

Overview of the Groundwater RI/FS at Badger Army Ammunition Plant

Michael Kelly



Agenda:

- Remedial Investigation
- Risk Assessment
- COCs
- Feasibility Study
- Alternatives

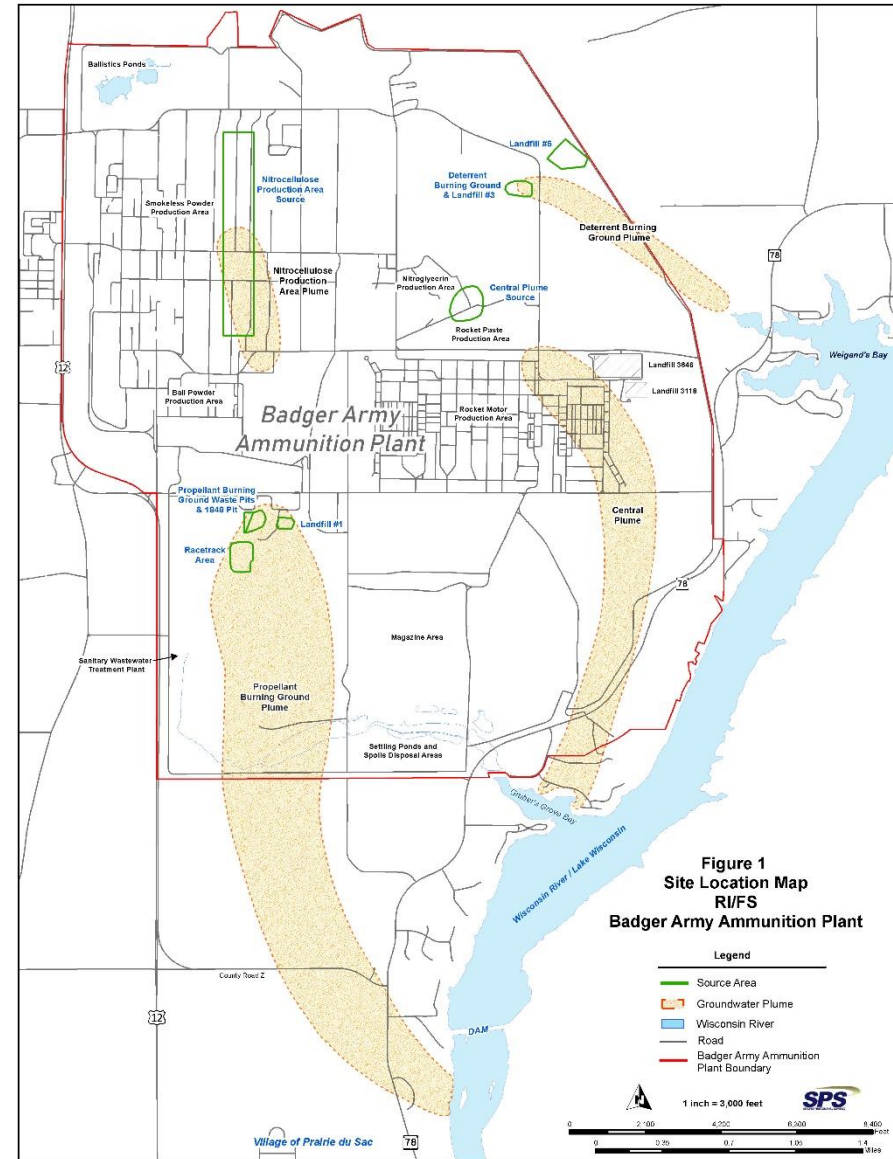
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Introduction

This Groundwater RI/FS presents

- Groundwater investigation results
- Human health risk assessment
- Analysis of remedial alternatives for contaminated groundwater



Remedial Investigation

Groundwater investigations began in 1980

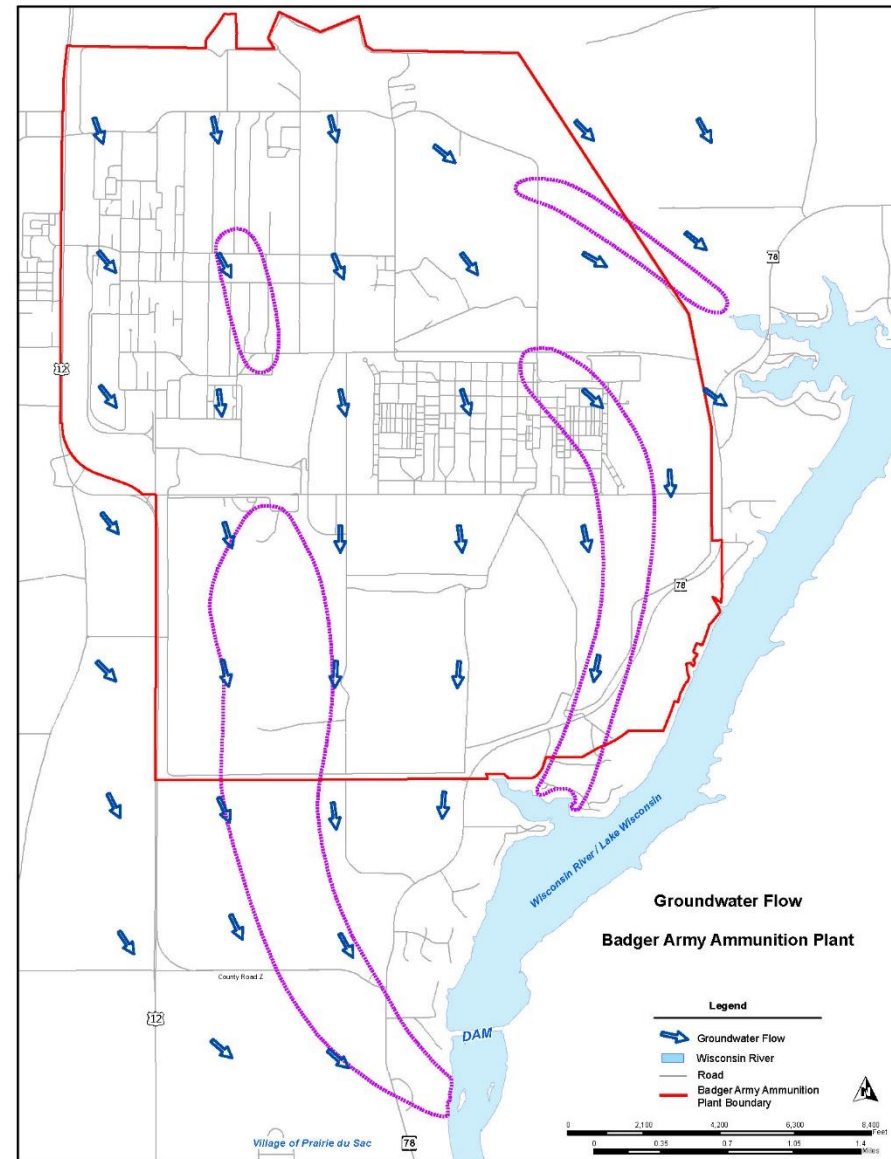
- Identified four groundwater plumes:
 - Propellant Burning Ground (PBG) Plume
 - Deterrent Burning Ground (DBG) Plume
 - Central Plume (CP)
 - Nitrocellulose Production Area (NC Area) Plume



Remedial Investigation

Groundwater Flow

- Regional groundwater flow direction is south-southeast
- The Wisconsin River acts as a discharge point for groundwater east and south of BAAP
- Groundwater is contaminated by chlorinated solvents and explosives



Remedial Investigation

Completed Source Actions

- Soil remedial actions addressed the source areas to the maximum extent possible
- The Army has received site closure from the WDNR on all soil related investigations and remedial actions

This RI/FS is for the groundwater contamination



Propellant Burning Ground Plume

Southwestern portion of BAAP and comprised of :

- 3 waste pits and an open burning area
 - Approximately 2,280 CY of soil were removed to approximately 23 ft BGS in 1999
 - A barrier cap was installed in 2008
- The 1949 Pit was a waste disposal area
 - Contains approximately 58,080 CY of waste
 - Barrier cap was installed in 1998
- The Racetrack/HWTTU area
 - In 1995, 3/4 was covered with clean soil, preventing contact with residual lead in the soil
 - Remaining contaminated soil was excavated and properly disposed in 1997
- Landfill 1 contains approximately 19,500 CY of waste
 - A barrier cap was installed in 1997



Nature and Extent PBG Plume

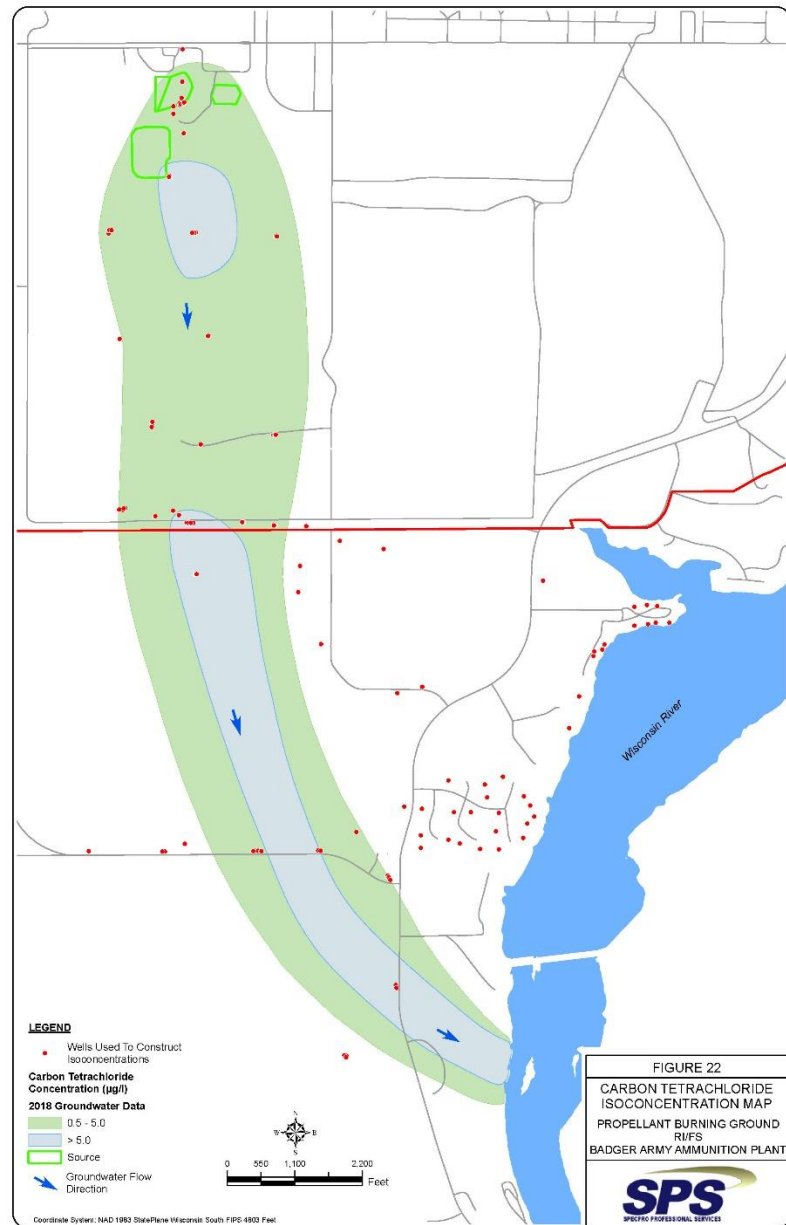
- Groundwater contamination first detected in 1982
- Off-site groundwater monitoring began in 1990
- The PBG Plume originates at the Waste Pits and extends south beyond the BAAP boundary
- South of BAAP, the plume turns southeast towards the Wisconsin River due to the influence of the WP&L dam, just north of Prairie du Sac
- In 1990s, three residential wells were replaced due to solvent contamination



