintenance

PBG Plume Alternative 6 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Source Area Treatment	**Direct Capital Cost**	Biochemical product (2 tankers)	$ 83,150	$201,433
		Drilling, well installation & development, injection & decontamination (9 locations)	$ 118,283	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 20,143	$90,645
		Legal/License/Permit (5% of Direct Capital Cost)	$ 10,072	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 20,143	
		Contingency (20% of Direct Capital Cost)	$ 40,287	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 4,511,746	$4,913,113
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
				$5,205,190

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

DBG Plume Alternative 2 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Monitored Natural Attenuation and Alternate Water Supply	**Direct Capital Cost**	No design cost to implement alternative	$ -	$0
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ -	$0
		Legal/License/Permit (5% of Direct Capital Cost)	$ -	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ -	
		Contingency (20% of Direct Capital Cost)	$ -	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 3,839,123	$4,240,490
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
				$4,240,490

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

DBG Plume Alternative 3 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Active Groundwater Remediation - Pump & Treat	**Direct Capital Cost**	Three groundwater extraction wells	$ 390,430	$2,776,030
		Three mobile treatment units	$ 1,845,000	
		Treatment area preparation, piping, utilities, SCADA System, buoy system, restoration	$ 540,600	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 277,603	$1,249,214
		Legal/License/Permit (5% of Direct Capital Cost)	$ 138,802	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 277,603	
		Contingency (20% of Direct Capital Cost)	$ 555,206	
	Annual O&M	24 years of groundwater monitoring at current groundwater sampling program	$ 3,199,269	$8,522,395
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 24 years	$ 1,184	
		Residential well replacement - 1 well every 3 years for 24 years	$ 333,333	
		Mobile treatment units - 22 years of O&M (2 for 22 years, 1 for 10 years)	$ 4,988,608	
				$12,547,639

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

DBG Plume Alternative 4 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Active Groundwater Remediation - Anaerobic Bioremediation	**Direct Capital Cost**	Biochemical product (149 tankers)	$ 7,033,063	$8,107,868
		Direct push, injection, hole abandonment & decontamination (406 locations)	$ 1,074,805	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 810,787	$3,648,540
		Legal/License/Permit (5% of Direct Capital Cost)	$ 405,393	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 810,787	
		Contingency (20% of Direct Capital Cost)	$ 1,621,574	
	Annual O&M	4 years of groundwater monitoring at current groundwater sampling program	$ 639,854	$706,748
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 4 years	$ 228	
		Residential well replacement - 1 well every 3 years for 4 years	$ 66,667	
				$12,463,156

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

DBG Plume Alternative 5 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Well Replacement - Plume Area	**Direct Capital Cost**	Replacement of 57 residential wells	$ 2,280,000	$2,280,000
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 228,000	$1,026,000
		Legal/License/Permit (5% of Direct Capital Cost)	$ 114,000	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 228,000	
		Contingency (20% of Direct Capital Cost)	$ 456,000	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 3,839,123	$3,839,123
				$7,145,123

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance

DBG Plume Alternative 6 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Source Area Treatment	**Direct Capital Cost**	Biochemical product (11 tankers)	$ 517,375	$645,631
		Direct push, injection, hole abandonment & decontamination (56 locations)	$ 128,256	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 64,563	$290,534
		Legal/License/Permit (5% of Direct Capital Cost)	$ 32,282	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 64,563	
		Contingency (20% of Direct Capital Cost)	$ 129,126	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 3,839,123	$4,240,490
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
				$5,176,654

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

Central Plume Alternative 2 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Monitored Natural Attenuation and Alternate Water Supply	**Direct Capital Cost**	No design cost to implement alternative	$ -	$0
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ -	$0
		Legal/License/Permit (5% of Direct Capital Cost)	$ -	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ -	
		Contingency (20% of Direct Capital Cost)	$ -	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 1,997,172	$2,398,538
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 30 years	$ 1,367	
		Residential well replacement - 1 well every 3 years for 30 years	$ 400,000	
				$2,398,538

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

Central Plume Alternative 3 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Active Groundwater Remediation - Pump & Treat	**Direct Capital Cost**	Eight groundwater extraction wells	$ 1,041,147	$6,939,247
		Eight mobile treatment units	$ 4,920,000	
		Treatment area preparation, piping, utilities, SCADA System, buoy system, restoration	$ 978,100	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 693,925	$3,122,661
		Legal/License/Permit (5% of Direct Capital Cost)	$ 346,962	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 693,925	
		Contingency (20% of Direct Capital Cost)	$ 1,387,849	
	Annual O&M	12 years of groundwater monitoring at current groundwater sampling program	$ 865,441	$7,953,709
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 12 years	$ 592	
		Residential well replacement - 1 well every 3 years for 12 years	$ 173,333	
		Mobile treatment units - 10 years of O&M	$ 6,914,343	
				$18,015,617

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

Central Plume Alternative 4 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Active Groundwater Remediation - Anaerobic Bioremediation	**Direct Capital Cost**	Biochemical product (291 tankers)	$ 13,627,063	$16,082,742
		Direct push, injection, hole abandonment & decontamination (988 locations)	$ 2,455,680	
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 1,608,274	$7,237,234
		Legal/License/Permit (5% of Direct Capital Cost)	$ 804,137	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 1,608,274	
		Contingency (20% of Direct Capital Cost)	$ 3,216,548	
	Annual O&M	4 years of groundwater monitoring at current sampling program	$ 332,862	$399,756
		Provision of bottled water - 20 gallons/month for 3 months, once every 3 years for 4 years	$ 228	
		Residential well replacement - 1 well every 3 years for 4 years	$ 66,667	
				$23,719,733

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance
Residential well replacement will be offered when a NR 140 ES is exceeded in consecutive sampling rounds.

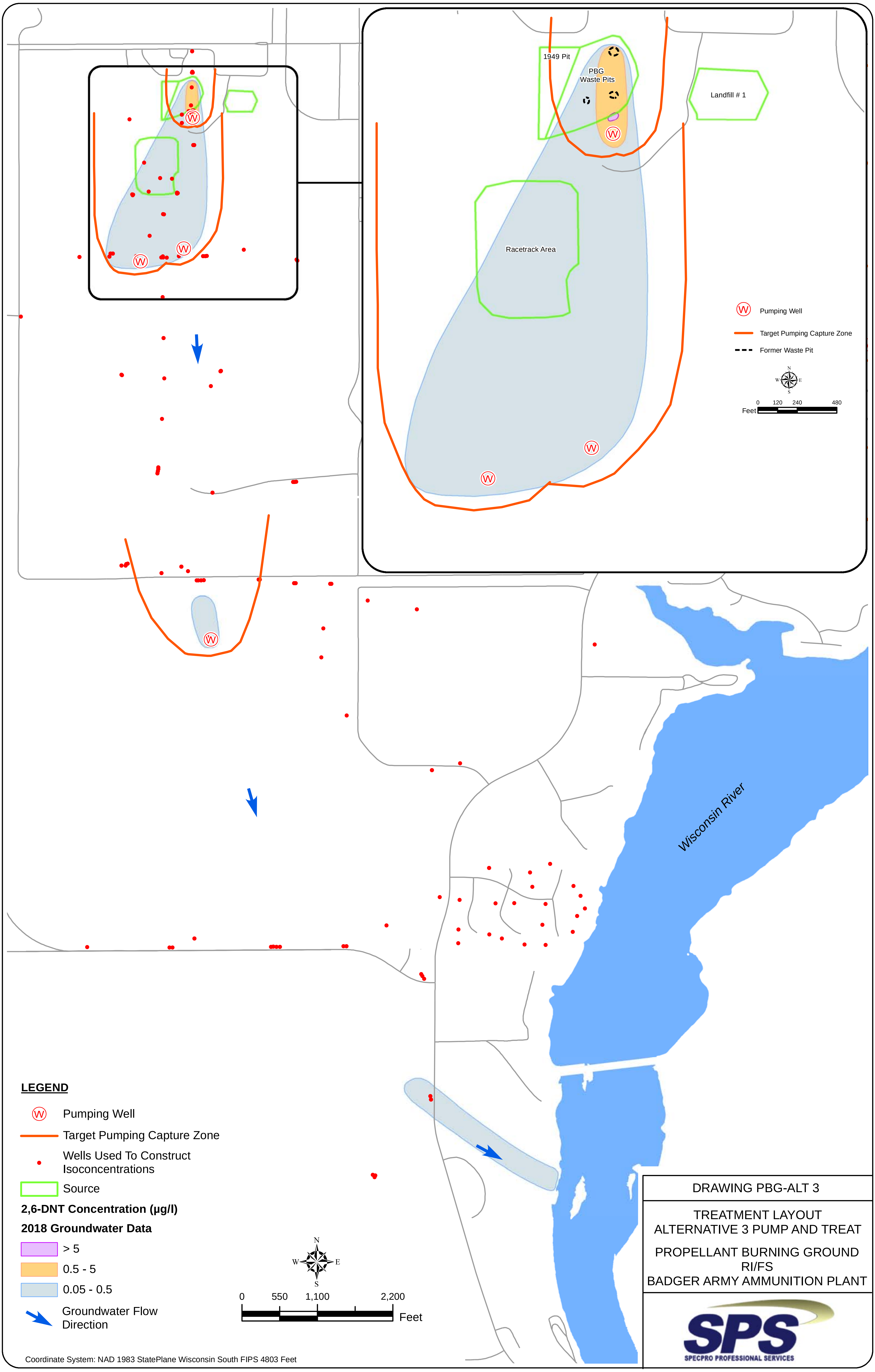
Central Plume Alternative 5 Cost Summary
Remedial Investigation/Feasibility Study
Badger Army Ammunition Plant