Nature and Extent of CTET in PBG Plume

Carbon Tetrachloride

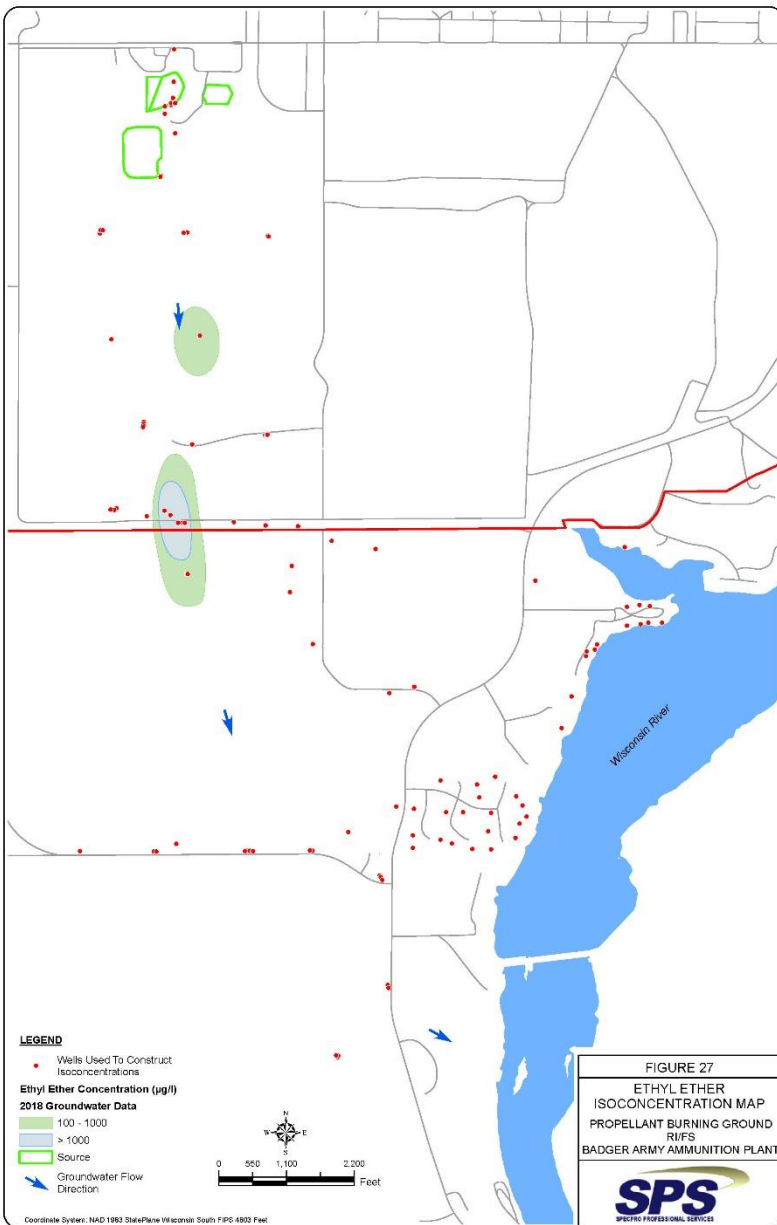
- 6 monitoring wells exceeded the WDNR NR 140 Enforcement Standard in 2018
- 31 monitoring wells exceeded the WDNR NR 140 Preventive Action Limit (PAL) in 2018
- 3 residential wells had detections below the WDNR NR 140 PAL during 2018
- Since 2010, CTET has been detected in these 3 residential wells



Nature and Extent of EE in PBG Plume

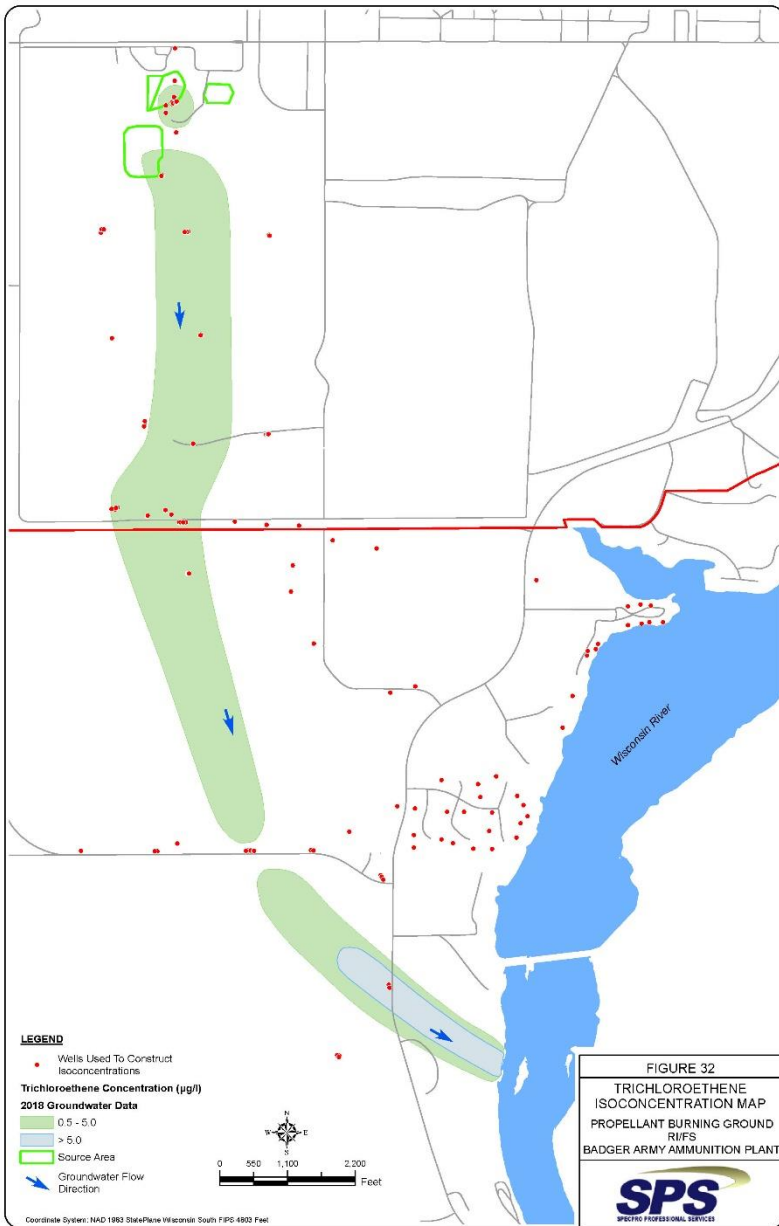
Ethyl Ether

- Ethyl ether concentrations are highest at the BAAP boundary
- Ethyl ether plume is approximately 60 feet thick
- The maximum depth of ethyl ether is 190 feet below the water table and at the top of the bedrock

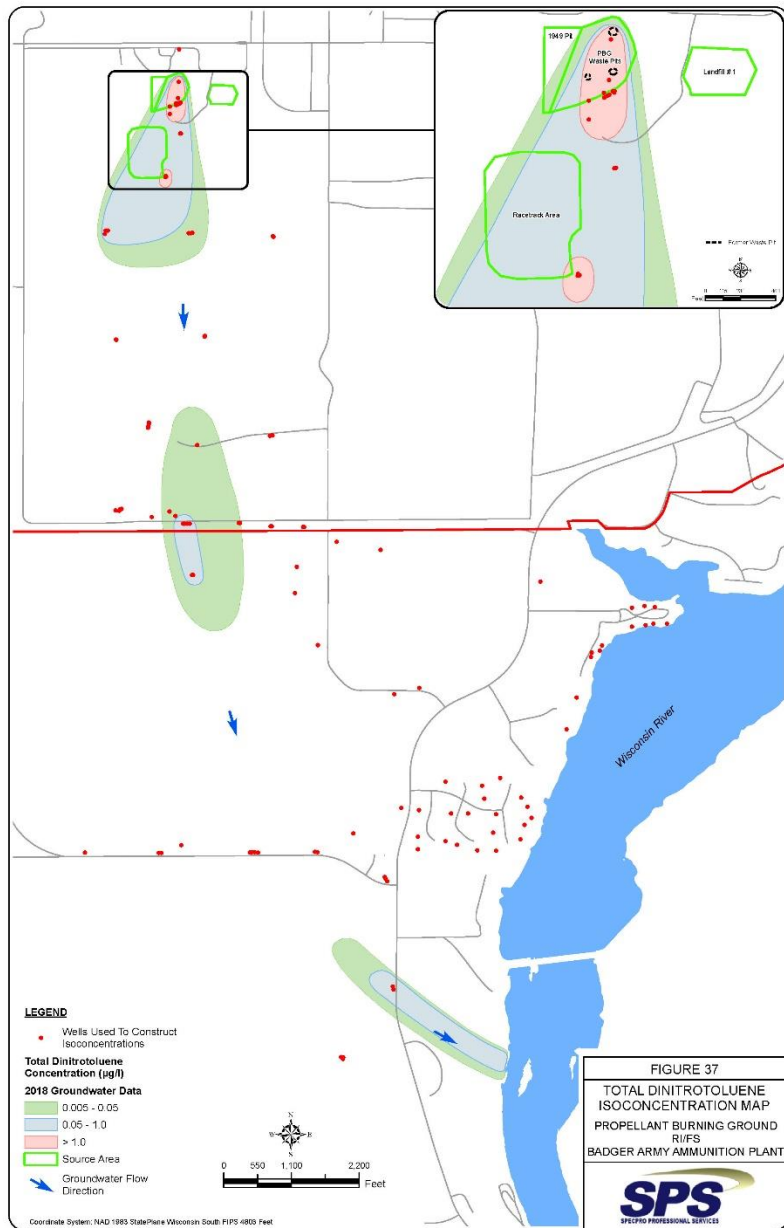


Nature and Extent of TCE in PBG Plume

- Highest TCE concentration detected during 2018 was 8.5 µg/l (2,300 ft upgradient of the Wisconsin River)
- TCE plume horizontal boundary extends to Wisconsin River but is much narrower than CTET plume
- TCE plume has an average thickness of 110 ft and a max depth of 145 ft below the water table
- TCE concentrations near source area are much lower than what is found downgradient
- Estimated boundary of TCE plume is approaching the Wisconsin River
- Several residential wells draw water from beneath the TCE plume



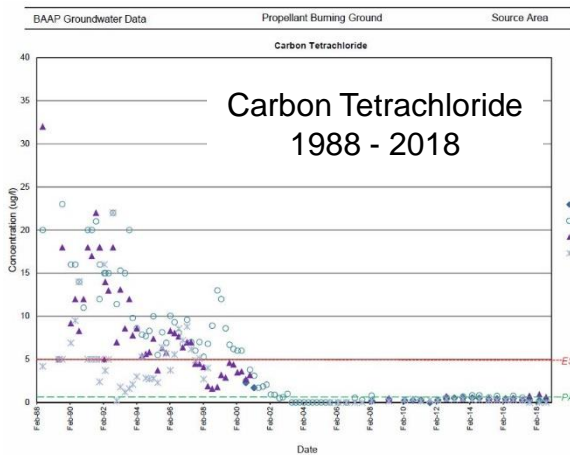
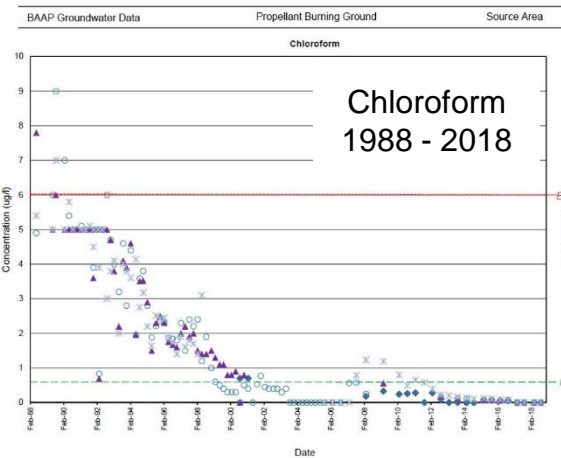
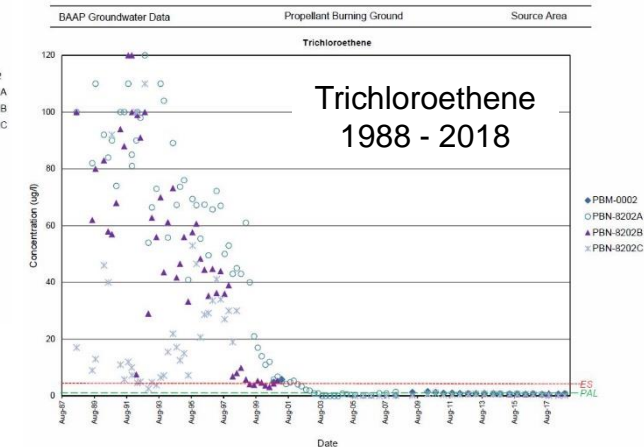
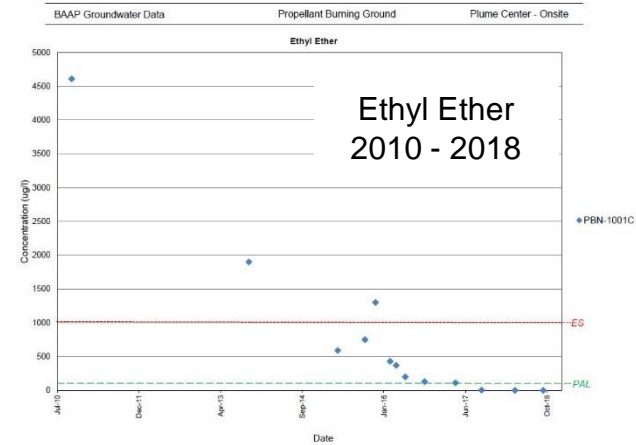
Nature and Extent of DNT in PBG Plume