Alternative	Item Description	Comments	Sub Totals	Total Costs
Well Replacement - Plume Area	**Direct Capital Cost**	Replacement of 23 residential wells	$ 920,000	$920,000
	Indirect Capital Cost	Engineering Design (10% of Direct Capital Cost)	$ 92,000	$414,000
		Legal/License/Permit (5% of Direct Capital Cost)	$ 46,000	
		Start-up & Shake-down (10% of Direct Capital Cost)	$ 92,000	
		Contingency (20% of Direct Capital Cost)	$ 184,000	
	Annual O&M	30 years of groundwater monitoring at current groundwater sampling program	$ 1,997,172	$1,997,172
				$3,331,172

Notes:
Costs are based on current monitoring plans and engineering estimates.
O&M - Operations and Maintenance

Appendix J

Remedial Alternative Treatment Area Drawings

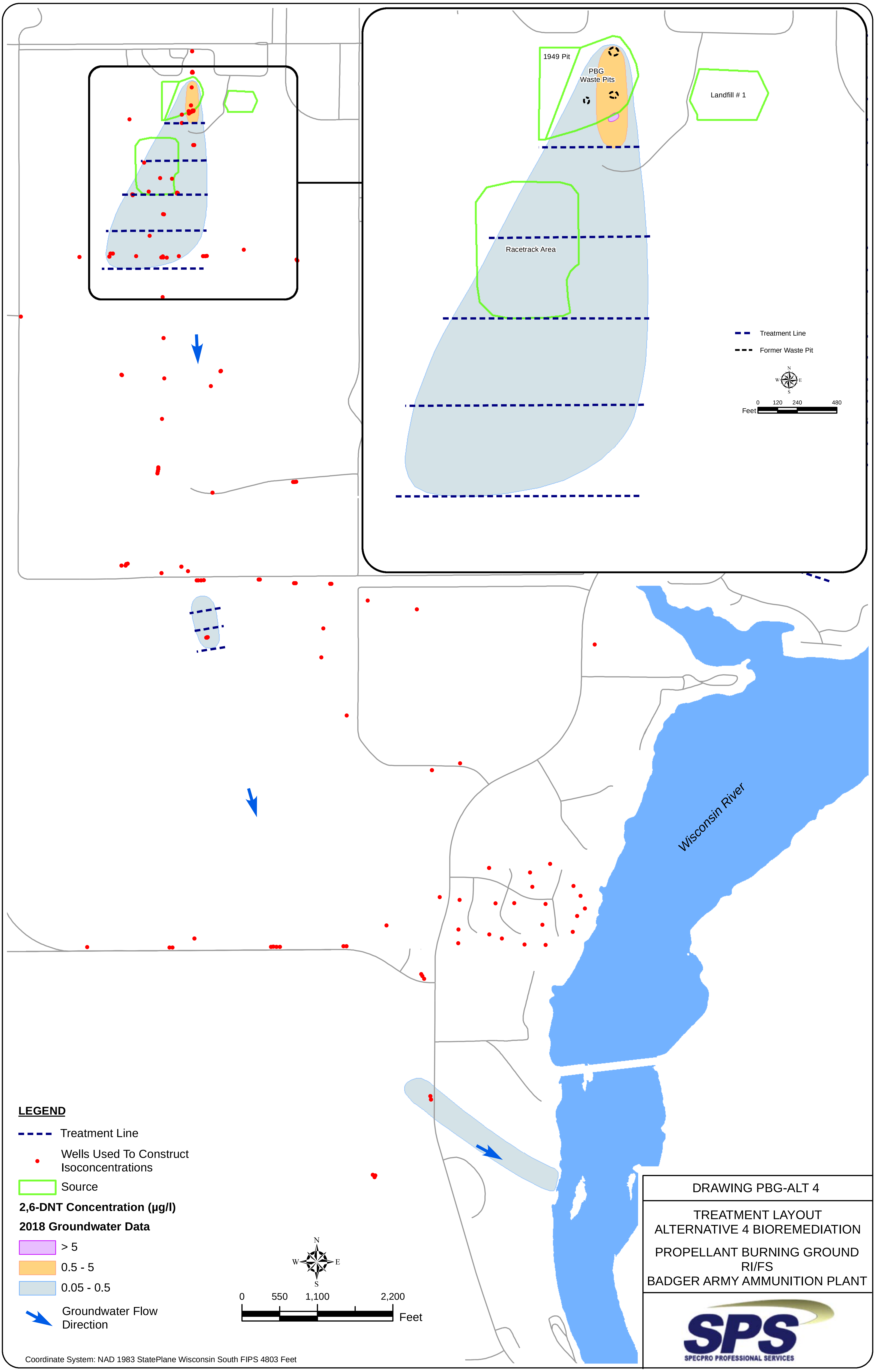


Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