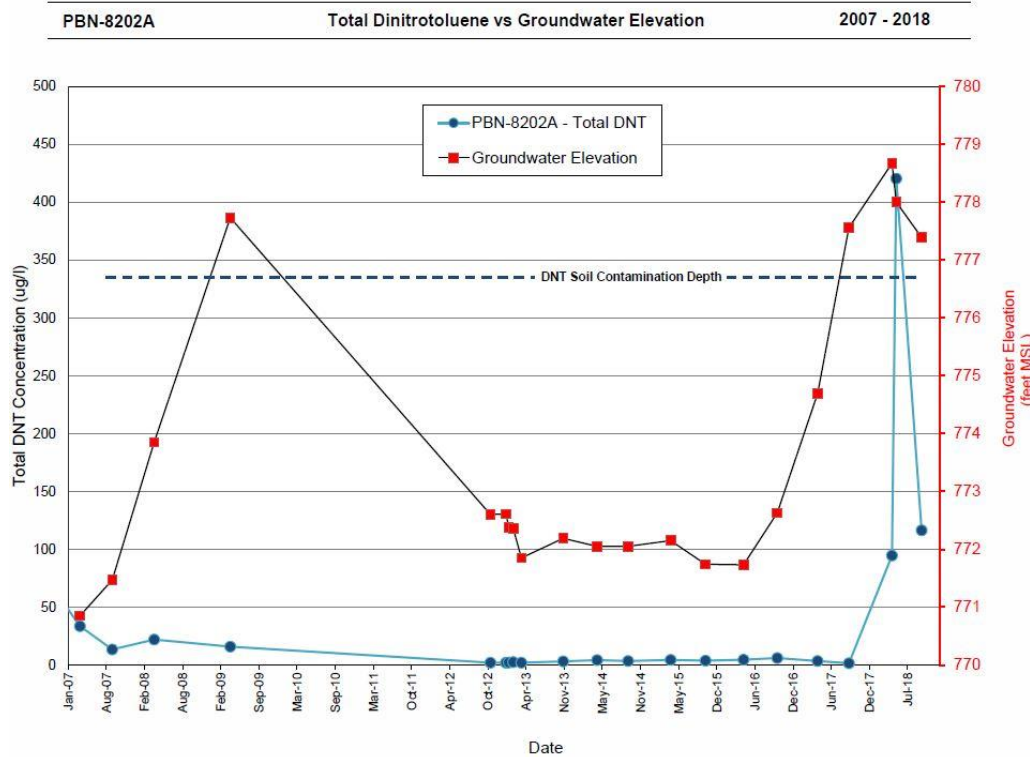
- Highest concentration of DNT was ~ 420 µg/L immediately downgradient of the PBG
- DNT plume has three separate areas possibly caused by the MIRM treatment system
- Higher concentrations are near the source
- DNT concentrations are highest in wells ~ 0-30 ft below water table
- Average plume thickness is 100 ft
- No evidence of DNT in the bedrock aquifer
- DNT plume is approaching the Wisconsin River

Contaminant Trends in PBG Plume

- Trend analysis includes CTET, chloroform, ethyl ether, TCE, & DNT
- CTET, chloroform, and TCE have been declining near the source area since the 1980's
- VOC compounds have declined to levels at or below WDNR NR 140 Enforcement Standard
- Ethyl ether concentrations are stable or decreasing



Contaminant Trends in PBG Plume

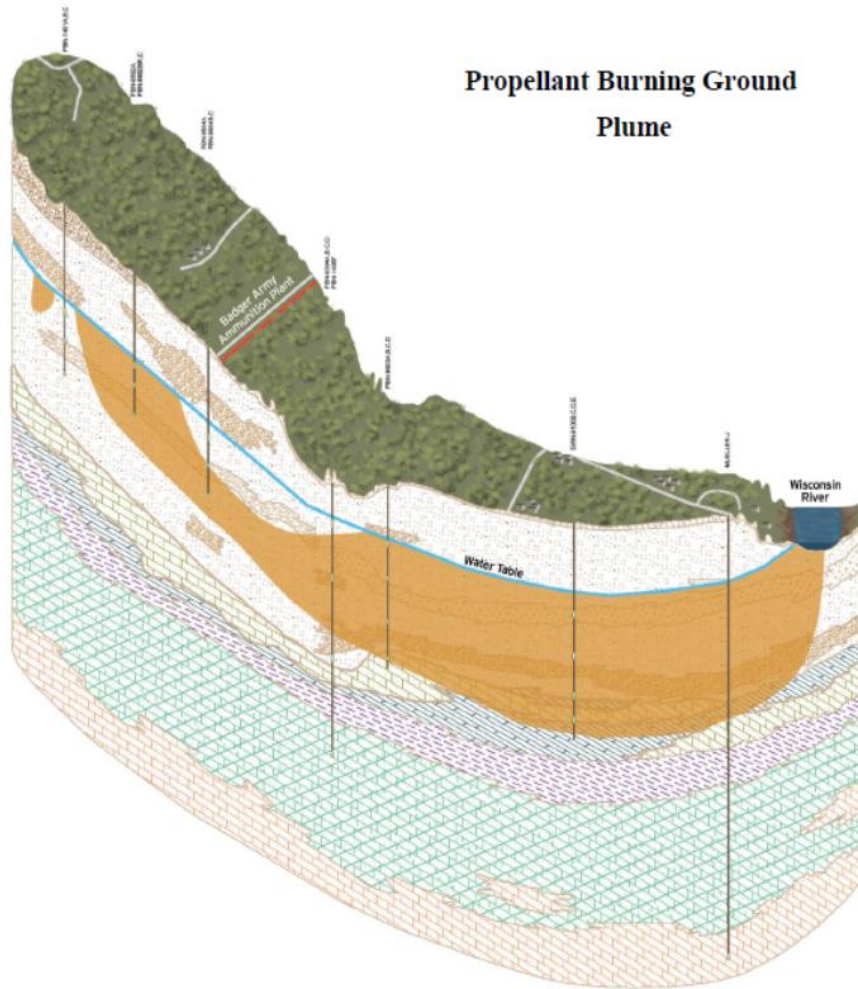


- Source area wells show decreases in DNT levels after BEST system operated from 2001 - 2005
- During December 2012, the IRM ceased groundwater pumping directly downgradient of the PBG Waste Pits
- DNT in source area wells stabilized at 1 - 5 $\mu\text{g/l}$ between 2012 - 2017

- DNT concentrations spiked downgradient from waste pits during 2018 (max ~ 420 $\mu\text{g/l}$)
- Water table near PBG Waste Pits rose 6.9 feet between 2016 - 2018
- Increase in DNT likely the result of groundwater rising to contact contaminated soil under the cap



PBG Plume Characteristics



Propellant Burning Ground
Plume

- Groundwater beneath the source areas ~ 105 ft deep
- As the plume migrates, it sinks lower into the sand aquifer
- Groundwater travels ~ 306 ft/yr
- Groundwater beneath residential areas ~ 80 feet deep
- Off-site contaminated groundwater (above WDNR NR 140 Enforcement Standard) in the sand aquifer (80 to 210 ft)
- Bedrock at 210 ft

GEOLOGIC DESCRIPTIONS:

FILL FILL MATERIAL AND CAP OVER PROPELLANT BURNING GROUND WASTE KITS	GP GRAVEL, POORLY GRADED, GLACIAL OUTWASH	
ML-SM SILT AND SILTY SAND MIXTURE, LOESS	GW GRAVEL, WELL GRADED, GLACIAL OUTWASH	
SM-SP SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL TILL	GP-GW GRAVEL MIXTURE, GLACIAL OUTWASH	
SW-SP-SM SAND, MIXTURE OF VARYING GRAIN SIZES, GLACIAL OUTWASH		
ML SILT, GLACIAL OUTWASH		



PILLUME



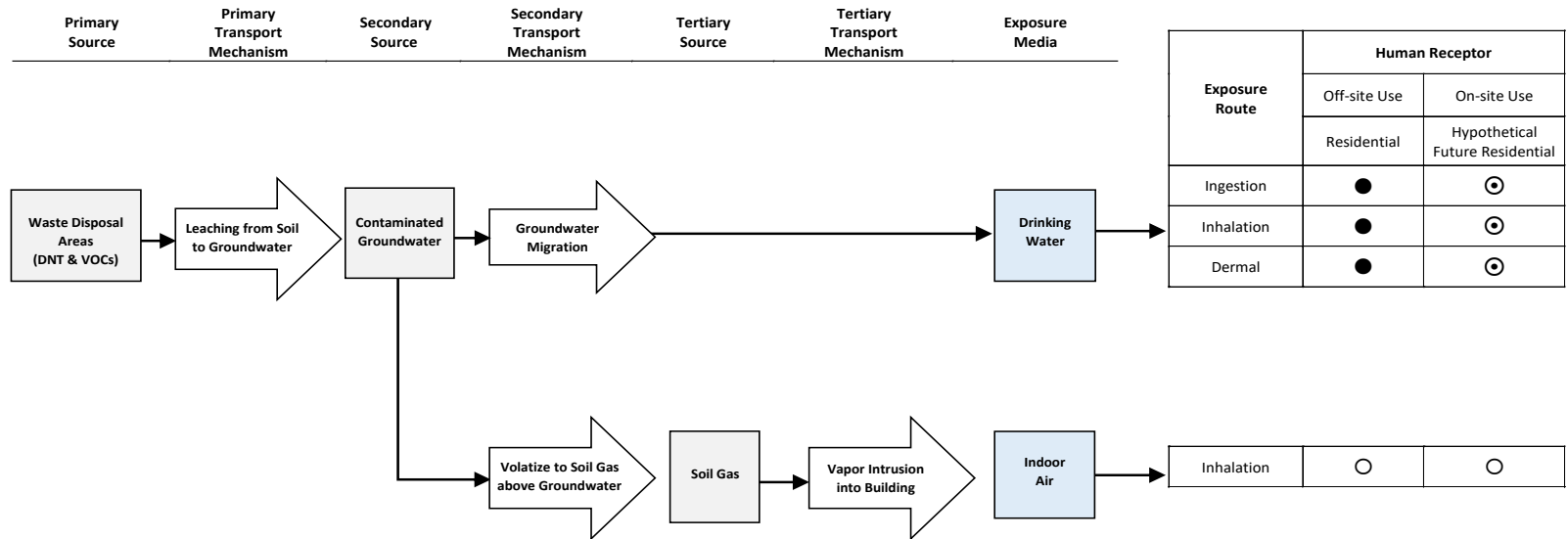
Risk Summary

Propellant Burning Ground	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
On-Site (Hypothetical Future Risk)	6×10^{-3}	53	2,6-Dinitrotoluene Ethyl Ether Trichloroethene
Off-Site (Current Risk)	1×10^{-4}	5	2,6-Dinitrotoluene Carbon Tetrachloride Chloroform Trichloroethene
Deterrent Burning Ground	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
On-Site (Hypothetical Future Risk)	9×10^{-5}	3	1,1,2-Trichloroethane
Off-Site (Current Risk)	2×10^{-5}	2	Chloroform Total Dinitrotoluenes Trichloroethene
Central Plume	Cumulative Cancer Risk	Non-cancer Hazard Index (HI)	Contaminants of Concern
On-Site (Hypothetical Future Risk)	3×10^{-6}	0.02	None
Off-Site (Current Risk)	4×10^{-5}	0.4	1,2-Dichloroethane 2,6-Dinitrotoluene Benzene Chloroform



PBG Plume Human Health Risk

Groundwater Conceptual Site Model – PBG Plume
Badger Army Ammunition Plant



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.

- Contaminants of Concern exceeding risk based levels include:
 - Chloroform
 - Ethyl ether
 - 2,6-DNT
 - CTET
 - TCE
- Both off-site and on-site cancer risks and non-cancer hazards were above the risk management criteria



Feasibility Study

Groundwater Remedial Action Objectives

- Restore groundwater COCs warranting action to WDNR NR 140 Enforcement Standards
- To protect human health by preventing exposure
- To minimize the impact on the environment

General Response Actions

- Land Use Controls
- Development of New Water Resources (well replacement)
- Groundwater Treatment
- Groundwater Containment

Technology Screening Criteria

- Effectiveness
- Implementability
- Cost



Remedial Alternatives – PBG Plume

Alternative 1: No Action

Alternative 2: Monitored Natural Attenuation

Alternative 3: Pump and Treat

Alternative 4: Anaerobic Bioremediation

Alternative 5: Well Replacement – Plume Area

Alternative 6: Source Area Treatment



PBG Plume

Alternative 1: No Action

- No impact on plume
- No groundwater monitoring of residential wells or monitoring wells
- No contaminant removal, treatment, containment or monitoring
- As a condition of the Army's property transfer, groundwater access restrictions would continue within the BAAP boundary
- Not compliant with ARARs
- Not effective or permanent solution
- No known reduction in toxicity, mobility or volume through treatment
- No cost



PBG Plume

Alternative 2: Monitored Natural Attenuation

MNA is expected to reduce the concentrations of COCs

- MNA includes a variety of processes that 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
- Compliant with ARARs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$4.9M

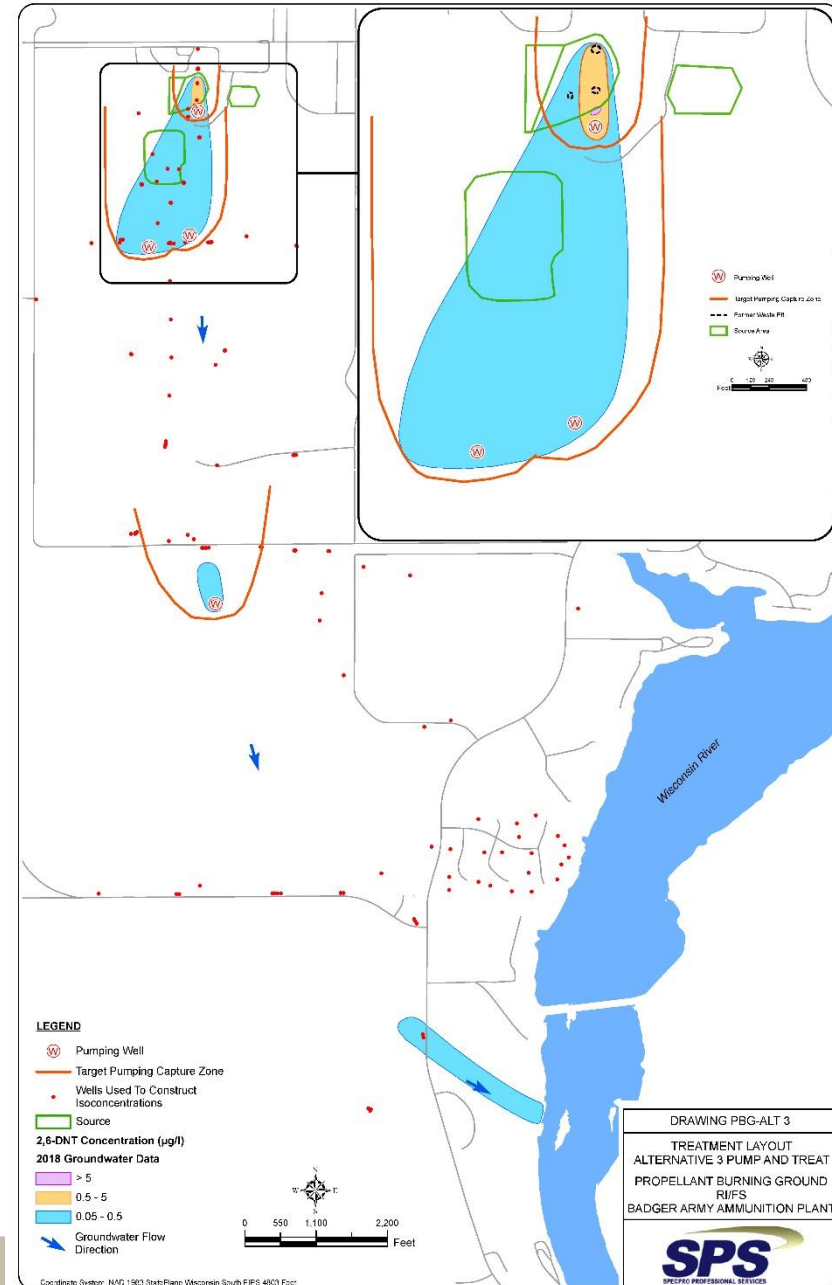


PBG Plume

Alternative 3: Pump and Treat

Remove and treat impacted groundwater for DNT; includes:

- Groundwater removal utilizing 4 extraction wells and 4 mobile treatment units (3 on-site and 1 off-site)
- On-site groundwater pumping for 8 yrs
- Off-site groundwater pumping for 6 yrs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$12.7M

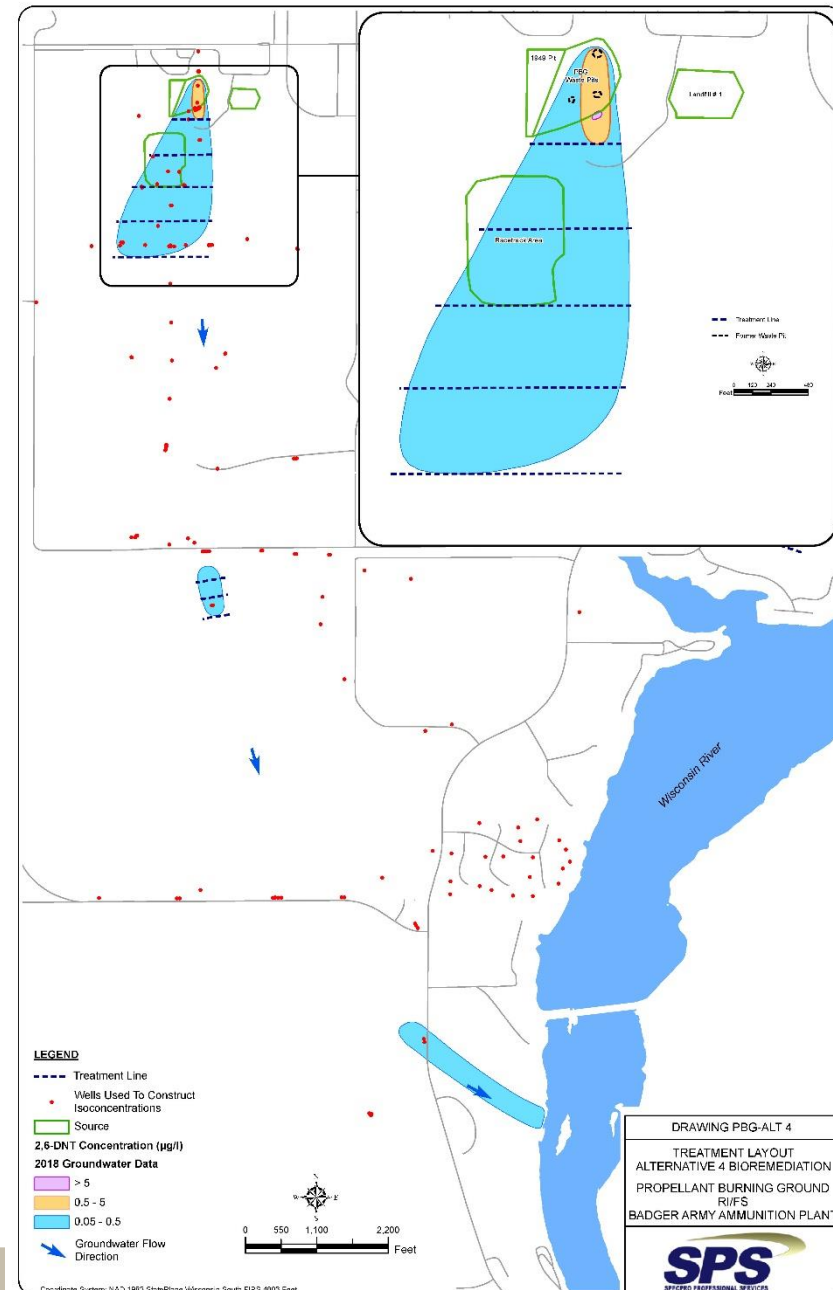


PBG Plume

Alternative 4: Anaerobic Bioremediation

Target treatment to impacted groundwater for DNT using emulsified vegetable oil (EVO); includes:

- Permanent EVO injection points installed along 1 line in the source area
- Temporary EVO injection points installed at downgradient locations
- EVO treatment zone expected to remain active for 2 yrs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$9.6M



PBG Plume

Alternative 5: Well Replacement – Plume Area

Replace shallow aquifer wells with deeper aquifer wells and include the following components:

- Replacement up to 47 existing residential wells with groundwater results exceeding action levels
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$7.9M

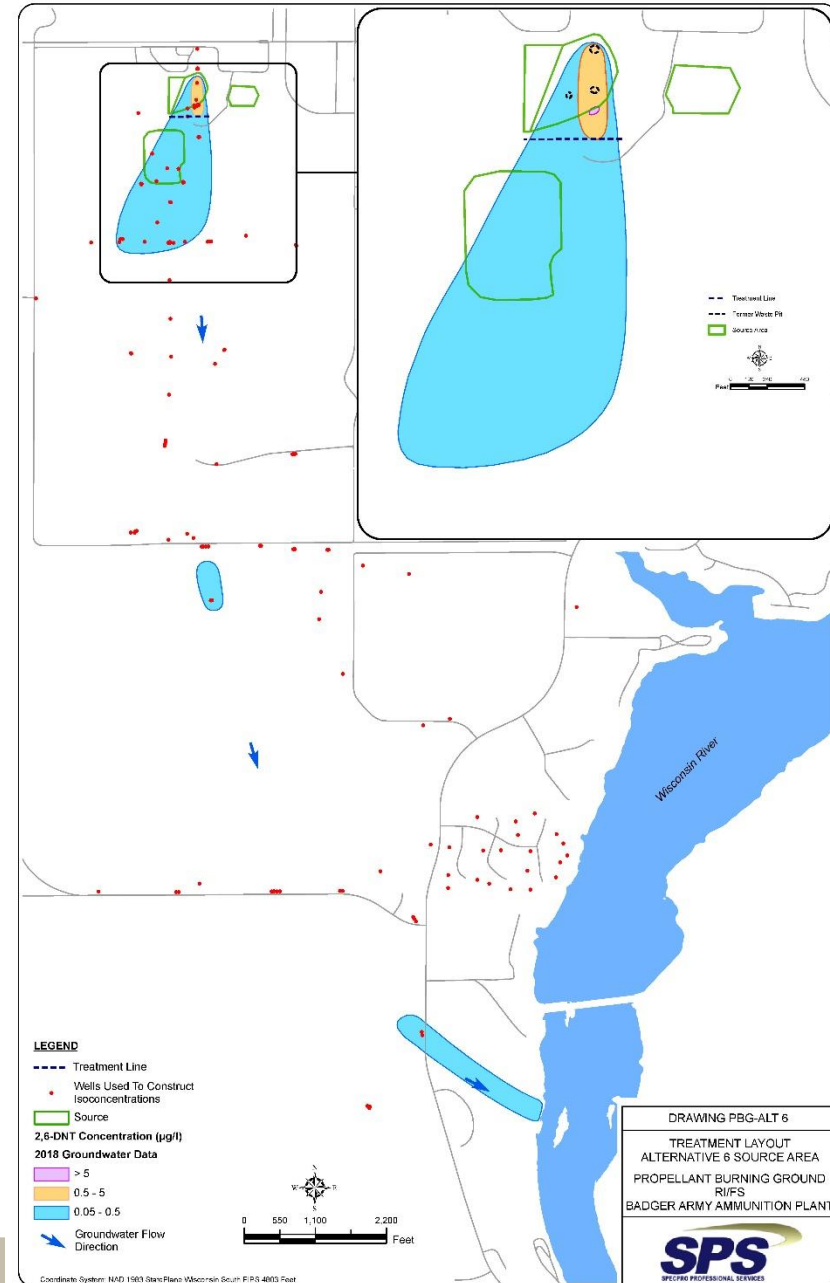


PBG Plume

Alternative 6: Source Area Treatment

Target treatment to impacted groundwater for DNT directly downgradient of the source area using emulsified vegetable oil (EVO); includes:

- Permanent EVO injection points installed directly downgradient of the source area
- EVO treatment zone expected to remain active for 2 yrs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$5.2M