DRAWING PBG-ALT 3

TREATMENT LAYOUT
ALTERNATIVE 3 PUMP AND TREAT

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

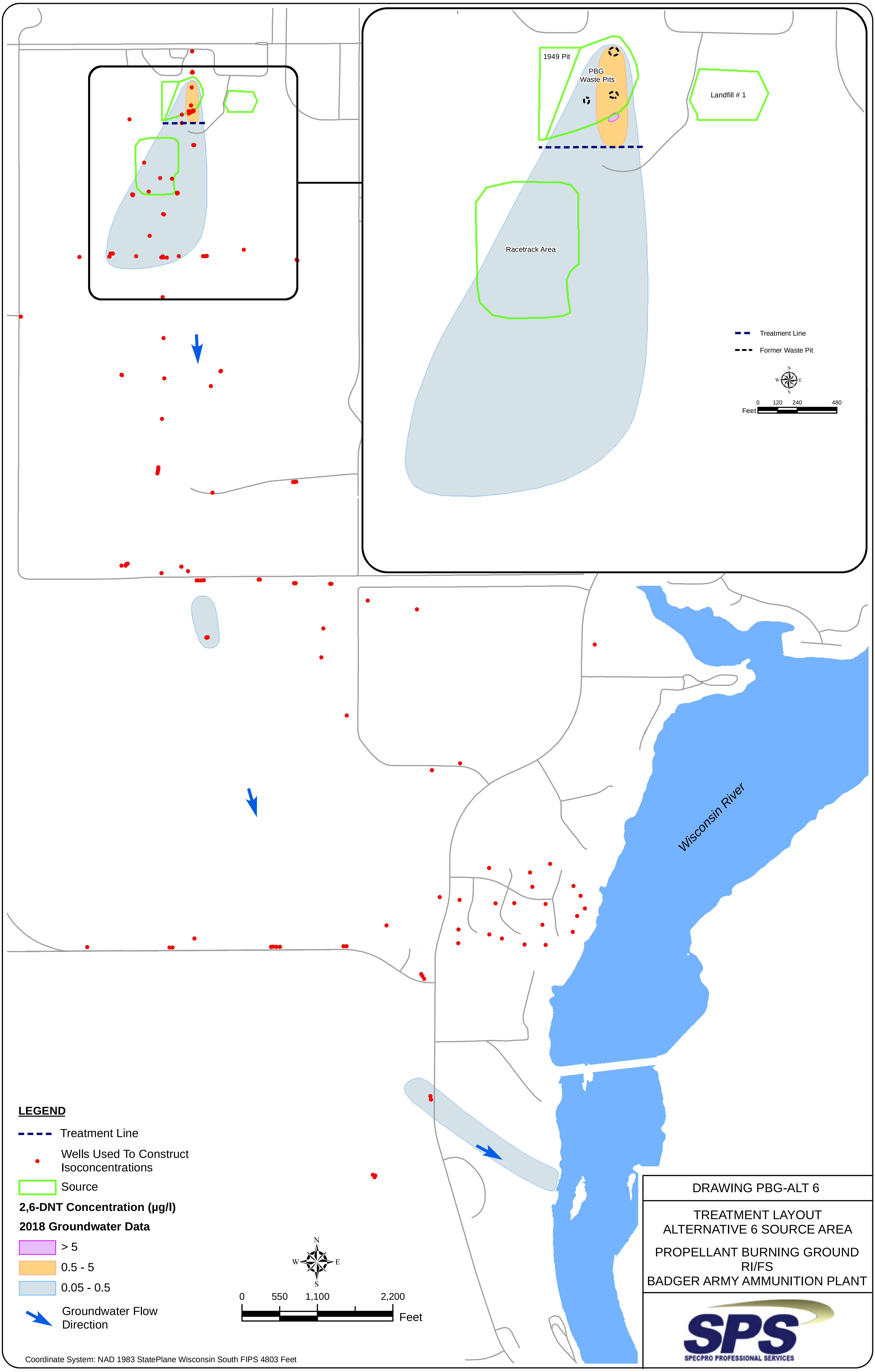


DRAWING PBG-ALT 4

TREATMENT LAYOUT
ALTERNATIVE 4 BIOREMEDIATION

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



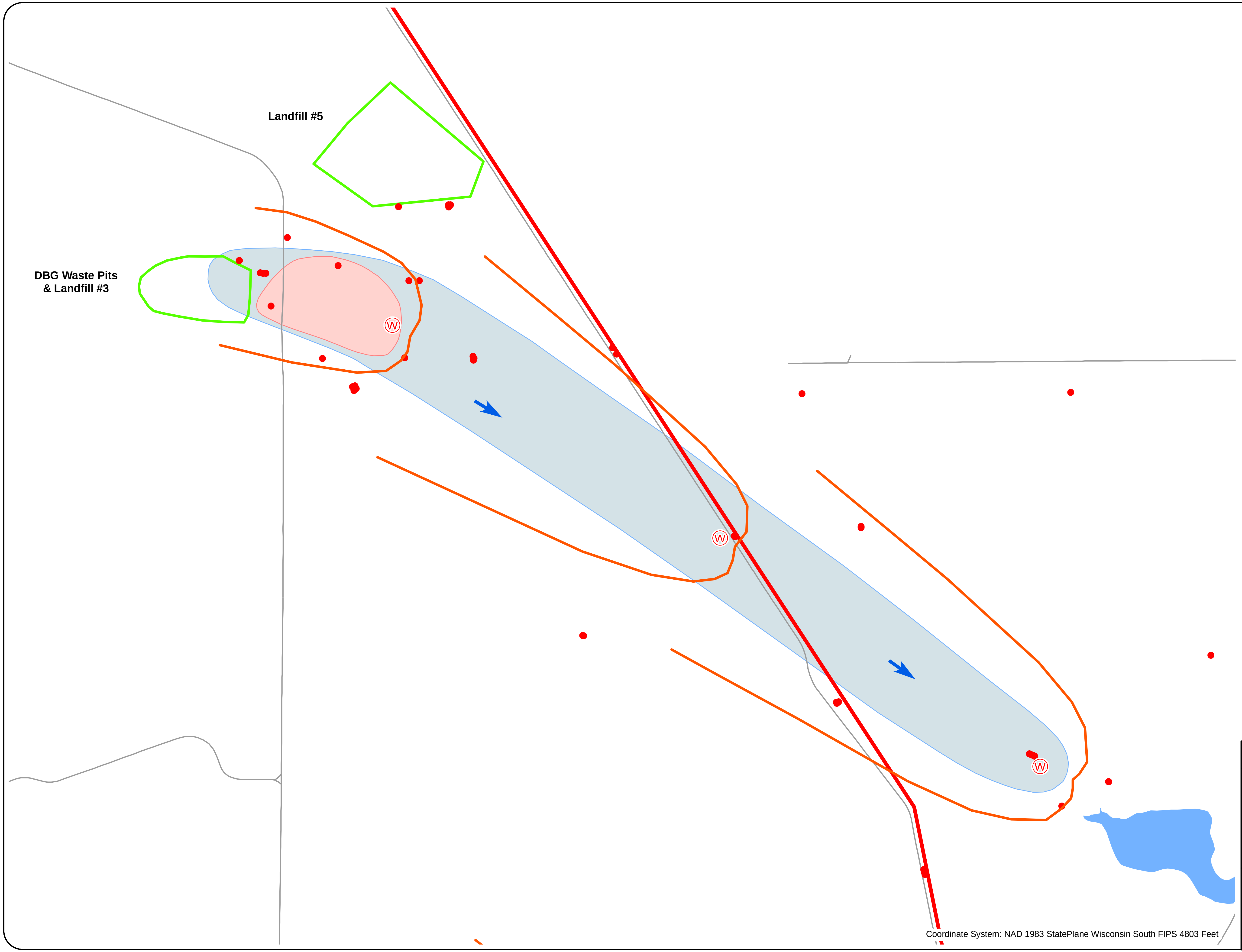
Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