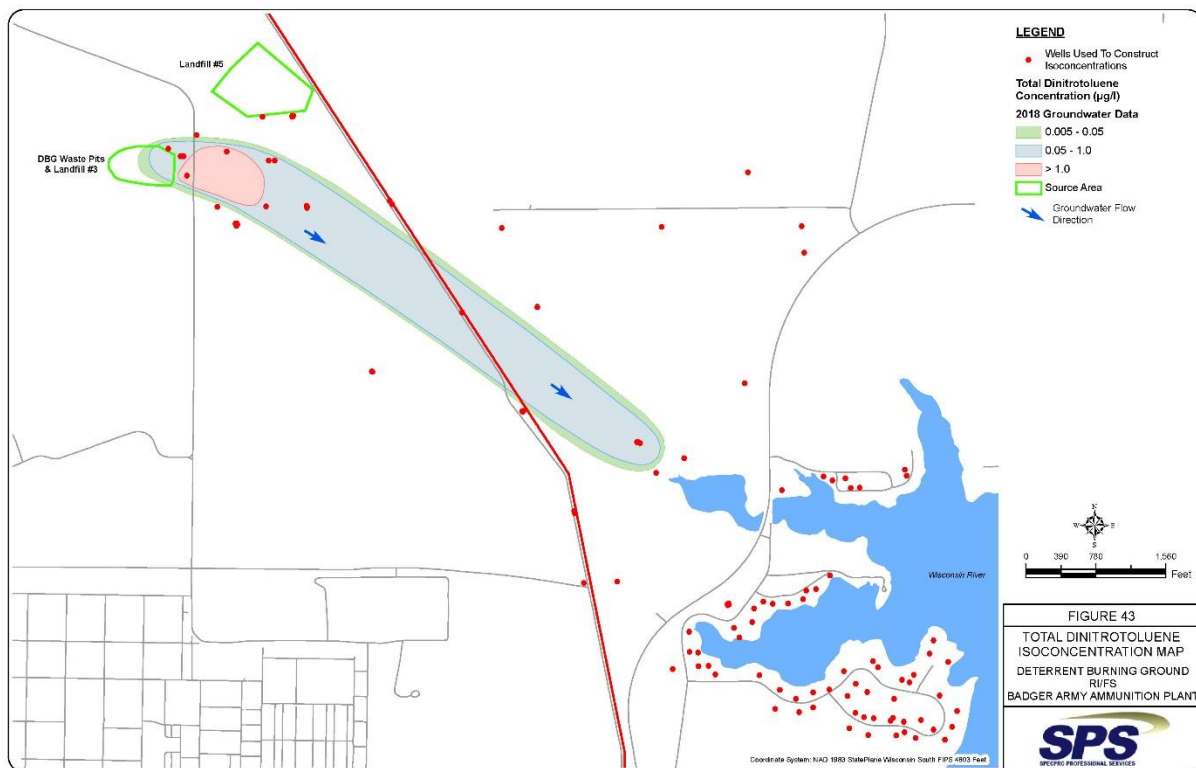
Deterrent Burning Ground Plume

Northeastern portion of BAAP

- Used as a sand borrow pit from 1940 – early 1960s
- Waste disposal site from 1940 – 1970s
 - 3 burn areas in a manmade depression
 - ❖ Approximately 3 acres
 - ❖ 20 feet deep depression
 - ❖ In 1999 excavated pits to ~15 ft and backfilled with clean soil
 - ❖ Capped with a geomembrane cap in 2003
 - ❖ DNT contaminated soil beneath the cap is ~26 feet above the water table
- Landfill #3 received coal ash, construction rubble, trash, and burned garbage
 - Geomembrane cap installed in 2003 with the DBG
- Landfill #5 received solid waste and coal ash from the power plant between 1979 and 1988
 - No hazardous materials disposal
 - Closed with a clay barrier cap in 1988



Nature and Extent of DNT in DBG Plume



- Plume is ~1,000 ft wide with a maximum depth of 55 ft below the water table
- Plume has migrated off-site & southeast towards Weigand's Bay

- Groundwater data at the DBG source shows a stable trend for DNT
- Off-site groundwater data shows increasing DNT in 2 monitoring wells
- In 2019, DNT was above WDNR NR 140 Enforcement Standard in a residential well; Army then replaced this well



Nature and Extent of Sulfate in DBG Plume



- Since 2013, residential wells no longer sampled for sulfate due to historically low detections and sulfate stability by Landfill #5
- Highest 2018 sulfate detect was 1,100 mg/l by Landfill #5
- Sulfate limits are approximately 500 by 850 feet

Nature and Extent of TCA in DBG Plume

- 1,1,2-TCA exceeds the WDNR NR 140 Preventive Action Limit (PAL) downgradient of Landfill #5 at 0.98 $\mu\text{g/l}$ (April 2018)
- 1,1,2-TCA is detected in other monitoring wells below the WDNR NR 140 PAL (0.5 $\mu\text{g/l}$)
- 1,1,2-TCA has a limited extent of detections near Landfill #5



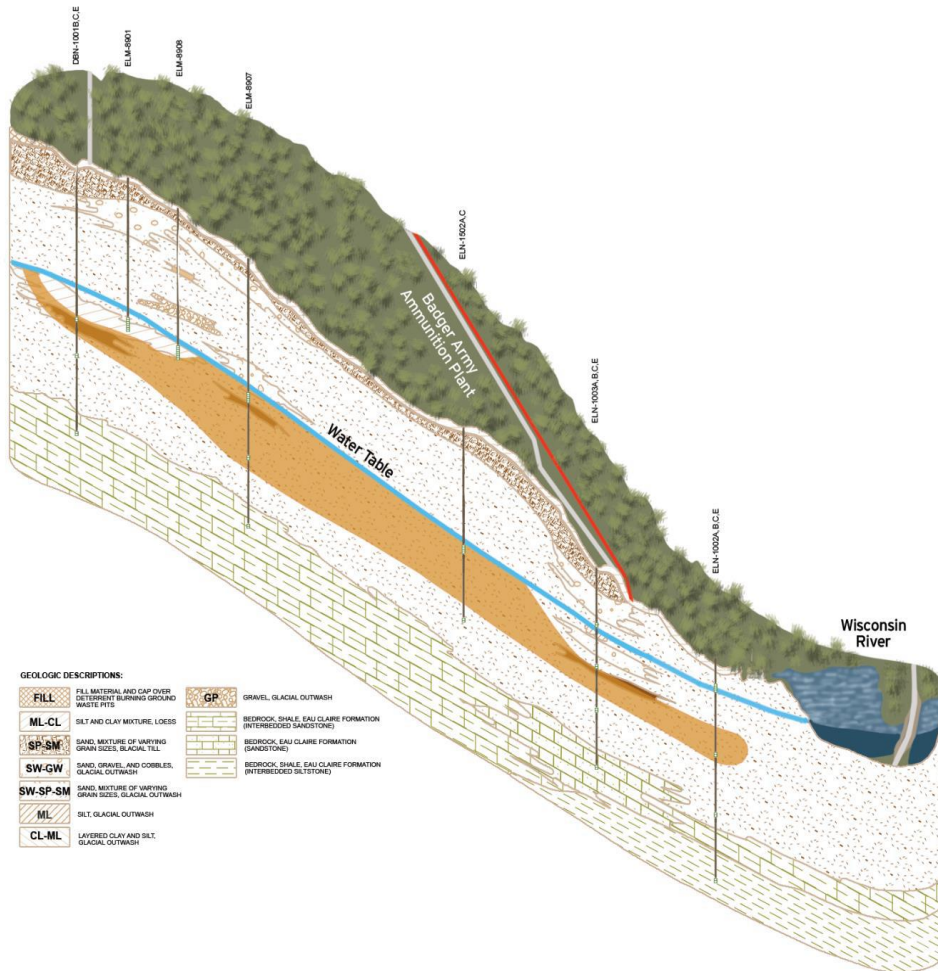
Nature and Extent of TCE in DBG Plume

- TCE was detected in 3 downgradient residential wells near Weigand's Bay (August 2018)
- TCE concentrations were below the site cleanup levels (MCL of 5 µg/l)
- There is no identified source of TCE upgradient of the Weigand's Bay area
- TCE has not been found in monitoring wells and an on-site source has not been identified
- Therefore, TCE is not a COC requiring action
- Maximum Chloroform and 1,2-Dichloroethane concentrations are below WDNR NR 140 Enforcement Standards



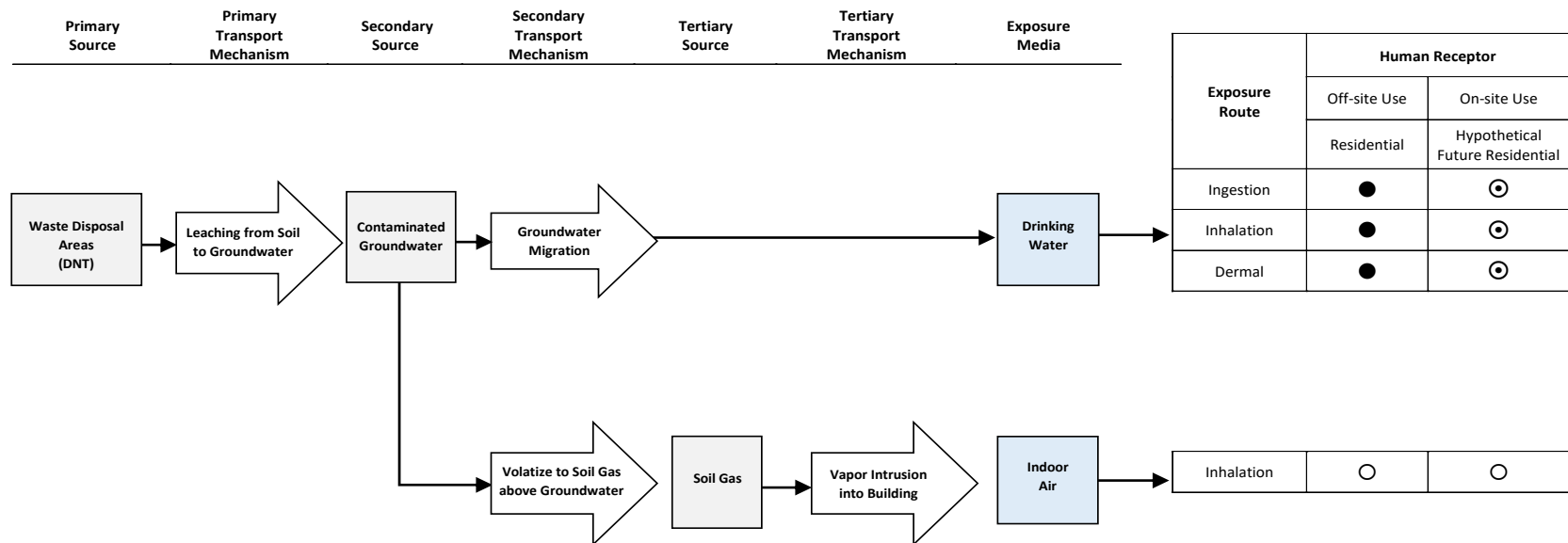
DBG Plume Characteristics

- Groundwater beneath the source areas is ~130 feet deep
- Migrating toward Weigand's Bay
- As the plume migrates, it sinks lower into the sand aquifer
- Groundwater travels ~ 109 ft/yr
- Groundwater beneath residents is ~ 25 feet deep
- Contamination above the WDNR NR 140 Enforcement Standard off-site is in the sand aquifer at depths between 50 and 180 ft
- Bedrock is at 216 ft



DBG Plume Human Health Risk

Groundwater Conceptual Site Model – DBG Plume
Badger Army Ammunition Plant



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.

- Contaminants of Concern exceeding risk based levels include :
 - 1,1,2-TCA
 - Chloroform
 - TCE
 - Total DNT
- Both off-site cancer and non-cancer risks & on-site non-cancer risks were above the risk management criteria



Remedial Alternatives – DBG Plume

Alternative 1: No Action

Alternative 2: Monitored Natural Attenuation

Alternative 3: Pump and Treat

Alternative 4: Anaerobic Bioremediation

Alternative 5: Well Replacement – Plume Area

Alternative 6: Source Area Treatment



DBG Plume

Alternative 1: No Action

- No impact on plume
- No groundwater monitoring of residential wells or monitoring wells.
- No contaminant removal, treatment, containment or monitoring
- As a condition of the Army's property transfer, groundwater access restrictions would continue within the BAAP boundary
- Not compliant with ARARs
- Not effective or permanent solution
- No known reduction in toxicity, mobility or volume through treatment
- No cost



DBG Plume

Alternative 2: Monitored Natural Attenuation

MNA is expected to reduce the concentrations of COCs

- MNA includes a variety of processes that 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
- Compliant with ARARs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$4.2M