DRAWING PBG-ALT 6

TREATMENT LAYOUT
ALTERNATIVE 6 SOURCE AREA

PROPELLANT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



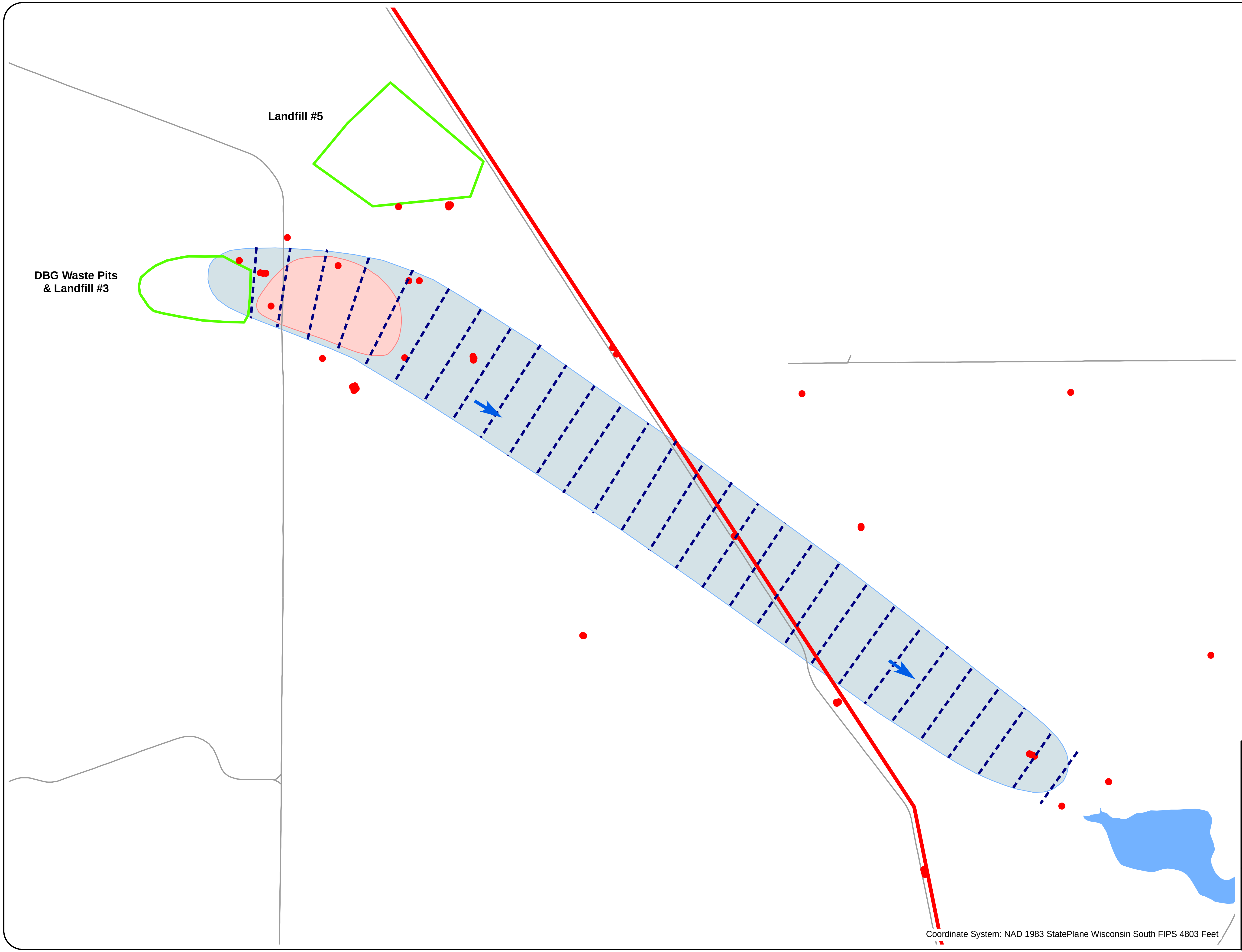
Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

DRAWING DBG-ALT 3

TREATMENT LAYOUT
ALTERNATIVE 3 PUMP AND TREAT

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPECPRO PROFESSIONAL SERVICES

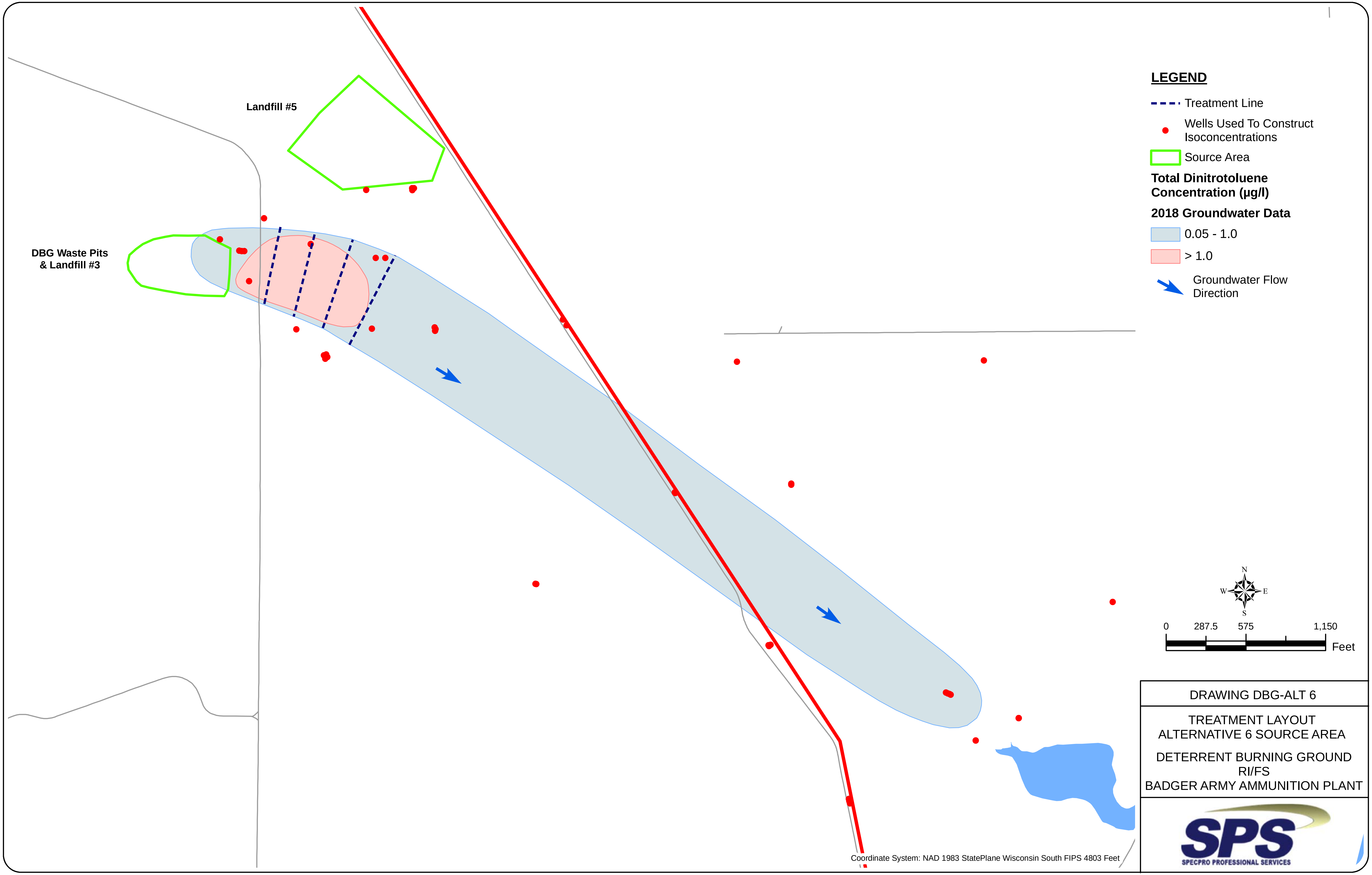


DRAWING DBG-ALT 4

TREATMENT LAYOUT
ALTERNATIVE 4 BIOREMEDIATION

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

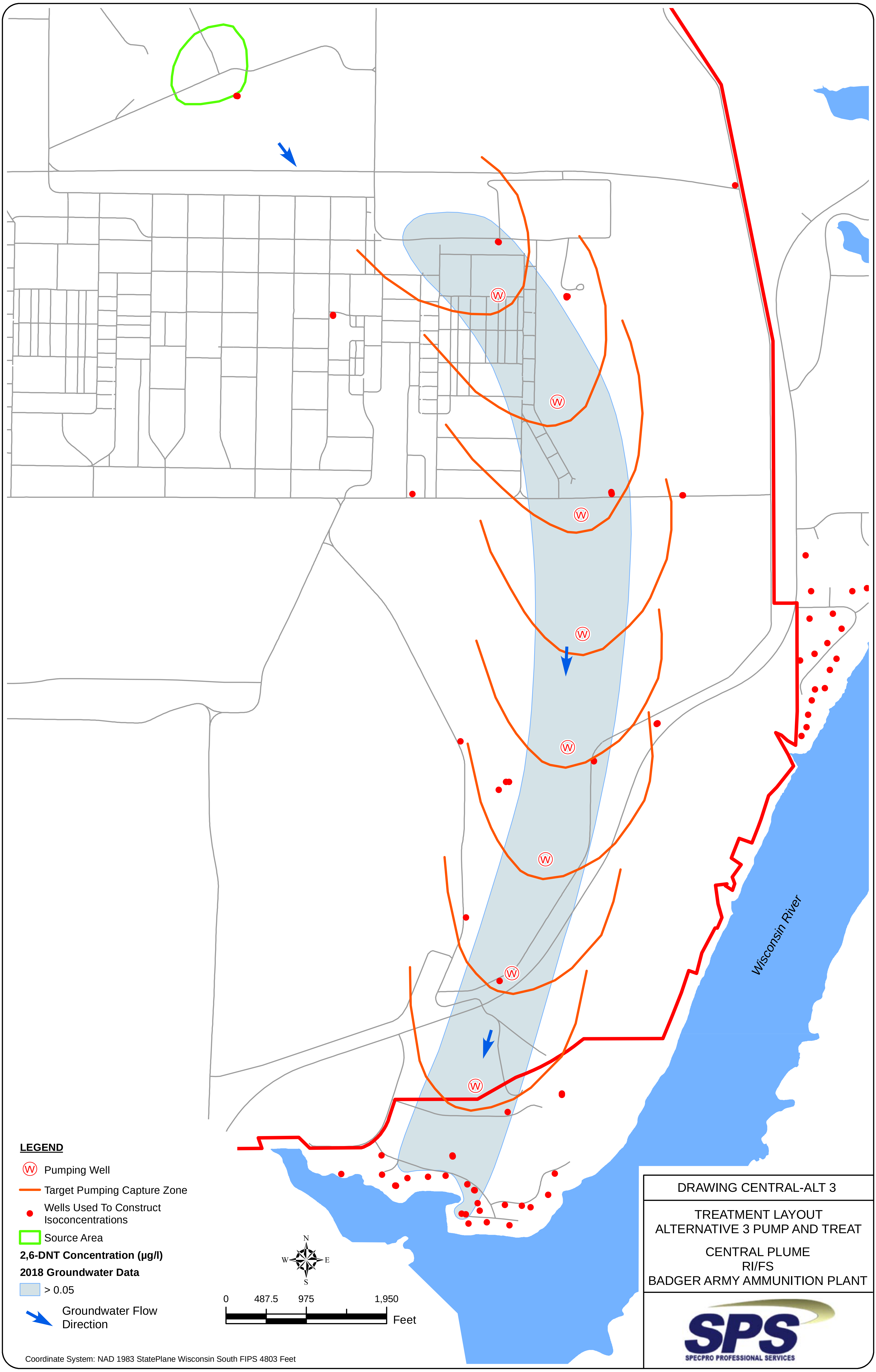


DRAWING DBG-ALT 6

TREATMENT LAYOUT
ALTERNATIVE 6 SOURCE AREA

DETERRENT BURNING GROUND
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