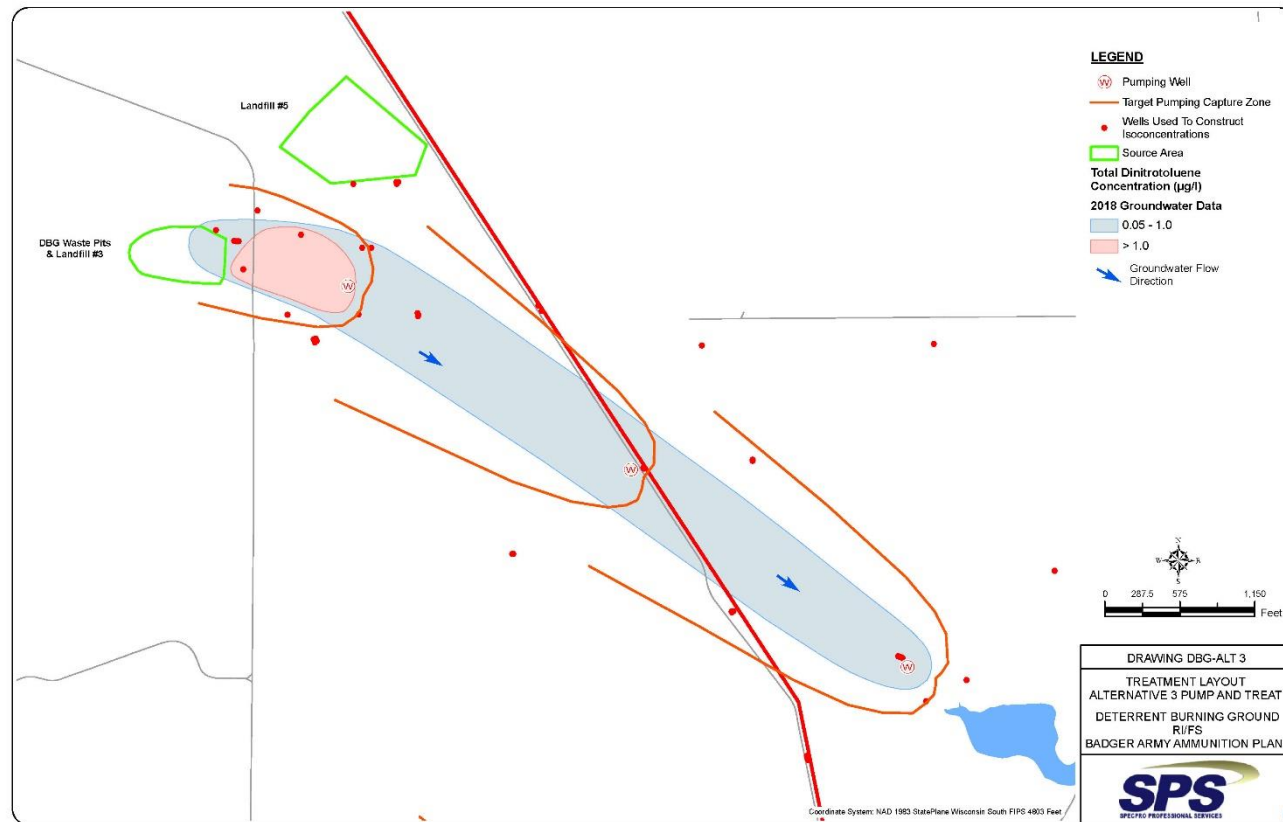


DBG Plume

Alternative 3: Pump and Treat

Remove and treat impacted groundwater for DNT; includes:

- Groundwater removal utilizing 3 extraction wells and 3 mobile treatment units
- On-site groundwater pumping for 10 yrs
- Off-site groundwater pumping for 22 yrs
- Sampling/monitoring for 24 yrs
- Cleanup Time: 24 yrs
- Estimated Cost: \$12.5M

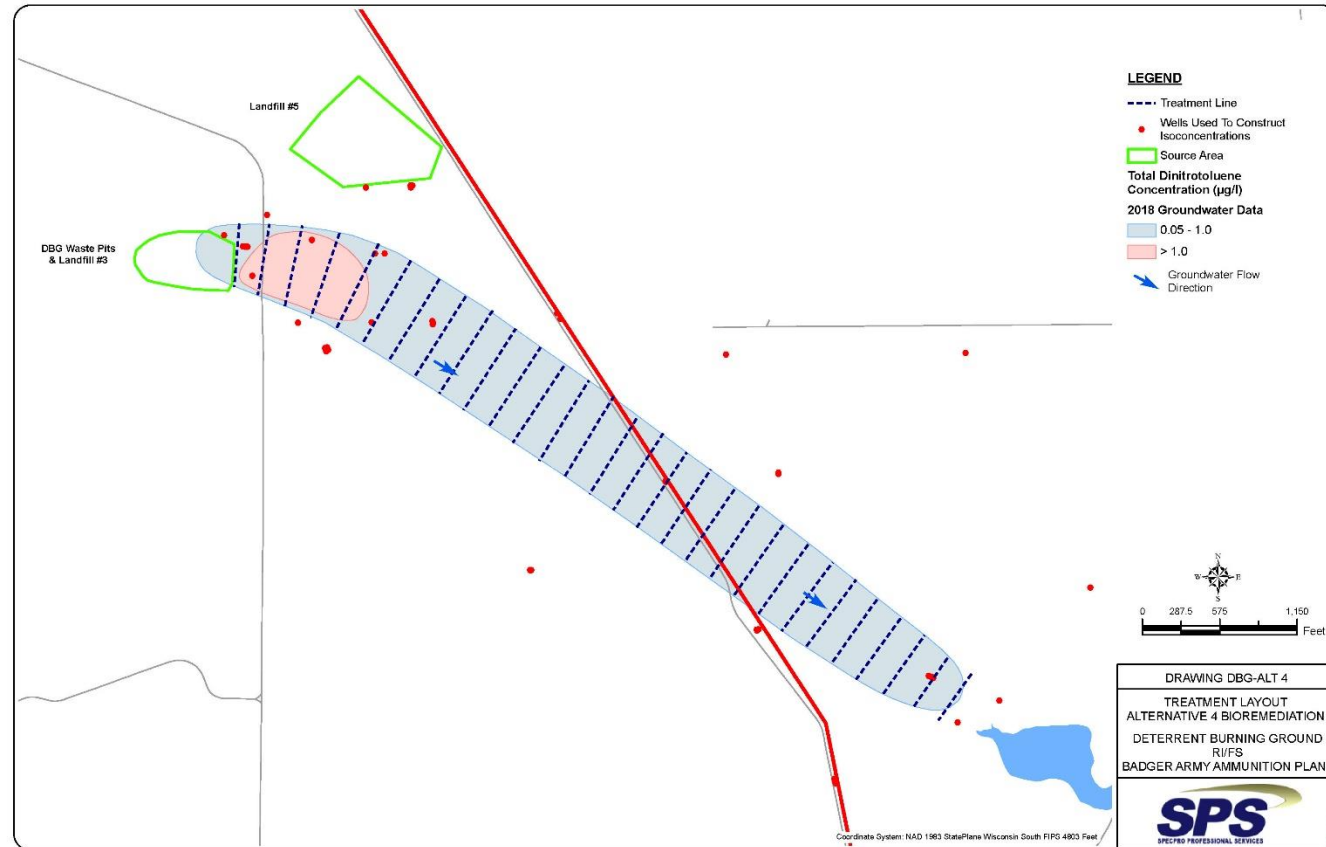


DBG Plume

Alternative 4: Anaerobic Bioremediation

Target treatment to impacted groundwater for DNT using emulsified vegetable oil (EVO); includes:

- EVO injections at 29 treatment lines
- Injections at 406 temporary locations
- EVO treatment zone expected to remain active for 2 yrs
- Sampling/monitoring for 4 yrs
- Cleanup Time: 4 yrs
- Estimated cost: \$12.5M



DBG Plume

Alternative 5: Well Replacement – Plume Area

Replace shallow aquifer wells with deeper aquifer wells and include the following components:

- Replacement up to 57 existing residential wells with groundwater results exceeding action levels
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$7.1M

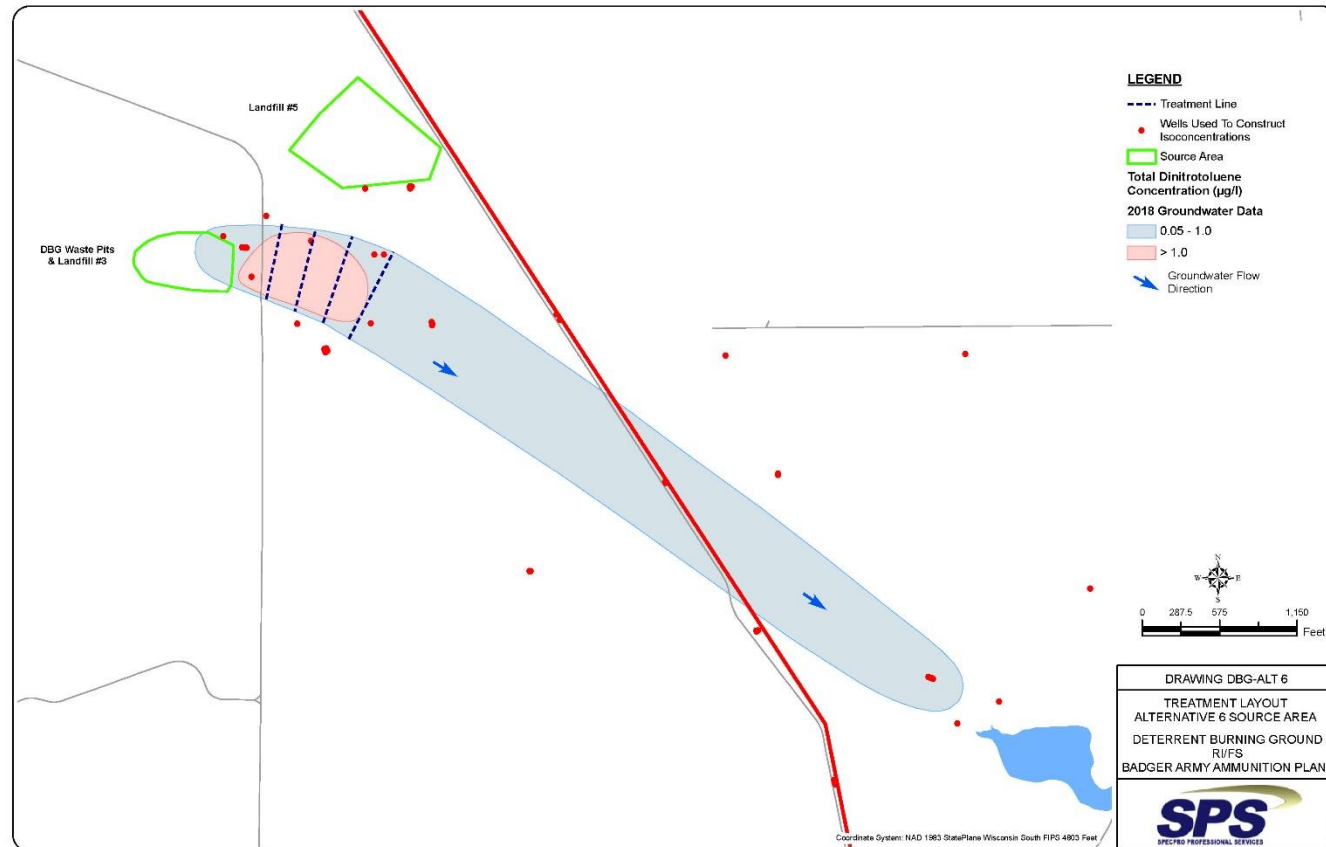


DBG Plume

Alternative 6: Source Area Treatment

Target treatment to impacted groundwater for DNT directly downgradient of the source area using emulsified vegetable oil (EVO); includes:

- EVO injections at 4 treatment lines (temporary) directly downgradient of the source area
- EVO treatment zone expected to remain active for 2 yrs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated cost: \$5.2M



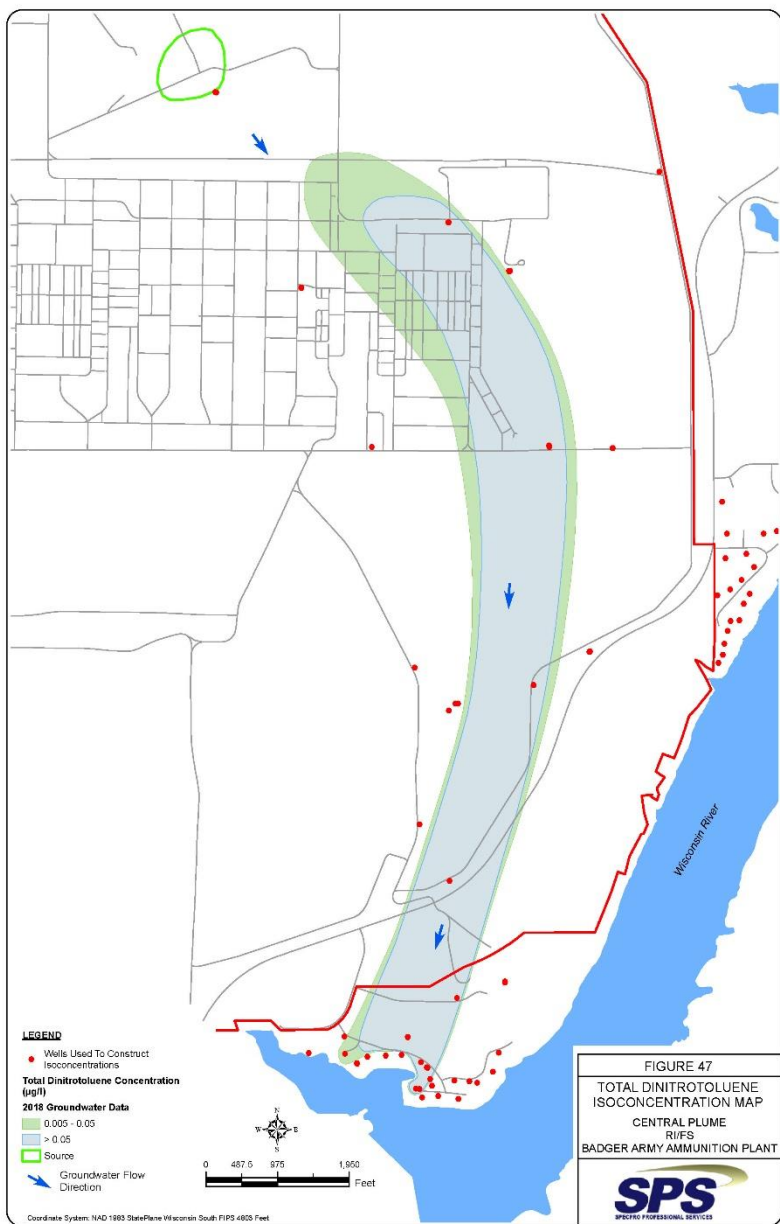
Central Plume

- DNT source believed to be in the north-central portion where nitroglycerin, rocket paste, and rocket propellant were produced
- Production waste water was discharged to open ditches
- No specific source was identified (i.e. waste disposal sites)
- Soil and sewer removal, and adjacent soil excavations were completed
- All contaminated soil and sewer piping were disposed of in the on-site licensed Landfill 3646



Nature and Extent of DNT in Central Plume

- DNT depleted near source area
- DNT has only been detected at shallow depths in the sand aquifer
- Highest DNT detected was 0.209 $\mu\text{g/l}$ in on-site monitoring well (2018)
- Residential wells in Water's Edge are mainly screened in sand aquifer and at the depth DNT plume occurs
- The Army replaced 3 residential wells that were above WDNR NR 140 Enforcement Standard in Water's Edge

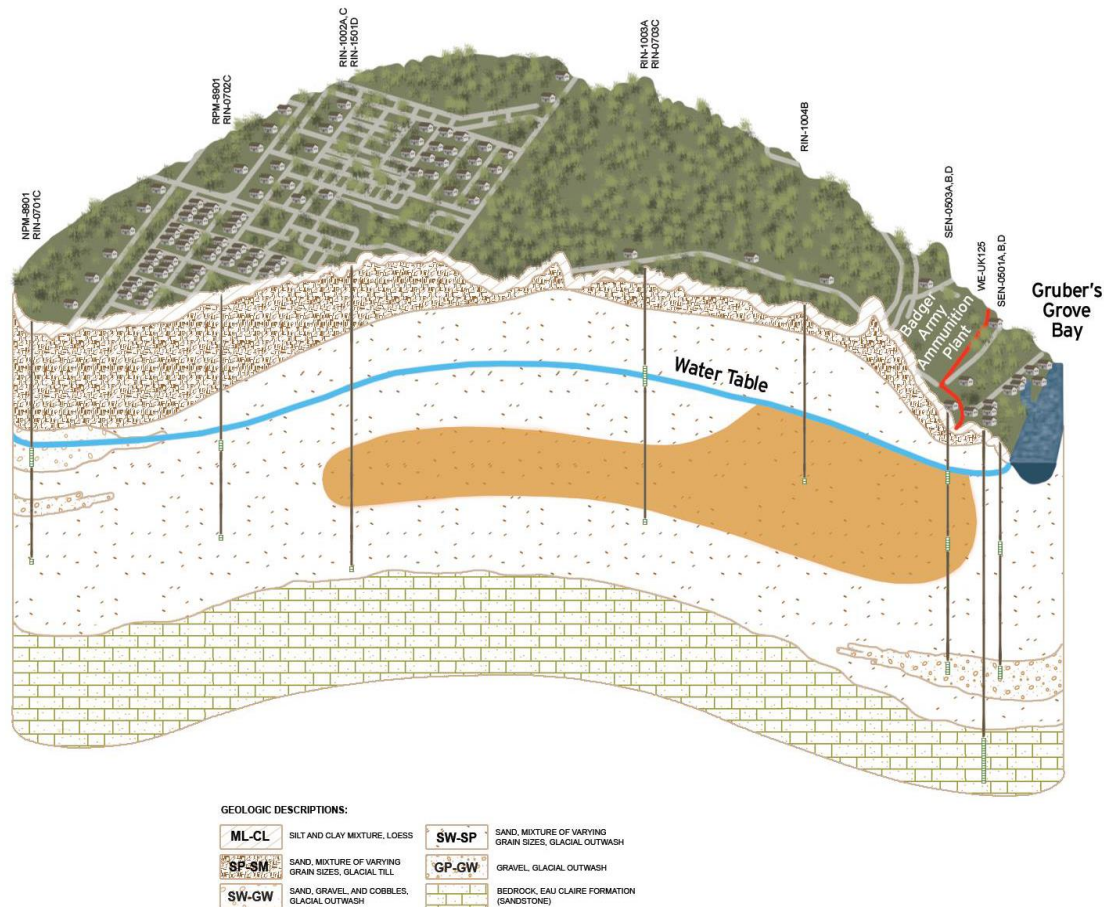


Nature and Extent of Benzene in Central Plume

- Benzene was detected (June 2017) above groundwater cleanup levels in an off-site monitoring well
 - No other wells had detections
 - Source of the benzene is unknown
 - No evidence that benzene is attributed to past Army actions
 - Benzene is not a COC warranting action
- Maximum Chloroform and 1,2-Dichloroethane concentrations are below cleanup levels (WDNR NR 140 Enforcement Standards)



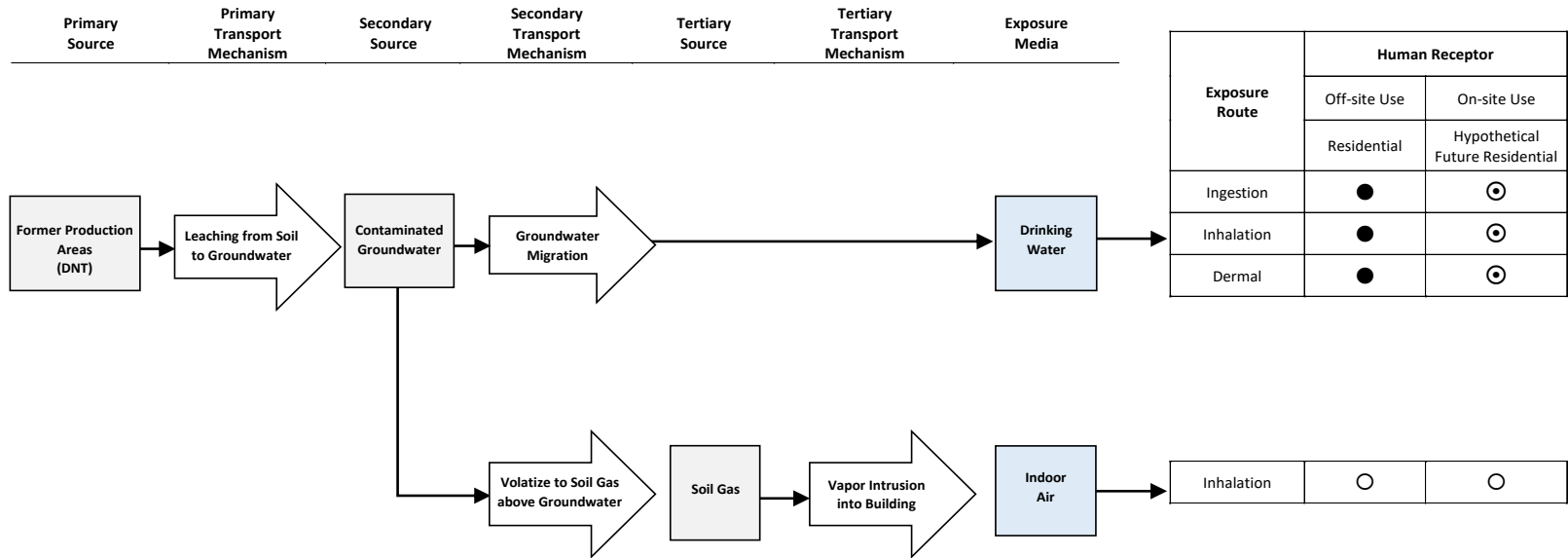
Central Plume Characteristics



- No evidence that Central Plume discharges to Wisconsin River
- Central Plume thickness narrows as it moves off-site
- Groundwater travels ~143 ft/yr
- Groundwater beneath source area is ~105 ft deep
- Groundwater above WDNR NR 140 Enforcement Standard is in the sand aquifer at depths between 85 and 130 ft
- Groundwater beneath the off-site residential areas is approximately 20 ft deep

Central Plume Human Health Risk

Groundwater Conceptual Site Model – Central Plume
Badger Army Ammunition Plant



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.

- Contaminants of Concern exceeding risk based levels include:
 - Chloroform
 - Benzene
 - 2,6-DNT
 - 1,2-Dichloroethane
- Only off-site cancer risks were above the risk management criteria



Remedial Alternatives – Central Plume

Alternative 1: No Action

Alternative 2: Monitored Natural Attenuation

Alternative 3: Pump and Treat

Alternative 4: Anaerobic Bioremediation

Alternative 5: Well Replacement – Plume Area



Central Plume

Alternative 1: No Action

- No impact on plume
- No groundwater monitoring of residential wells or monitoring wells.
- No contaminant removal, treatment, containment or monitoring
- As a condition of the Army's property transfer, groundwater access restrictions would continue within the BAAP boundary
- Not compliant with ARARs
- Not effective or permanent solution
- No known reduction in toxicity, mobility or volume through treatment
- No cost



Central Plume

Alternative 2: Monitored Natural Attenuation

MNA is expected to reduce the concentrations of COCs

- MNA includes a variety of processes that 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
- Compliant with ARARs
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$2.4M

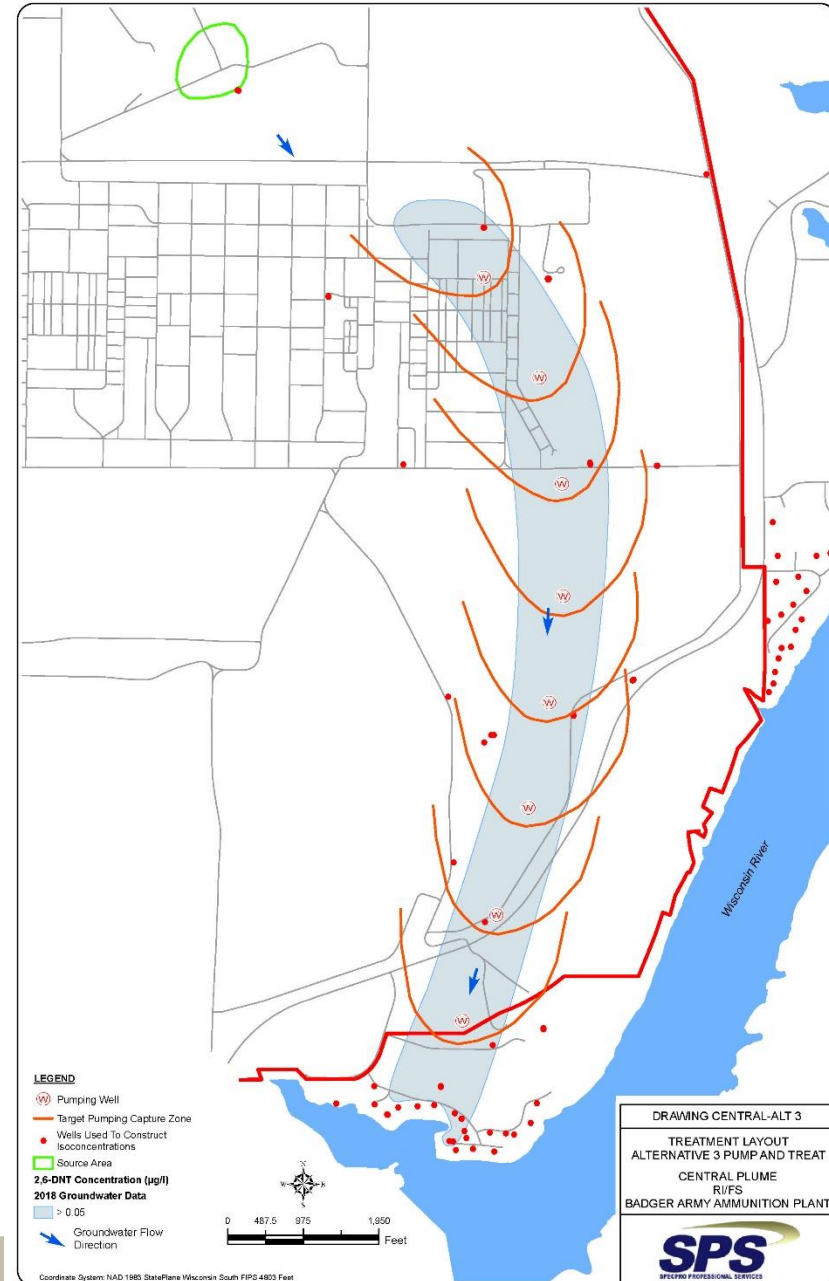


Central Plume

Alternative 3: Pump and Treat

Remove and treat impacted groundwater for DNT; includes:

- Groundwater removal utilizing 8 extraction wells and 8 mobile treatment units
- Groundwater pumping for 10 yrs
- Sampling/monitoring for 12 yrs
- Cleanup Time: 12 yrs
- Estimated Cost: \$18M

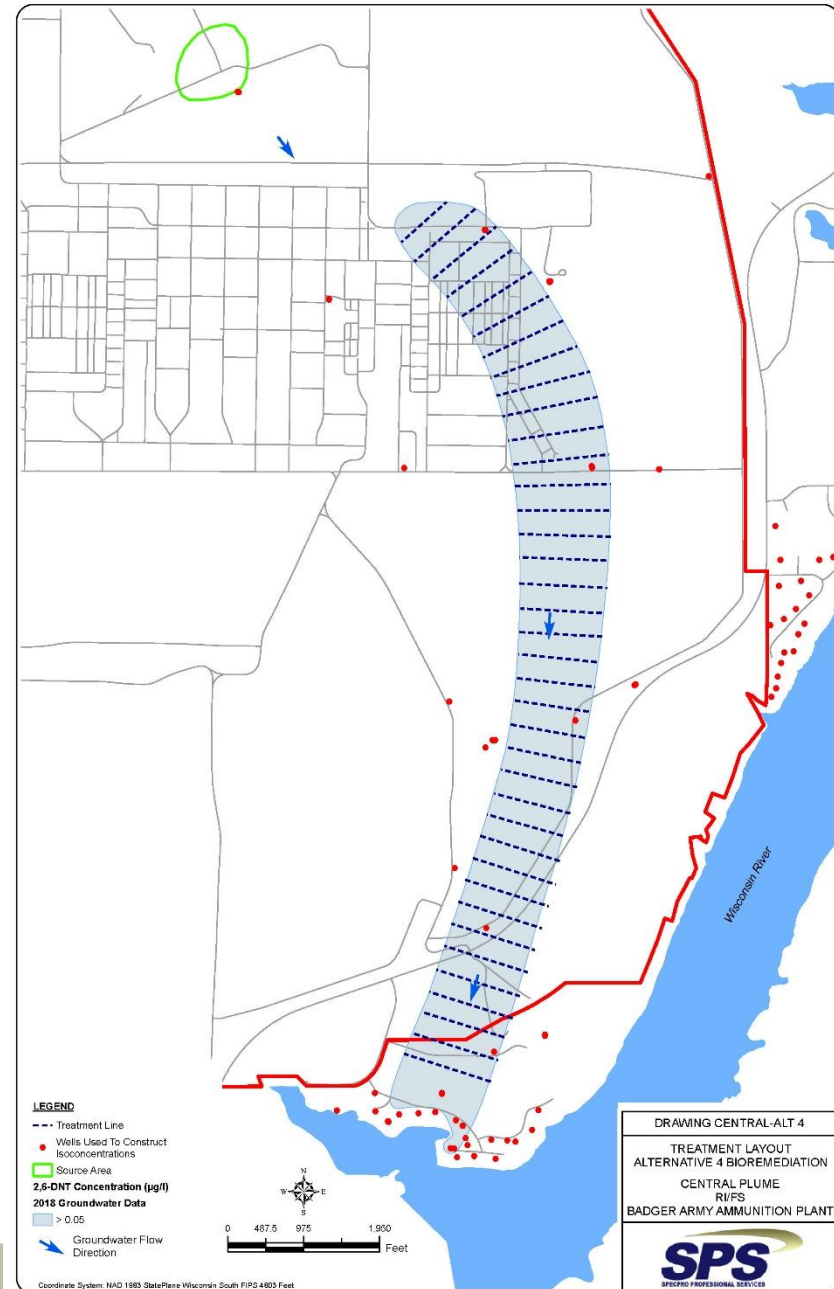


Central Plume

Alternative 4: Anaerobic Bioremediation

Target treatment to impacted groundwater for DNT using emulsified vegetable oil (EVO); includes:

- EVO injections at 38 treatment lines
- Injections at 988 temporary locations
- EVO treatment zone expected to remain active for 2 yrs
- Sampling/monitoring for 4 yrs
- Cleanup Time: 4 yrs
- Estimated Cost: \$23.7M



Central Plume

Alternative 5: Well Replacement – Plume Area

Replace shallow aquifer wells with deeper aquifer wells and include the following components:

- Replacement up to 23 existing residential wells with groundwater results exceeding action levels
- Sampling/monitoring for at least 30 yrs
- Cleanup Time: At least 30 yrs
- Estimated Cost: \$3.3M



Public Comments on RI/FS

**THE PUBLIC COMMENT PERIOD IS
NOV. 13 to JAN. 17, 2020**

Submit all written comments to:

U.S. Army Environmental Command
ATTN: West ESSD/Lynch
2455 Reynolds Road Mailstop 112
JBSA Fort Sam Houston, TX 78232-7588
Bryan.P.Lynch.civ@mail.mil

To review a copy of the RI/FS, please visit <https://aec.army.mil/index.php/baap>



TAPP Assistance

Technical Assistance for Public Participation (TAPP)

- A TAPP assistance grant to review the RI/FS is available to the RAB
- Please send any questions regarding the TAPP service to Michele Hopp, the RAB co-chair



End of Brief

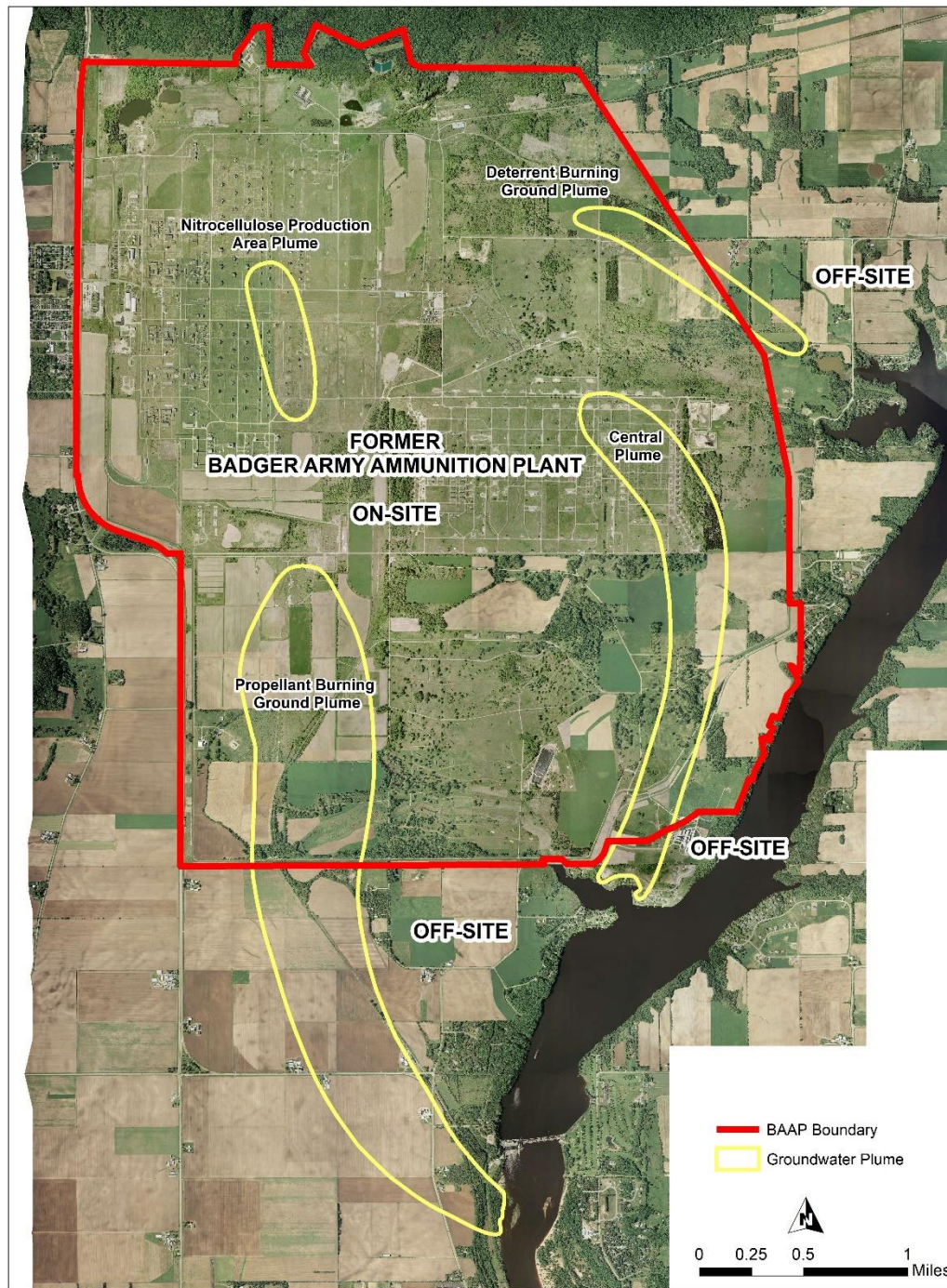
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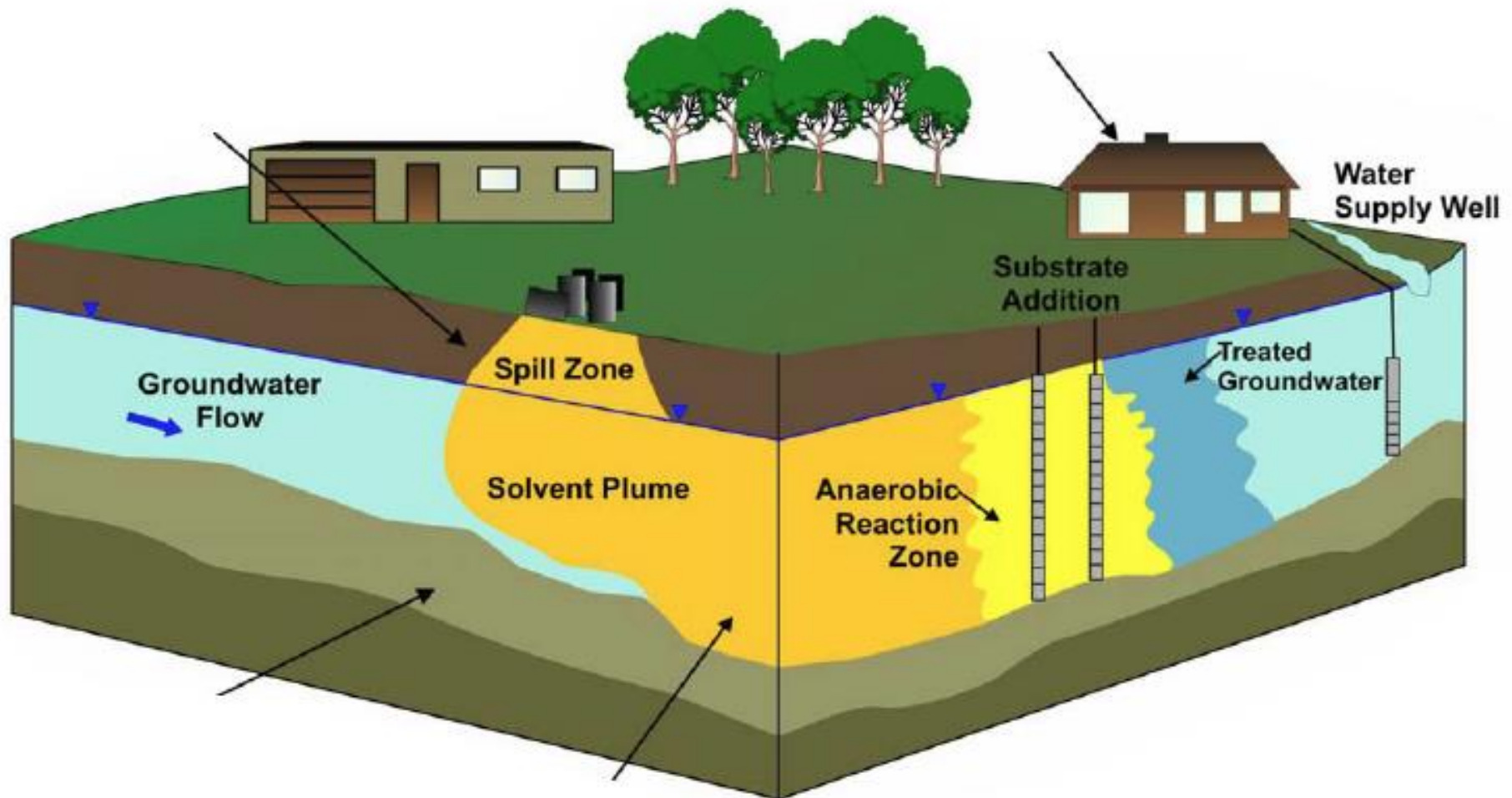
Backup Slides

Backup Slides





Conceptual Site Model Anaerobic Bioremediation



CERCLA PROCESS

Comprehensive Environmental Response,
Compensation and Liability Act