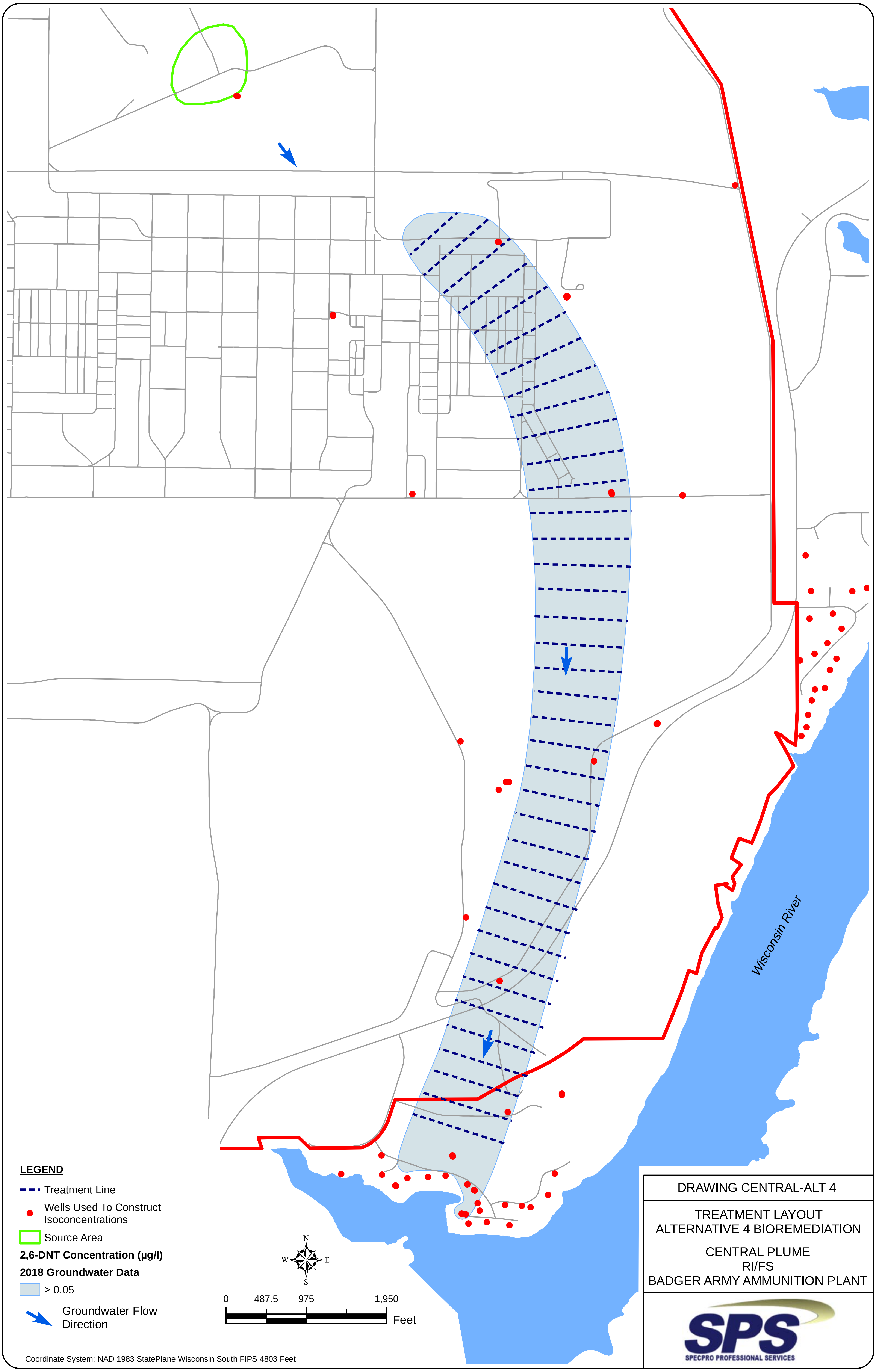
Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet

DRAWING CENTRAL-ALT 3

TREATMENT LAYOUT
ALTERNATIVE 3 PUMP AND TREAT

CENTRAL PLUME
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES



DRAWING CENTRAL-ALT 4

TREATMENT LAYOUT
ALTERNATIVE 4 BIOREMEDIATION

CENTRAL PLUME
RI/FS
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet