EA Engineering, Science, and Technology, Inc., PBC

320 Gold Avenue SW, Suite 1300
Albuquerque, NM 87102
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RECEIVED
By PSTB at 3:02 pm, Sep 27, 2022

September 26, 2022

Mr. Corey Jarrett
Geoscientist/Project Manager
Remedial Action Program
New Mexico Environment Department
Petroleum Storage Tank Bureau
121 Tijeras Ave NE, Suite 1000
Albuquerque, NM 87102

Injection Completion Report
Barelas Bridge, 800 Bridge Blvd., SW, Albuquerque, NM
Release ID #: 54 Facility #: 29854 Deliverable ID 4266-4
Contract #: 22 667 3200 0012

Dear Mr. Jarrett:

EA Engineering, Science, and Technology, Inc. PBC (EA) prepared the attached Injection Completion Report to document the injection of PetroFix® at the Barelas Bridge site located at 800 Bridge Boulevard, SW in Albuquerque, New Mexico.

Please feel free to contact me at (505) 296-1070 or vmustafin@eaest.com if you have questions or comments.

Respectfully,

EA Engineering, Science, and Technology, Inc., PBC

V. Mustafin

Vener Mustafin, P.E.
Project Manager/Engineer

Attachments:

Injection Completion Report

CC:

Ms. Katherine MacNeil, P.E., Engineer, NMED PSTB
Mr. Scott Prall, Senior Maintenance Manager, Delek Companies
Mr. Andy Paz, Maintenance Manager, Delek Companies (via e-mail)

EA Engineering, Science,
and Technology, Inc.

INJECTION COMPLETION REPORT
BARELA'S BRIDGE SITE
800 BRIDGE BLVD., SW, ALBUQUERQUE, NM

PSTB FACILITY #: 29854
RELEASE ID #: 54
WPID #: 4266
DELIVERABLE ID #: 4266-2
CONTRACT #: 22-667-3200-0012

Submitted to:
New Mexico Environment Department
Petroleum Storage Tank Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Submitted by:
EA Engineering, Science,
and Technology, Inc., PBC
320 Gold Avenue SW, Suite 1300
Albuquerque, NM 87102

Distribution:

1 Copy Mr. Corey Jarrett, Project Manager, NMED PSTB
1 Copy Ms. Katherine MacNeil, P.E. Engineer, NMED PSTB

September 26, 2022 EA Project No. 6381201

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1.0 INTRODUCTION

1.1. Contractual

EA Engineering, Science, and Technology, Inc. PBC (EA) has prepared this Injection Completion Report to document the injection of Regenesis PetroFix® to address residual groundwater contamination at the Barela's Bridge Site located at 800 Bridge Blvd. in Albuquerque, New Mexico. The report was prepared under Contract number 22 667 3200 0012 and work plan identification (WPID) number 4266, approved by the New Mexico Environment Department (NMED) Petroleum Storage Tank Bureau (PSTB) on March 11, 2022. The injection was performed under the approved Final Remediation Plan (FRP) (EA, June 2022).

1.2. Background

- In 1989, after the release was reported, contaminated soil in the former underground storage tank (UST) pit area was excavated and removed. Contaminated soil along the southern site boundary was excavated and removed. The current USTs were installed in 2012.
- In 1989 – 1990, initial and additional hydrogeologic investigations were performed.
- In 1992, an air sparge/soil vapor extraction system was installed.
- The June 2021 groundwater monitoring results indicated total naphthalene concentrations exceeding the 30 micrograms per liter (µg/L) standard in VP-5 (84 µg/L), MW-8 (68 µg/L), and MW-9 (39.8 µg/L). BTEX concentrations were below the standards.
- Saturated soil consists of sand with gravel. The vadose zone soil consists of sand and some clay.

1.3. April 2022 Groundwater Field Data Results

Provided below is a summary of field data:

- The average depth to water was 8.18 feet below the top of the well casing. The corresponding average groundwater elevation was 4,935.48 feet above the mean sea level. Groundwater flow direction was to the east at a gradient of 0.0003 (Drawing G-2).
- The average groundwater temperature was 14.55 degrees Celsius.
- The average specific conductance was 819 micro-Siemens per centimeter.
- The average pH was 7.30 pH units.
- The average ORP was -99 millivolts.
- The average DO was 1.75 milligrams per liter.

Table 1. A Summary of Field Data

Well ID	Depth to Water	Well Casing Elevation	Ground Water Elevation	Temperature	Specific Conductance	pH	Oxidation-Reduction Potential	Dissolved Oxygen
	feet bTOC	*feet AMSL*	*feet AMSL*	*degrees Celsius*	*micro-Siemens per centimeter*	*units*	*millivolts*	*micrograms per liter*
MW-4	7.72	4,943.23	4,935.51	14.37	666	7.39	-3.8	1.87
MW-7	7.81	4942.94	4,935.13	15.20	774	7.51	-74.7	2.43
MW-8	9.06	4944.59	4,935.53	14.48	957	7.5	-180.8	1.65
MW-9	8.50	4943.98	4,935.48	14.79	727	7.14	-101.6	1.44
VP-2	8.15	4943.73	4,935.58	14.97	989	7.04	-98.7	1.36
VP-5	7.85	4943.52	4,935.67	13.47	803	7.2	-135.5	1.74
Average	8.18	4943.67	4935.48	14.55	819	7.30	-99.2	1.75

bTOC below the top of the well casing
AMSL above mean sea level

1.4. April 2022 Groundwater Laboratory Analysis Results

Provided below is a summary of the recent laboratory analytical results:

- Concentrations of benzene, toluene, ethylbenzene, xylenes, and methyl tertiary butyl ether were below the standards.
- Concentrations of total naphthalenes in MW-8 of 65 micrograms per liter (µg/L) and VP-5 of 154 µg/L were above the standard of 30 µg/L (Drawing G-3).
- Nitrate concentrations were below the detection limits and the standard of 10 milligrams per liter (mg/L).
- The total dissolved solids concentration in VP-2 was 356 milligrams per liter.

Table 2. A Summary of Recent Laboratory Analytical Results

Well Number	Date Sampled	Benzene	Toluene	Ethyl-benzene	Total Xylenes	MTBE	Total Naphthalenes	Nitrate	Total Dissolved Solids
Standard		***5***	***1000***	***700***	***620***	***100***	***30***	***10***	***1,000***
MW-4	**4/6/2022**	<1.0	<1.0	<1.0	<1.5	<1.0	<10	<0.50	
MW-4	6/22/2021	<1.0	<1.0	<1.0	<1.5	<1.0	<10		
MW-4	3/26/2019	<1.0	<1.0	<1.0	<1.5	<1.0	<10		
MW-4	5/19/2015	<1.0	<1.0	<1.0	<1.5	<1.0	**8.1**		
MW-7	**4/6/2022**	<1.0	<1.0	<1.0	<1.5	<1.0	<10	<0.10	
MW-7	6/22/2021	<1.0	<1.0	<1.0	<1.5	<1.0	**2.3**		
MW-7	3/26/2019	<1.0	<1.0	<1.0	<1.5	<1.0	<10		
MW-7	5/19/2015	<1.0	<1.0	<1.0	<1.5	<1.0	<10		
MW-8	**4/6/2022**	<1.0	<1.0	**10**	**2.7**	<1.0	**65**	<0.10	
MW-8	6/22/2021	<1.0	<1.0	**10**	**12.7**	<1.0	**68**		
MW-8	3/26/2019	<1.0	<1.0	**9.7**	**2.4**	<1.0	**45**		
MW-8	5/19/2015	<1.0	<1.0	**22**	**4.4**	<1.0	**124**		
MW-9	**4/6/2022**	<1.0	<1.0	**1.5**	**1.9**	<1.0	<10	<0.50	
MW-9	6/22/2021	<1.0	<1.0	**7.2**	**11**	<1.0	**39.8**		
MW-9	3/26/2019	**4.7**	<1.0	**9.0**	**32**	<1.0	**25.9**		
MW-9	5/19/2015	**21**	**3.0**	**18**	**18**	<1.0	**2.7**		
VP-2	**4/6/2022**	<1.0	<1.0	<1.0	<1.5	<1.0	<10	<1.0	**356**
VP-2	6/22/2021	<1.0	<1.0	<1.0	<1.5	<1.0	**2.0**		
VP-2	3/26/2019	<1.0	<1.0	<1.0	<1.5	<1.0	**8.7**		
VP-2	5/19/2015	<1.0	<1.0	<1.0	<1.5	<1.0	<10		
VP-5	**4/6/2022**	<1.0	<1.0	<1.0	<1.5	<1.0	**154**	<0.10	
VP-5	6/22/2021	<1.0	<1.0	<1.0	<1.5	<1.0	**84**		
VP-5	3/26/2019	<1.0	<1.0	<1.0	<1.5	<1.0	**166.5**		
VP-5	5/19/2015	<1.0	<1.0	<1.0	<1.5	<1.0	**203**		

Empty cells indicate that analysis was not conducted
Bold values indicate concentrations above the laboratory limits
Red Bold values indicated concentrations above the standards
Standards are New Mexico Administrative Code 20.6.2.3103
"Standards for Ground Water of 10,000 mg/L TDS Concentration or less"
Concentrations for VOCs are in micrograms per liter. Concentrations for nitrate and TDS are in milligrams per liter.
Volatile Organic Compounds were analyzed using EPA Method 8260B. Sulfate and Nitrate were analyzed by EPA Method 300

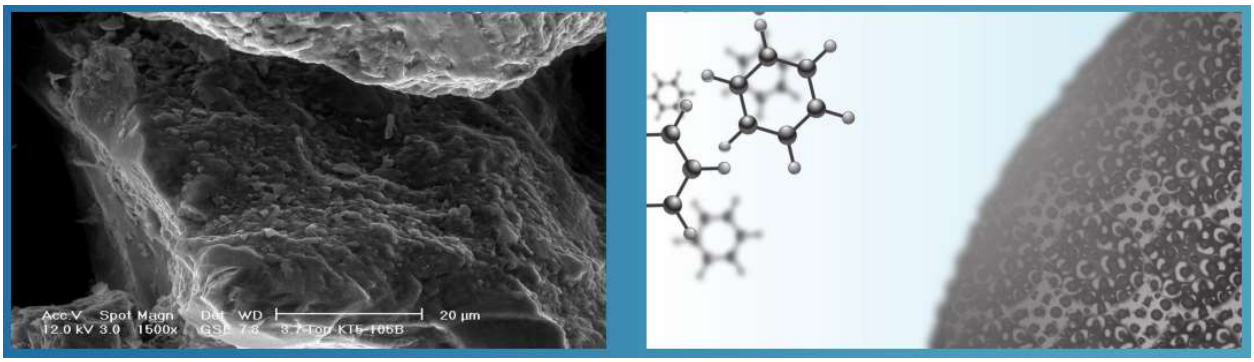
2.0 SITE REMEDIATION

2.1. The Goal of Remediation

The goal of the remediation is to mitigate recalcitrant petroleum hydrocarbon concentrations in monitoring wells MW-8, MW-9, and VP-5 to facilitate a No Further Action at the site. In recent years, total naphthalene concentrations in these wells were above the New Mexico Administrative Code (NMAC) 20.6.2.3103 Standards for Ground Water. The remediation goal is to decrease total naphthalene concentrations to below 30 µg/L, which are the corresponding NMAC 20.6.2.3103 standards.

2.2. Injected Amendment

The NMED PSTB Request for Quote specified "trap-and-treat" as the preferred technology for site remediation. EA selected Regenesis PetroFix™, which is a suspension of 1-2 micron activated carbon with nitrate and sulfate electron acceptors. PetroFix™ will remove hydrocarbons from the dissolved phase by adsorbing them onto activated carbon particles ("trap"). Thereafter, nitrate and sulfate electron acceptors will stimulate hydrocarbon biodegradation ("treat"). Nitrate is a fast-acting electron acceptor that will be utilized by bacteria first. This will be followed by the utilization of sulfate. Activated carbon will be self-regenerating as adsorbed contaminants degrade over time. PetroFix™ manufacturer specifications are provided in Appendix A.



2.3. Underground Injection Control Discharge Permit

The injection was performed under the Underground Injection Control Discharge Permit (UIC DP) DP-1947 approved by the NMED Groundwater Quality Bureau on September 15, 2022, and valid through September 14, 2027 (Appendix B).

2.4. Final Remediation Plan

Per 20.5.119.1923 NMAC, EA prepared the Final Remediation Plan that was submitted to the NMED PSTB (EA, June 10, 2022). As part of the FRP, EA and PSTB provided public notice 20.5.119.1923.D.(10).

2.5. Notifications

Before the injection, EA notified Mr. Corey Jarrett, NMED PSTB project manager, Mr. Scott Prall, Senior Maintenance Manager, and Mr. Andy Paz, Maintenance Manager, of Delek Companies.

2.6. Injection Contractor

To perform the injection, EA contracted Enviro-Drill LLC, a New Mexico Licensed Drilling Company, License # WD-1186.

2.7. NM 811 Clearance

Before the injection, EA marked the site with white paint in preparation for the underground utility clearance. Enviro-Drill LLC. requested the NM811 clearance and the utility companies marked the existing underground infrastructure.

2.8. Target Area

The immediate areas around monitoring wells MW-8, MW-9, and VP-5 were the target areas. The injection points were spaced approximately 7.5 feet apart and were located approximately 4-5 feet from the monitoring wells (Drawing C-1).

2.9. Injection Method

A direct push (DP) Geoprobe® 7720D rig was used to inject the remediation fluids using a top-down 1-foot non-retractable tool.

2.10. Mixing and Batching

PetroFix® was first homogenized using a hand-held mechanical mixer within the drum. Thereafter, water was added to a mixing vessel followed by PetroFix®. The solution was mixed using the integral vessel mechanical paddle mixer. Once the solution was homogenized, the electron acceptor was added and thoroughly mixed before the injection. Batching was repeated until the target quantities were injected.

2.11. Injection Pump

A progressive cavity Liberty 2LL4 pump was used to inject the fluids. The pump was located at the base of the mixing vessel and was connected to the drilling rod using a high-pressure hose.

2.12. Injection Dates, Interval, Quantities, Pressures, and Flowrates

The injection took place on September 21, 22, and 23, 2022.

The injection interval was from 9 feet bgs to 13 feet bgs near MW-8, from 9 feet bgs to 19 feet bgs near MW-9, and from 8 feet bgs to 13 feet bgs near VP-5.

Approximately 1,200 gallons of the remediation solution were injected into ten boreholes at pressures ranging from 20 pounds per square inch by the gauge (psig) to 220 psig at flow rates ranging from 4 gallons per minute (gpm) to 6 gpm. Out of this, 110 gallons (1,074 pounds) was PetroFix® and 1,090 gallons was water. Details are provided in Table 1.

2.13. Deviations

The following are the deviations:

- BB-02 and BB-05 were moved 1 foot to the northwest due to the presence of underground utilities.
- Additional 269 pounds of PetroFix® was injected around MW-9 due to dosage error. The error was biased high.

2.14. Surfacing and Well Intrusion

Surfacing and well intrusion did not occur. If later PetroFix® will move into the monitoring wells, wells should not be sampled for approximately 3 months or until concentrations of PetroFix® in the wells decrease to below 100 mg/L, as PetroFix® may affect laboratory equipment. The "Colloidal Activated Carbon Groundwater Sampling Guidance Document" is provided in Appendix C.

2.15. Groundwater Levels

Groundwater level fluctuations before and after the injection were less than 0.05 foot in MW-8 indicating that the injection did not result in a substantial groundwater upwelling. MW-9 and VP-5 could not be accessed due to rain run-off flooding of the MW-9 vault and the inability to open the vault in VP-5.

Well ID	Before Injection	After Injection	Difference
MW-8	9.18	9.23	0.05
MW-9	vault filled with rain run-off		
VP-5	unable to open the vault		
Values are in feet below the top of the well casing			

2.16. Borehole Plugging and Site Restoration

Upon completion, boreholes were plugged with bentonite grout, the site was restored, materials and equipment removed, and personnel demobilized.

2.17. Records

A summary of the injection is presented in Table 1. Photographs are provided in Appendix D and field records are presented in Appendix E.

2.18. Post-Injection Monitoring.

A follow-up quarterly post-injection monitoring is recommended to evaluate concentrations of constituents of concern at the site. The post-injection monitoring was not a part of EA's scope of work under the existing contract. The suggested monitoring scope includes the following:

- Gauge six (6) monitoring wells (VW-2, VP-5, MW-4, MW-7, MW-8, and MW-9).
- Purge stagnant groundwater.
- Collect groundwater samples from six (6) wells (VW-2, VP-5, MW-4, MW-7, MW-8, and MW-9).
- Analyze samples for volatile organic compounds (VOCs), including total naphthalenes, by the United States Environmental Protection Agency (EPA) Method 8260B and sulfate and nitrate by EPA Method 300.1. Also, analyze a sample from VP-2 for Total Dissolved Solids by SM 2540C.
- Prepare and submit a groundwater monitoring report.

2.19. Annual Evaluation.

Per 20.5.12.119.1927 NMAC, the effectiveness of the injection should be evaluated annually and provide an analysis of the trend of contaminant concentrations in groundwater, project trends for contaminant concentration decline, evaluation of the effectiveness of the remediation based on injection performance, an estimated time to achieve remediation goals, and recommendations for remediation enhancements. The annual evaluation was not scoped within the EA's current contract.

2.20. Recommendations.

EA recommends conducting quarterly groundwater monitoring at the site to evaluate concentrations of contaminants of concern after the injection.

3.0 REFERENCES

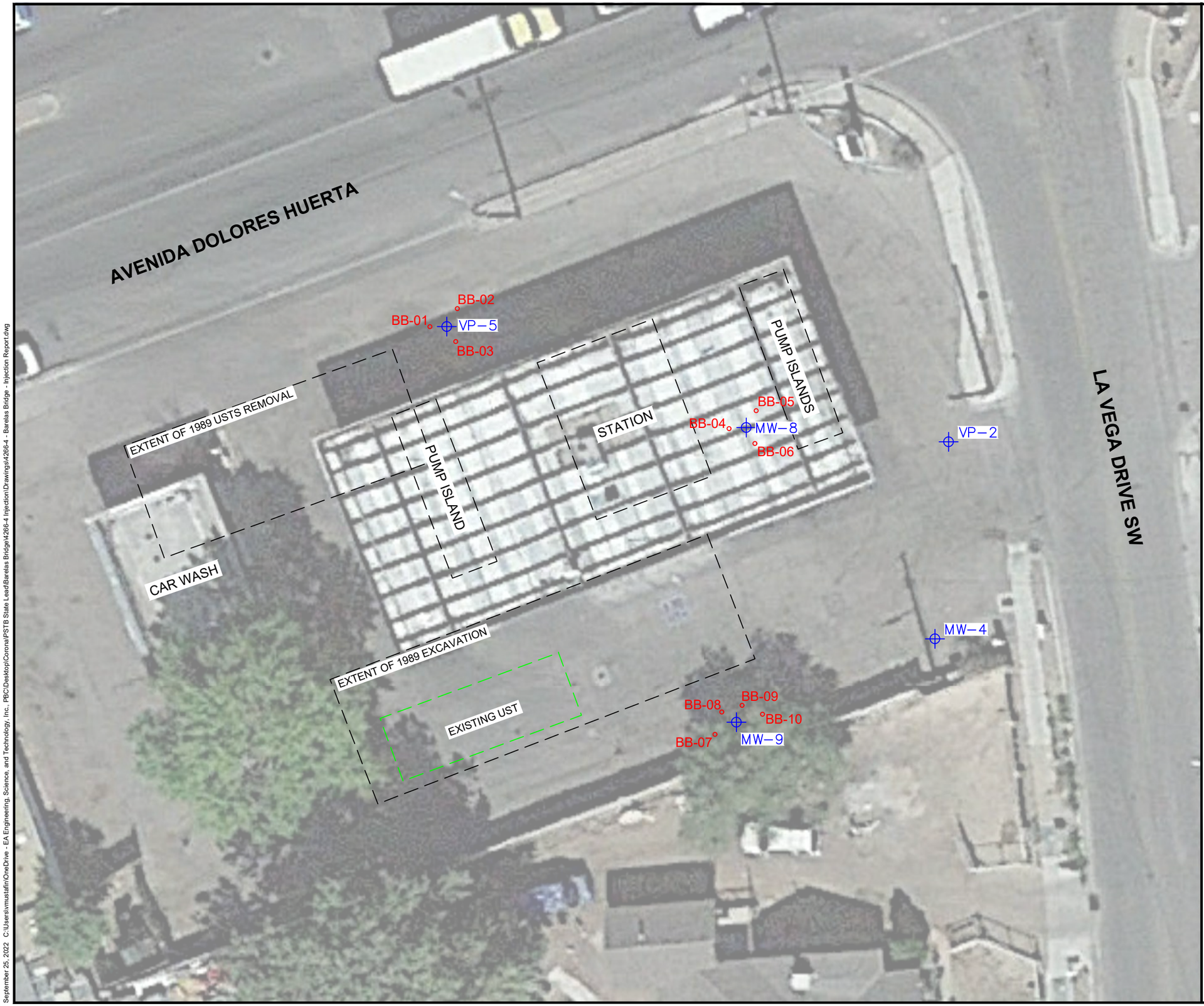
EA Engineering, Science, and Technology, Inc. PBC (EA), 2022. Barela's Bridge Work Plan for Site Remediation. March 4.

EA, 2022. Barela's Bridge. Pre-Injection Groundwater Monitoring Report. May 17.

EA, 2022. Barela's Bridge. Final Remediation Plan. June 10.

State of New Mexico. 2022. Professional Services Contract No. 22 667 3200 0012. February 23.

DRAWING



LEGEND:

- MONITORING WELL
- INJECTION POINT

NOTE: LOCATIONS OF FEATURES ARE APPROXIMATE AND BASED ON WESTERN TECHNOLOGIES AND LEGETTE, BRAHEARS, & GRAHAM INC. FIGURES.

20 10 0 20

SCALE IN FEET

REVISIONS				
REV	DATE	DRAWN	CHECKED	REMARKS
0	09/26/22	VM	VM	4266-4 INJECTION COMPLETION REPORT

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.
320 Gold Avenue, SW Suite 1300
Albuquerque, NM 87102
Phone: (505) 224-9013
Fax: (505) 224-9016

BARELA'S BRIDGE
800 BRIDGE BLVD., ALBUQUERQUE, NM
INJECTION COMPLETION REPORT

LOCATIONS OF THE INJECTION POINTS

PROJECT NUMBER: 6381201

DRAWING NO.: C-1

TABLE

TABLE 1. A SUMMARY OF PETROFIX INJECTION
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW ALBUQUERQUE, NEW MEXICO

Injection Point	Associated Well	Date	Inveval *feet bgs*	Interval Length *feet*	Solution Volume *gallons*	Mix	Injected PetroFix Volume *gallons*	Injected PetroFix Mass *pounds*	Target PetroFix Mass *pounds*	PetroFix Mass Variance *pounds*	Water Volume *gallons*	Electron Acceptor Mass *pounds*	Pressure *psig*	Flowrate *gpm*
BB-01	VP-5	9/23/2022	8 - 13	5	133	2.1	9.3	91	89	0	124	4.4	60	6
BB-02	VP-5	9/23/2022	8 - 13	5	133	2.1	9.1	89	89	0	124	4.4	20-75	6
BB-03	VP-5	9/23/2022	8 - 13	5	133	2.1	9.1	89	89	0	124	4.4	60-100	6
Subtotal	***VP-5***				***400***		***27.6***	***270***	***267***	***0***	***373***	***13.3***		
BB-04	MW-8	9/22/2022	9 - 13	4	133	2.1	9.1	89	89	0	124	4.4	75-100	6
BB-05	MW-8	9/22/2022	9 - 13	4	133	2.1	9.1	89	89	0	124	4.4	150-200	6
BB-06	MW-8	9/22/2022	9 - 13	4	133	2.1	9.1	89	89	0	124	4.4	150-220	6
Subtotal	***MW-8***				***400***		***27.3***	***268***	***267***	***0***	***373***	***13.3***		
BB-07	MW-9	9/22/2022	9 -19	10	100	4.1	13.7	134	89	45	86	3.3	50	6
BB-08	MW-9	9/21/2022	9 -19	10	100	4.1	13.7	134	89	45	86	3.3	50-100	4
BB-09	MW-9	9/21/2022	9 -19	10	100	4.1	13.7	134	89	45	86	3.3	40-50	5
BB-10	MW-9	9/21/2022	9 -19	10	100	4.1	13.7	134	89	45	86	3.3	50-60	6
Subtotal	***MW-9***				***400***		***54.7***	***536***	***267***	***269***	***345***	***13.3***		
Total					**1,200**		**110**	**1,074**	**800**	**274**	**1,090**	**40**		

Notes:

bgs	below ground surface
gpm	gallons per minute
psig	pounds per square inch by gauge

APPENDIX A – PETROFIX® MANUFACTURER SPECIFICATIONS

PetroFix™ Specification Sheet

PetroFix Technical Description

PetroFix is a new remedial technology designed to treat petroleum fuel spills in soil and groundwater. A simple-to-use fluid that can be applied under low pressure into the subsurface or simply poured into open excavations, PetroFix offers a cost-effective solution for environmental practitioners and responsible parties to address petroleum hydrocarbon contaminants quickly and effectively.

PetroFix has a dual function; quickly removing hydrocarbons from the dissolved phase, by absorbing them onto the activated carbon particles, while added electron acceptors stimulate hydrocarbon biodegradation in-place. PetroFix does not require high pressure "fracking" for application and can be applied with ease using readily available equipment associated with direct push technology.

The remedial fluid is a highly concentrated water-based suspension consisting of micron-scale activated carbon and biostimulating electron acceptors. PetroFix has a viscosity higher than water and is black in appearance. Its environmentally-compatible formulation of micron-scale activated carbon (1-2 microns) is combined with both slow and quick-release inorganic electron acceptors. A blend of additional electron acceptors is included along with the PetroFix fluid. Practitioners can select between a sulfate and nitrate combination blend (recommended), or sulfate only for the additional electron acceptors required.

PetroFix Design Assistant

REGENESIS has developed a proprietary web-based design assistant called PetroFix Design Assistant™ that provides environmental professionals the ability to input their site parameters, determine the required product amount, and order the product through REGENESIS' customer service. The PetroFix Design Assistant includes defaults and warnings throughout the process to guide users toward effective designs that will offer best results.

To access the PetroFix Design Assistant, create an account and login at www.PetroFix.com

PetroFIX™ Remediation Fluid

PetroFix Fluid Chemical Composition	Properties
Activated Carbon - CAS 7440-44-0 > 30% Calcium Sulfate Dihydrate - CAS 10101-41-4 < 10%	**Appearance:** Black Fluid **Viscosity:** 1500-3500 cP (corn syrup-like) **pH:** 8-10

PetroFix Electron Acceptor Powder Chemical Composition	Properties
OPTION 1 - EA Blend (preferred) Sodium Nitrate - CAS 7631-99-4, 50% Ammonium Sulfate - CAS 7783-20-2, 50% OPTION 2 - EA Blend NF Potassium Sulfate - CAS 7778-80-5, 50% Ammonium Sulfate - CAS 7783-20-2, 50%	**Appearance:** White Powder

Storage and Handling Guidelines

Storage:

- Store away from incompatible materials
- Store in original closed container
- Store at temperatures between 40°F and 95°F
- Do not allow material to freeze or store in direct sunlight.
- Freezing and hot weather technical memo can be accessed at www.petrofix.com/resources or at this ***link*** here.
- Dispose of waste and residues in accordance with local authority requirements

Handling:

- Never add additives to solution prior to mixing with water
- Wear appropriate personal protective equipment
- Do not taste or ingest
- Observe good industrial hygiene practices
- Wash hands after handling

Applications

PetroFix is mixed with water on-site and easily applied onto the sub-surface using low pressure injections, or mixed in excavations. PetroFix is compatible with and can be used with ORC Advanced® to expedite rates of biodegradation. For more information about co-application with ORC Advanced, contact REGENESIS.

REGENESIS®

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Tel: +44 (0) 1225 61 81 61

www.regenesis.com

APPENDIX B – UNDERGROUND INJECTION CONTROL DISCHARGE PERMIT

NEW MEXICO ENVIRONMENT DEPARTMENT GROUND WATER QUALITY BUREAU

UNDERGROUND INJECTION CONTROL

GENERAL DISCHARGE PERMIT

Certified Mail- Return Receipt Requested

Facility Name:	**Barela's Bridge**
Facility Location:	**800 Bridge Boulevard SW, Albuquerque, NM** **Section 30 Township 10 North Range 3 East** **Bernalillo County**
Legally Responsible Party:	**NMED Petroleum Storage Tank** **Bureau 121 Tijeras Avenue NE Suite** **1000 Albuquerque, NM 87102** **(505) 372-8335**
Remediation Oversight Agency Contact:	**NMED Petroleum Storage Tank Bureau Corey Jarrett, Project Manager, Geoscientist 505-372-8335** **NM State Contract Number: 22-667-3200-0012**
Remediation or Injection Plan Identification:	**Barelas's Bridge Final Remediation Plan** **FID 29854 RID 54 Work Plan ID 4266**
Permitting Action:	**New DP-1947**
PPS Contact	**Andrew Romero** **(505) 660-8624**
EFFECTIVE DATE: September 15, 2022	**TERM ENDS:** September 14, 2027

Justin D. Ball
Chief, Ground Water Quality Bureau

[Subsection H of 20.6.2.3109 NMAC, NMSA 1978, § 74-6-5.I]

I. UIC GENERAL DISCHARGE PERMIT

The New Mexico Environment Department (NMED) Ground Water Quality Bureau (GWQB) issues this Underground Injection Control General Discharge Permit (UIC Permit) for the subsurface emplacement of additive fluids through a Class V UIC injection well for the purpose of facilitating vadose zone or groundwater remediation. The GWQB issues this UIC Permit to New Mexico Environment Department Petroleum Storage Tank Bureau (Permittee) pursuant to the New Mexico Water Quality Act (WQA), NMSA 1978 §§74-6-1 through 74-6-17, and the New Mexico Water Quality Control Commission (WQCC) Ground and Surface Water Protection Regulations, 20.6.2 NMAC.

In issuing this UIC Permit, the GWQB has determined that the requirements of Subsection C of 20.6.2.3109 NMAC have been met. The activities authorized by this UIC Permit are principally governed by Work Plan for Site Remediation (Injection Plan), under the authority of NMED PSTB, with oversight by the NMED PSTB. Compliance with this UIC Permit requires compliance with the terms, requirements, and conditions of the Injection Plan. The term of this UIC Permit shall be no longer than five years from the effective date of this UIC Permit.

The injection activities, the location of the injection site, the type of injection and quantities of additives being used are briefly described as follows:

Injection Activities (summary: including injection well type, number of wells, and injection frequency)

Copy of the Injection Plan Attached (required): ☒
Summary of Injection Plan: Soil and groundwater impacted by the past releases of gasoline from underground storage tanks in the area will be remediated by injecting 800 pounds of Regenesis PetroFix and electron acceptors mixed with water for a total volume of 1,200 gallons injected into approximately 9 direct push injection points between 9 and 13 feet bgs. A licensed New Mexico Driller will perform the work. Work will be performed under the New Mexico State Contract 22 667 3200 0012 under the supervision and directives of the Ne Mexico Environment Department Petroleum Storage Tank Bureau.

Injection Site Information

Depth to most shallow groundwater (required): 8 ft
Existing concentration of total dissolved solids (TDS) in groundwater (required): 356mg/L
Location (required): 800 Bridge Blvd., SW, Albuquerque, NM
County (required): Bernalillo
Latitude: 35.068967
Longitude: -106.66422
Map Showing Area of Injection Sites Attached (required): ☒

Additives Being Used (including volumes, manufacturer, and mixing ratios)

Approximately 800 pounds of Regenesis PetroFix will be mixed with 40 pounds of electron acceptors and potable water for a total injectate volume of approximately 1,200 gallons and injected using a direct push rig. PetroFix is a suspension of 1-2 micron-size activated carbon with nitrate and sulfate electron acceptors. Sodium Nitrate and Ammonium Sulfate will be utilized by bacteria to degrade petroleum hydrocarbons and are anticipated to be used up by bacteria within one year after injection.

Anticipated Precipitation, Dissolution, Adsorption, and Desorption Products

Activated carbon, similar to the one used for household drinking water filtration, is inert and will coat soil and adsorb petroleum hydrocarbons. Sodium Nitrate and Ammonium Sulfate are used as amendments within the mix to biologically degrade the adsorbed petroleum hydrocarbons. These amendments are utilized for the degradation of petroleum hydrocarbons by the native bacteria that incorporate them into the bacterial cells or use them for metabolism. Amendments are expected to be utilized by the bacteria within one year after the injection.

Public Notice Posting Locations

2 inch by 3 inch Newspaper Ad required for Renewal applications.
Newspaper: Albuquerque Journal or another selected by the GWQB

3 inch by 4 inch Newspaper Ad required for New, Modification, and Renewal/Modification applications.
Newspaper: Albuquerque Journal or another selected by the GWQB

2 feet by 3 feet sign posted for 30 days in a location conspicuous to the public at or near the facility required for New, Modification, and Renewal/Modification applications.
Sign Location: Onsite at 800 Bridge Blvd., SW, Albuquerque, NM

8.5 inch by 11 inch or larger posted off-site location conspicuous to the public (e.g. public library). Required for New, Modification, and Renewal/Modification applications.
Flyer Location: South Broadway Public Library, 1025 Broadway Blvd., SE, Albuquerque, NM 87102

This UIC Permit consists of the complete and accurate completion of this UIC Permit form as determined by the GWQB.
Issuance of this UIC Permit does not relieve the Permittee of the responsibility to comply with the WQA, WQCC Regulations, and any other applicable federal, state and/or local laws and regulations, such as zoning requirements and nuisance ordinances.

Signatures

Signature must be that of the person listed as the legally responsible party on this application.

I, the applicant, attest under penalty of law to the truth of the information and supporting documentation contained in this application for an Underground Injection Control General Discharge Permit.

Applicant's Signature

Signature: Lorena Goerger Digitally signed by Lorena Goerger Date: 2022.05.19 10:53:20 -06'00' Date: 5/19/2022

Printed Name: Lorena Goerger Title: Acting Bureau Chief

Applicant Note that Submissions Must Include:

1- One electronic copy of the application delivered to the GWQB via email or other format

2- Two hardcopies of the application delivered to: Ground Water Quality Bureau
Harold Runnels Building
1190 Saint Francis Drive
P.O. Box 5469
Santa Fe, NM 87502-5469

3- Payment by check or electronic transfer of one application fee of $100.00

II. FINDINGS

In issuing this UIC Permit, GWQB finds:

1. The Permittee is injecting fluids so that such injections will move directly or indirectly into groundwater within the meaning of Section 20.6.2.3104 NMAC.
2. The Permittee is injecting fluids so that such fluids will move into groundwater of the State of New Mexico which has an existing concentration of 10,000 mg/L or less of TDS within the meaning of Subsection A of 20.6.2.3101 NMAC.
3. The Permittee is using a Class V UIC well as described in 20.6.2.5002(B)(5)(d)(ii) NMAC for in situ groundwater remediation by injecting a fluid that facilitates vadose zone or groundwater remediation.
4. The Permittee is injecting fluids into groundwater in order to achieve the remediation goals identified in the Injection Plan.

III. AUTHORIZATION TO DISCHARGE

The Permittee is authorized to inject chemical additives into groundwater in accordance with this UIC Permit and the Injection Plan under the oversight of NMED PSTB.

[20.6.2.3104 NMAC, Subsection C of 20.6.2.3106 NMAC, Subsection C of 20.6.2.3109 NMAC]

IV. CONDITIONS

The conditions of this UIC Permit shall be complied with by the Permittee and are enforceable by GWQB.

1. The Permittee shall perform remediation activities in accordance with the Injection Plan and shall notify GWQB of any changes prior to making them.

   [20.6.2.3107 NMAC]

2. The Permittee shall monitor the injection activities and their effects on groundwater quality as required by the Injection Plan and shall provide GWQB with electronic copies of the required reporting and any pertinent documentation of activities at the site.

   [20.6.2.3107.A NMAC, 20.6.2.3109.A NMAC]

3. If the GWQB or the Permittee identifies any failure of the Injection Plan or this UIC Permit to comply with 20.6.2 NMAC not specifically noted herein, GWQB may require the Permittee to submit a corrective action plan and a schedule for completion of corrective actions to address the failure.

   Additionally, the GWQB may require the Permittee to submit a proposed modification to the Injection Plan, this UIC Permit, or both.

   [20.6.2.3107.A NMAC, 20.6.2.3109.E NMAC]

4. ADDITIONAL MONITORING REQUIREMENTS – (RESERVED) - Placeholder for any added monitoring and reporting requirements.

5. TERMINATION – Within 30 days of completion of activities authorized by this UIC Permit the Permittee shall submit a closure report and a request to terminate the UIC Permit to the GWQB for its approval. The closure report shall identify how the injection well(s) was (were) closed in accordance with the Injection Plan. The Permittee shall provide NMED GWQB with a copy of this closure report.

   [20.6.2.5005 NMAC, 19.27.4 NMAC]

6. INSPECTION and ENTRY – The Permittee shall allow a representative of the NMED to inspect the facility and its operations subject to this UIC Permit and the WQCC regulations. The GWQB representative may, upon presentation of proper credentials, enter at reasonable times upon or through any premises in which a water contaminant source is located or in which are located any records required to be maintained by regulations of the federal government or the WQCC.

   The Permittee shall allow the GWQB representative to have access to, and reproduce for their use, any copy of the records, and to perform assessments, sampling or monitoring during an inspection for the purpose of evaluating compliance with this UIC Permit and the WQCC regulations.

   Nothing in this UIC Permit shall be construed as limiting in any way the inspection and entry authority of GWQB under the WQA, the WQCC Regulations, or any other local, state, or federal regulations.

   [20.6.2.3107.D NMAC, NMSA 1978, §§ 74-6-9.B and 74-6-9.E]

7. MODIFICATIONS and/or AMENDMENTS – In the event the Permittee proposes a change to the injection plan that would result in a change in the volume injected; the location of the injections; or the concentration of the additives being injected by the facility, the Permittee shall notify GWQB prior to implementing such changes. The Permittee shall obtain approval (which may require modification of this UIC Permit) by GWQB prior to implementing such changes.

   [20.6.2.3107.C NMAC, 20.6.2.3109.E and G NMAC]

8. COMPLIANCE with OTHER LAWS – Nothing in this UIC Permit shall be construed in any way as relieving the Permittee of the obligation to comply with all applicable federal, state, and local laws, regulations, permits, or orders.

   [NMSA 1978, § 74-6-5.L]

9. PERMIT FEES – Payment of permit fees is due at the time of UIC Permit approval. Permit fees shall be paid in a single payment remitted to GWQB no later than 30 days after the UIC Permit effective date.

   Permit fees are associated with issuance of this UIC Permit. Nothing in this UIC Permit shall be construed as relieving the Permittee of the obligation to pay all permit fees assessed by GWQB. A Permittee that ceases injecting or does not commence injecting during the term of the UIC Permit shall pay all permit fees assessed by GWQB. An approved UIC Permit shall be suspended or terminated if the facility fails to remit a payment by its due date.

   [20.6.2.3114.F NMAC, NMSA 1978, § 74-6-5.K]

Work Plan for Site Remediation (Injection Plan)

EA Engineering, Science,
and Technology, Inc., PBC

320 Gold Avenue SW, Suite 1300
Albuquerque, NM 87102
Telephone: 505-224-9013
www.eaest.com

March 4, 2022

Mr. Corey Jarrett
Geoscientist/Project Manager
Remedial Action Program
New Mexico Environment Department
Petroleum Storage Tank Bureau
121 Tijeras Ave NE, Suite 1000
Albuquerque, NM 87102

Site Remediation Work Plan
Barelas Bridge, 800 Bridge Blvd., SW, Albuquerque, NM
Release ID #: 54 Facility #: 29854
Contract #: 22 667 3200 0012

Dear Mr. Jarrett:

EA Engineering, Science, and Technology, Inc. PBC (EA) has prepared this Work Plan for remediation activities at the Barelas Bridge site located at 800 Bridge Boulevard, SW in Albuquerque, New Mexico (Figure 1). Remediation activities will be performed under State of New Mexico Environment Department Professional Services Contact No. 22 667 3200 0012. The objective of the remedial action is to trap and treat recalcitrant hydrocarbon concentrations to facilitate a No Further Action at the site.

The remediation activities will be performed in accordance with the requirements of the New Mexico Petroleum Storage Tank Regulations, NMAC 20.5.119. EA maintains the New Mexico Construction Division (CID) GS-29 license #359538 and New Mexico Professional Engineer licensure. All remediation activities will be conducted under the direct supervision of Vener Mustafin, New Mexico Professional Engineer License #17630.

BACKGROUND

A summary of the site background is provided below:

- Contaminated soil in the former UST pit area was excavated and removed in 1989 after the release was reported. Contaminated soil along the southern site boundary was excavated and removed. The current USTs were installed in 2012.
- In 1989 – 1990, initial and additional hydrogeologic investigations were performed.
- In 1992, an air sparge/soil vapor extraction system was installed.
- June 2021 groundwater monitoring results indicated total naphthalene concentrations exceeding the 30 micrograms per liter (µg/L) standard in VP-5 (84 µg/L), MW-8 (68 µg/L), and MW-9 (39.8 µg/L). BTEX concentrations were below the standards.
- Groundwater is encountered approximately 10 feet below ground surface (ft bgs); the hydraulic gradient is 0.002 ft/ft and flow is to the south-southeast.
- Dissolved oxygen in the wells of interest ranged between 1 and 5 milligrams per liter, oxidation-reduction potential ranged between 50 and 200 millivolts, and pH was near neutral around 7.5 pH units.
- Saturated soil consists of sand with gravel. Vadose zone soil consists of sands and some clay.

GENERAL APPROACH

The remediation approach includes the following major elements: 1) perform pre-injection monitoring, 2) obtain a discharge permit, 3) develop a Final Remediation Plan (FRP), 4) implement FRP, and 5) perform post-injection groundwater monitoring. Each of these elements is discussed below.

1. PERFORM PRE-INJECTION MONITORING

The following is the scope of work for pre-injection (baseline) groundwater monitoring:

- Gauge six (6) monitoring wells (VW-2, VP-5, MW-4, MW-7, MW-8, and MW-9).
- Purge stagnant groundwater
- Collect groundwater samples from six (6) wells (VW-2, VP-5, MW-4, MW-7, MW-8, and MW-9).
- Analyze samples for volatile organic compounds (VOCs), including total naphthalenes, by the United States Environmental Protection Agency (EPA) Method 8260B and sulfate and nitrate by EPA Method 300.1. Also, analyze a sample from VP-2 for Total Dissolved Solids by SM 2540C.
- Prepare and submit a one-page analytical summary and provide laboratory reports.

The following activities will be completed as part of the pre-injection groundwater monitoring:

- Before conducting fieldwork, EA will prepare a site-specific Health and Safety Plan (HASP) describing activities, hazards, personal protective equipment, route to the hospital, emergency contacts, and other required elements.
- EA assumes that the Mexico Environment Department (NMED) Petroleum Storage Tank Bureau (PSTB) has an access agreement with the site owner that will be utilized to access the site.
- EA will notify the NMED PSTB project manager and site owner at least 96-hours before conducting field activities.
- EA personnel will review the work plan, HASP, order equipment, obtain supplies, and discuss the scope of work with the project manager.
- Before gauging, well caps will be removed on each monitoring well to allow groundwater to equilibrate with the atmospheric pressure.
- Gauging will be conducted using an interface probe.
- Before sampling, purging will be performed to remove stagnant water using dedicated, clean, disposable bailers and twine or a variable speed peristaltic pump. Three casing volumes will be purged before sample collection. If wells go dry, they will be allowed to recover until a sufficient sample aliquot is present to collect a sample.
- During purging, dissolved oxygen (DO), oxygen-reduction potential (ORP), pH, temperature, and specific conductivity will be measured using a calibrated water quality meter.
- Samples will be collected in clean sealed containers supplied by Hall Environmental Analysis Laboratory (HEAL), labeled, placed in protective pockets and into coolers packed with ice, entered onto a chain of custody, and delivered to HEAL under direct custody.
- Upon receipt of the laboratory analytical data, EA will prepare and submit a one-page analytical summary with the laboratory report.

2. OBTAIN DISCHARGE PERMIT

Before injection, EA will obtain an Underground Injection Control General Discharge Permit (UIC DP) from the NMED Ground Water Quality Bureau (NMED GWQB). As part of the UCI DP, the following will be completed:

- EA will prepare and submit a UIC DP application to the NMED GWQB on behalf of the NMED PSTB.
- Public notice will be published in the local newspaper.
- A 2' x 3' sign will be posted for 30 days in a location conspicuous to the public at or near the site.
- An 8.5" x 11" notice will be posted in a public library.
- A public notice flyer will be mailed by 1st Class mail to the property owners within 1/3 mile of the site.
- A public notice flyer will be mailed by certified mail to the owner of the site.
- An affidavit of posting of a public notice, a list of names and addresses to whom the public notice was mailed, a list and names and addresses of owners of discharge sites, certified mail receipts, and a copy of the newspaper ad will be submitted to the NMED GWQB.

3. DEVELOP FINAL REMEDIATION PLAN

An FRP will be prepared in accordance with 20.5.119.1923 NMAC. The design and engineering of the FRP will be executed under the supervision of Vener Mustafin, P.E., Professional Engineer registered to practice engineering in the State of New Mexico. The FRP will minimally include the following:

- Goals of remediation and target concentrations.
- A site history summary, which includes current soil and groundwater conditions.
- Site maps identifying roads, buildings, utilities, existing monitoring wells, groundwater contours, dissolved-phase contaminant distribution, and planned injection locations.
- A discussion of the planned injection strategy, including a description of the planned injectate, rationale for the selected injectate, the injection process, target injection depth intervals, and calculations supporting planned injection point spacing and volumes.
- An implementation schedule.
- A discussion of planned observations and monitoring during the injection.
- Copies of required discharge permits and anticipated public and agency notifications.
- Copies of subcontractor/injection contractor's datasheets.
- A health and safety plan.
- Additionally to the contract-defined scope, EA 1) will post FRP public notice onsite and in the local library and 2) EA will mail FRP public notice flyers to the owners of the adjacent properties by certified mail.
- NMED PSTB will publish twice the FRP public notice in the Albuquerque Journal or another local publication.

4. IMPLEMENT FINAL REMEDIATION PLAN

Target Area and Contaminants. The objective of remediation will be to address recalcitrant naphthalene concentrations in the monitoring wells MW-8, MW-9, and VP-5 (Figure 1). The injection will be conducted around these recalcitrant wells. The remediation goal is to decrease total naphthalene concentrations to below 30 µg/L.

Selected Injectate. Regenesis PetroFix™, which is a suspension of 1-2 micron activated carbon with nitrate and sulfate electron acceptors, was selected as a trap-and-treat remediation amendment. PetroFix™ will remove hydrocarbons from the dissolved phase by adsorbing them onto activated carbon particles ("trap"). Thereafter, nitrate and sulfate electron acceptors will stimulate hydrocarbon

biodegradation ("treat"). Nitrate is a fast-acting electron acceptor that will be utilized by bacteria first. This will be followed by the utilization of sulfate. Activated carbon will be self-regenerating as adsorbed contaminants degrade in time. PetroFix™ combines elements of trap-and-treat and in-situ degradation.

Access. EA assumed that NMED PSTB has existing site access as it typically has for other existing State-Lead projects that it will provide to EA.

Dosage. A conservative estimate of up to 10 mg/L TPH-gasoline concentration was used to estimate the dosing of PetroFix™. Using an online Regenesis PetroFix™ calculator and extrapolation to residual site contaminant levels, dosing was estimated to be approximately 800 pounds of PetroFix™. To deliver PetroFix, it will be mixed with water for a mixture volume of approximately 1,200 gallons (Attachment A). Initially, a small batch will be mixed and injected to determine a practical injectable volume. Based on that, the dilution with water will be adjusted to match site conditions.

Utilities and Notifications. Before intrusive activities, a utility locate will be requested and marked by the respective utility entities. At least 96-hours before field activities, NMED PSTB, and site owner will be notified.

Injection Methodology, Spacing, Target Zone, Pressure. Direct push technology will be used to inject the remediation fluids using a top-down application. Concrete surfaces will be cored before advancing direct pushrods. Spacing of 10-foot on-center was selected for borehole placement based on professional judgment (Figure 1). This spacing would result in approximately 9 injection points and is considered sufficient for distribution of injectate in the subsurface and is practical to fit the scope of the small procurement project. Injection points will be placed around the impacted wells. The site is an active gas station with a convenience store, pumping islands, canopy, underground conveyance, underground storage tanks, and utilities; therefore, after locating and marking underground utilities, locations of the injection points may be adjusted based on site conditions. Injectate will be delivered into the saturated impacted zone between 9 and 13 feet below bgs. Pressures will be increased gradually to preclude surfacing. If surfacing occurs, the tool will be advanced deeper and injection attempted again. If that fails, the injection tool will be advanced in another location in the general vicinity. Injections will be moved between locations to dissipate pressure. Dilution factor will be decreased if delivery of estimated volume is not achievable for the site conditions. Mixing and Injection. PetroFix™ and electron acceptors will be mixed with potable water using a mechanical mixer in a mixing vessel. An injection pump equipped with control valves and a pressure gauge will be used to inject fluids through the injection tool. A high-pressure hose will be run from the pump to the top of the drilling rod. Injection volume will be measured using a mixing vessel or a totalizing flow meter. Injection volume, pressure, and times will be recorded on the field forms. Activities will be documented by taking photographs.

Monitoring. During injection, the following monitoring will be performed:

- Proportions of PetroFix™ acceptors and water in each batch will be recorded.
- Groundwater levels in VP-5, MW-8, and MW-9 and surrounding wells will be measured before and during the injection. A bailer may be lowered to evaluate the color of groundwater; black color may indicate the arrival of PetroFix™ into the well.
- Injection interval, pressure, and volume for each borehole/interval will be recorded.

Plugging and Restoration. Upon completion, boreholes will be plugged with bentonite pellets or grout. Surfaces will be restored and material, supplies, and equipment will be removed.

Schedule and Costs. Schedule and costs are provided as Attachment B.

Duration of Remediation. The initial adsorption of contaminants would occur shortly after injection upon contact with contaminated groundwater. Additional adsorption will occur as contaminated groundwater flows through the injected zone. Utilization of nitrate and sulfate for biodegradation is anticipated to occur within a year. As contaminants are degraded, new areas would become available for sorption onto activated carbon. Overall, it is anticipated that concentrations would be decreased to below the standard within the first year.

Plugging and Restoration. Upon completion, injection boreholes will be plugged with bentonite pellets or grout. The surface will be restored to match existing conditions and materials, supplies, and equipment will be removed.

Prepare a Completion Report. Within 30 days after completion of the injection, EA will prepare a report which will include the following:

- A discussion of the injection process;
- A site map showing the injection locations;
- Table(s) of injection depth intervals, pressures, and volumes;
- Field notes; and
- Photographic documentation.

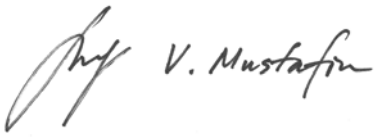
5. PERFORM POST-INJECTION GROUNDWATER MONITORING

The post-injection monitoring will be identical in scope and execution to Task 1.

Please feel free to contact me at (505) 296-1070 or vmustafin@eaest.com if you have questions or comments.

Sincerely,

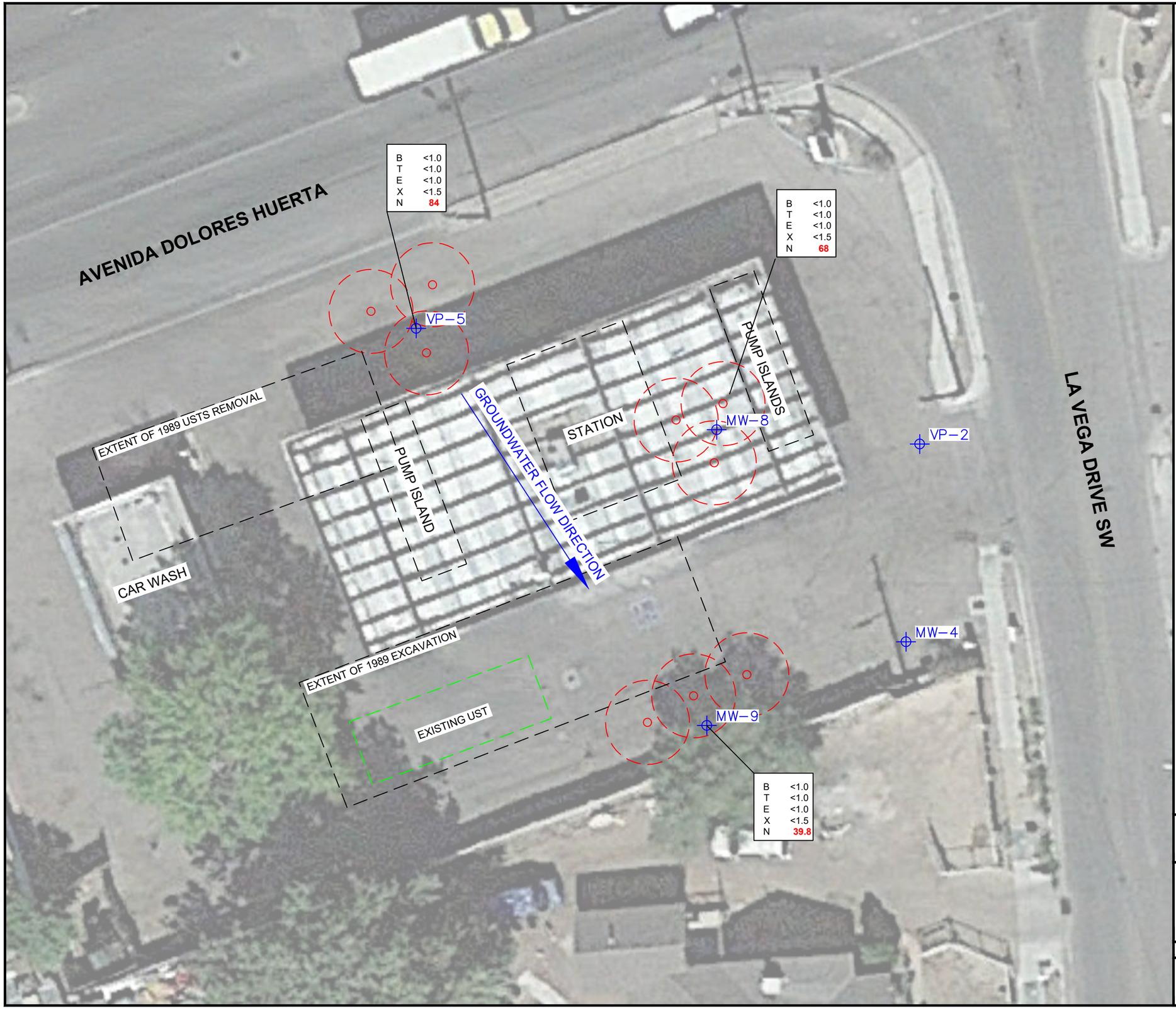
EA Engineering, Science, and Technology, Inc., PBC



Vener Mustafin, P.E.
Project Manager/Engineer

Attachments:	Figure 1 – Site Layout and Proposed Injection Points
Attachment A	Dosage and Mixture
Attachment B	Tasks, Costs, Payment Triggers, and Schedule

FIGURE



LEGEND:

- MONITORING WELL
- PROPOSED BOREHOLE LOCATION WITH ESTIMATED RADIUS OF INFLUENCE
- GROUNDWATER FLOW DIRECTION

B	BENZENE
T	TOLUENE
E	ETHYLBENZENE
X	XYLENES
N	NAPHTHALENES

NOTE: LOCATIONS OF FEATURES ARE APPROXIMATE AND BASED ON WESTERN TECHNOLOGIES AND LEGETTE, BRAHEARS, & GRAHAM INC. FIGURES.

N

20 10 0 20

SCALE IN FEET

BARELAS BRIDGE, 800 BRIDGE BLVD SW, ALBUQUERQE, NEW MEXICO

FIGURE 1
SITE LAYOUT AND PROPOSED INJECTION POINTS

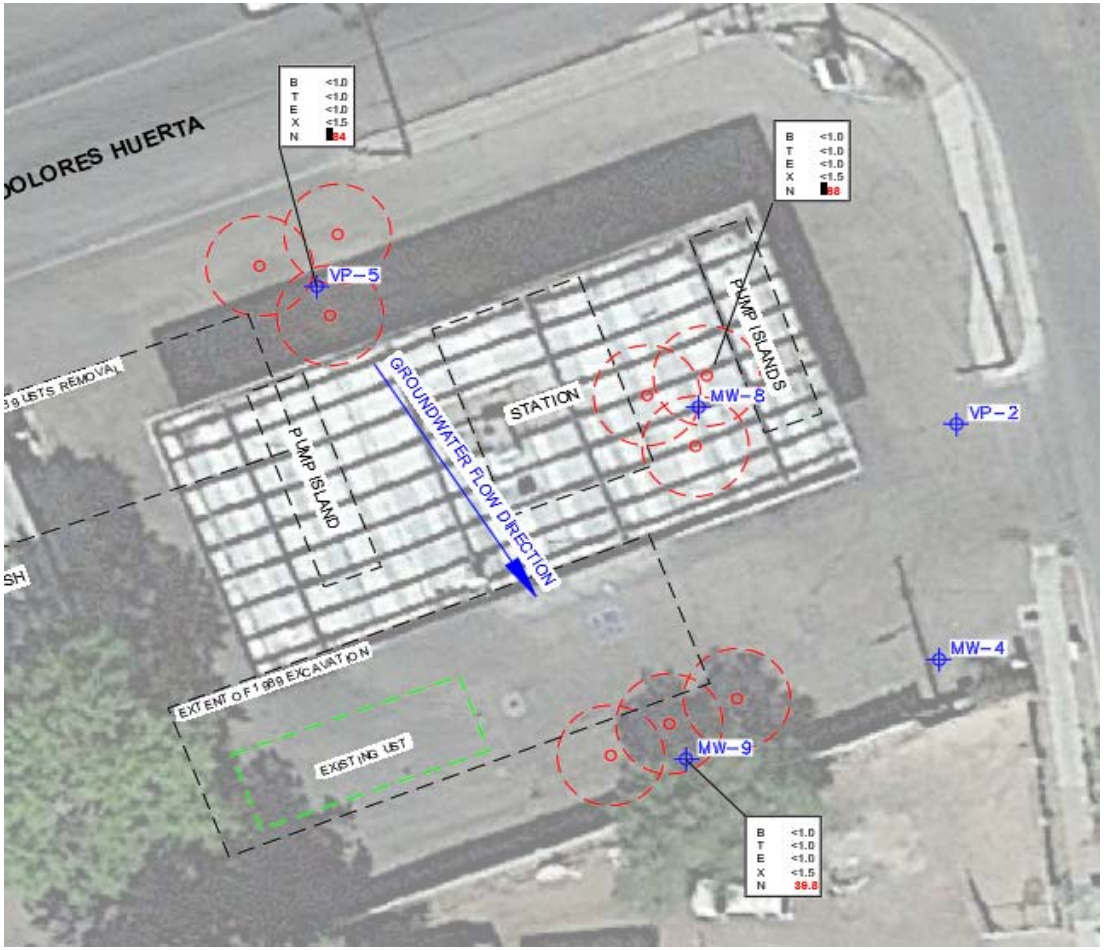
PROJECT #:	PROPOSAL	PROJECT PHASE:	01	PROJECT MANAGER:	VM

320 Gold Avenue, SW Suite 1300
Albuquerque, NM 87102
Phone: (505) 224-9013
EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC. PBC

ATTACHMENT A

CALCULATIONS AND DOSAGE

ATTACHEMENT A - DOSAGE AND MIXTURE
BARELAS BRIDGE, ALBUQUERQUE, NEW MEXICO
EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC. PBC



REVIEW OR ADJUST
Application Details

Injection volume and point spacings are critical to achieving good product coverage. We have provided recommended starting values, but you may edit the fields as needed. Warnings are displayed for concerns with edited values.

MIX TANK VOLUME
275 gal

INJECTION POINT SPACING
10 ft

CAUTION: Injection point spacing is larger than recommended to ensure adequate coverage. Larger injection spacing is possible, but should be field verified. Download application instructions for more detail.

DILUTION FACTOR
9.8

BARELAS BRIDGE
Application Summary

DELIVERY POINTS	**9**
Product Volume	82 Gal
Water Volume	721 Gal
TOTAL VOLUME	**802 Gal**
Inject Volume/Point	89 Gal
Volume Per Vertical ft.	22 Gal
Soil Type	>75% sand/gravel
EFFECTIVE PORE VOL. FILLED	**12%**
Mix Tank Fill Volume	275 Gal
Product to Add	28 Gal
Water to Add	247 Gal
Number of Batches Required	2.92

Barelas Bridge Results

LAST UPDATED: 12.30.21

Reported GW Concentrations (µg/L)	
Benzene	1
Toluene	1
Ethylbenzene	1
Xylenes	1
Trimethylbenzenes	1
Naphthalenes	50
MTBE	5
TPH-GRO	10,000
TPH-DRO	0
Total Groundwater Concentration	10,056

TREATMENT AREA	900 ft^2
TREATMENT THICKNESS	4.0 ft
TREATMENT VOLUME	133 yd^3
SUGGESTED DOSE	6.00 lb/yd^3

TOTAL
Product Required
800 lbs

APPENDIX C – COLLOIDAL ACTIVATED CARBON GROUNDWATER SAMPLING GUIDANCE DOCUMENT

REGENESIS®

Colloidal Activated Carbon (CAC) Groundwater Sampling Guidance Document

Best Practices for Collecting Samples Following CAC Applications

PetroFIX® Remediation Fluid

PLUME STOP® Liquid Activated Carbon


REGENESIS
Joshua

Contents

Introduction

Figure 1 - Image of groundwater with suspended colloidal carbon poured into a bucket. The groundwater appears quite dark but once tested was safe to send to an analytical laboratory for accurate samples.

During injection, PlumeStop® or PetroFix® may flow into nearby monitoring wells, as evidenced by sampling the well and finding the watercolor to be black. This occurrence is not uncommon and is simply the result of the colloidal activated carbon (CAC) of the product transported through the natural flux zones of the aquifer. In most situations, the observance of PlumeStop or PetroFix in monitoring wells, or even in collected soils samples, is desired because this tells us that we are getting proper distribution at a site. At most sites, groundwater treated with PlumeStop or PetroFix will clarify to safe sampling concentrations by the first quarter after injection.

Most sites can be sampled by 3 months post application even if darkened water is present because CAC concentrations have fallen to safe sampling concentrations.

REGENESIS' rule-of-thumb is to sample your site no earlier than 3 months post application.

However, we recognize that some situations may require sampling sooner or at a minority of sites, PlumeStop or PetroFix may stay suspended longer than normal (> 3 months) at concentrations not considered safe for sampling. This document is intended to give our customers a comprehensive evaluation of techniques to help attain good groundwater samples at any phase of the project.

Figure 2 - Image of groundwater samples in a VOA bottle and exactly at 100 mg/L with some visible light coming through. Anything at this concentration or lower is safe to send to an analytical laboratory.

Table 1 and Table 2 (next pages) summarize best practices to prevent PlumeStop or PetroFix from interfering with commercial analytical methods and the specific techniques are described in order in this document.

PetroFix can be safely and accurately sampled at concentrations below 100 mg/L which is still dark. A person can just see through 100 mg/L of colloidal carbon in groundwater when in a 40mL VOA bottle. Very little colloidal carbon is needed to darken the water. DO NOT evaluate the ability to sample with only visual observations of groundwater in large plastic drink containers, buckets, etc. because larger volumes of PetroFix appear darker than in 40mL VOAs.

Always use 40mL VOA bottles to begin the evaluation of sampling appropriateness. Field concentration test kits are available from REGENESIS for PlumeStop projects or shipped with each PetroFix order.

Table 1: Guidance for Sampling <Q1

Category	Time Frame	Technique	Importance
Prevent PlumeStop® or PetroFix® in samples	Prior or during application	Standard well sampling practice[1]	Recommended
		Over purge wells or points during sampling	Recommended
		Rehabilitate and desilt wells if low-flow sampling cannot be used	Recommended
		In situ flocculation, $CaCl_2$ parking around wells	Recommended
		Passive diffusion bags (collect baseline before injection)[2]	Recommended
		Install and develop temporary sentinel piezometer	Optional
Treat PlumeStop® or PetroFix® in samples	After Application	Standard well sampling practice[1]	Recommended
		Over purge wells or points during sampling	Recommended
		Rehabilitate and desilt wells if low-flow sampling cannot be used	Recommended
		In situ flocculation, $CaCl_2$ parking around wells	Recommended
		Wait and sample when colloidal carbon <100 ppm	Optional
		Passive diffusion bags (PDBs)[2]	Optional
		Filter (<0.4 micron)[3]	Optional
		VOA sample clarification with alum[4]	Optional

1. Remove tubing and bailers between events, keep wells watertight, use standard development methods, allow post-purge recovery time, gently lower bailers/meters, and don't allow any sampling equipment to touch the bottom of the well.
2. Take baseline before CAC injection; Not all analytes can be measured with PDBs (see acceptable analytes on page 14)
3. State and analyte-specific – would need to be pre-approved by state and client.
4. Modified lab technique would need to be pre-approved by state and client.

Table 2: Guidance for Sampling >Q1

Category	Time Frame	Technique	Importance
Prevent PlumeStop® or PetroFix® in samples	Prior or during application	Standard well sampling practice[1]	Recommended
		Over purge wells or points during sampling	Recommended
		Rehabilitate and desilt wells if low-flow sampling cannot be used	Recommended
		In situ flocculation, $CaCl_2$ parking around wells	Optional
		Passive diffusion bags (collect baseline before injection)[2]	Optional
		Install and develop temporary sentinel piezometer	Optional
Treat PlumeStop® or PetroFix® in samples	After Application	Standard well sampling practice[1]	Recommended
		Over purge wells or points during sampling	Recommended
		Rehabilitate and desilt wells if low-flow sampling cannot be used	Recommended
		In situ flocculation, $CaCl_2$ parking around wells	Recommended
		Wait and sample when colloidal carbon <100 ppm	Recommended
		Passive diffusion bags (PDBs)[2]	Optional
		Filter (<0.4 micron)[3]	Optional
		VOA sample clarification with alum[4]	Optional

1. Remove tubing and bailers between events, keep wells watertight, use standard development methods, allow post-purge recovery time, gently lower bailers/meters, and don't allow any sampling equipment to touch the bottom of the well.
2. Take baseline before CAC injection; Not all analytes can be measured with PDBs (see acceptable analytes on page 14)
3. State and analyte-specific – would need to be pre-approved by state and client.
4. Modified lab technique would need to be pre-approved by state and client.

Well Housekeeping

Standard Practices

Figure 3 - Image of tubing left in well and coated with PetroFix

At various remediation sites, the age of the wells or poor maintenance practices can affect PlumeStop or PetroFix sampling. One example is the accumulation of settled fines in the bottom that may have colloidal carbon attachment and that churn up or re-suspend in a monitoring well during normal groundwater sampling activities. The resuspension of darkened fines is often mistaken for *in situ* colloidal carbon suspensions. This section is intended to provide remediation practitioners with solutions to overcome sampling issues related to monitoring wells during groundwater sampling.

Good well-keeping practices go a long way in ensuring good samples are collected from monitoring wells. Here is a list of minimum practices that should be observed for every site.

1. Keeping monitoring well plugs (aka, J-Plugs), monitoring well covers, bolts, and gaskets water-tight. Loosely fitting plugs and well covers permit stormwater and sediments to enter the monitoring well.
2. Remove all tubing, bailers, and rope from monitoring wells after each sampling event (i.e., dedicated sampling tubing should not be used since colloidal carbon can coat tubing).
3. Utilize industry-wide well development and purging methods before sampling.
4. After purging, allow wells proper recovery time before sampling. Where there are concerns with colloidal carbon affecting the sampling, we recommend waiting at least 4 hours, but up to 24 hours where necessary, between purging and sampling.
5. Sampling should be performed by gently lowering the bailer into the well.
6. Water level meter probes should be gently lowered into the well.
7. Bailers, tubing, or sampling equipment should not contact the bottom of the well at any time during the sampling process

Over Purging

Figure 4 - Dark water pulled from a well and indicating that over purging or other well rehabilitation may be necessary.

Where colloidal carbon is present near a monitoring well, over purging may help to restore the monitoring well to a representative sampling point. Typically, purging conducted before sampling will remove approximately 1-3 well pore volumes or about 2-5 gallons from a 2" internal diameter (ID) monitoring well. During over purging, 5-10 pore volumes or more are recommended to be removed. Over purging can be completed using a downhole well pump or a bailer. The colloidal carbon in the monitoring well should begin to decline during the purging process. If over purging is effective, purge water may still be relatively turbid; however, the dark carbon color should fade and become gray or translucent.

The purge water in a 5-gallon bucket can be misleading (see Figure 1) and is not recommended to determine effectiveness because turbidity can affect the color. To determine if the over purging is adequate, we recommend looking at occasional samples of the purge water in a clear 40 ml vial or similar clear containers. We recommend waiting at least 24 hours before performing groundwater sampling upon over purging. As a cautionary note, we recommend stopping if the purge water from the well during the over purging process does not appear to become clearer after ten pore volumes. We also recommend stopping if over purging needs to be conducted on more than two events. Alternatively, the well may require rehabilitation, or a Calcium Chloride flush, as discussed in later sections.

Well Rehabilitation

In some cases, standard housekeeping practices and over purging are ineffective because there are more significant problems with the monitoring well itself. Occasionally, fine silts can build up at the base of the well screen and surrounding well pack. These fine silts are often coated with colloidal carbon following a PlumeStop or PetroFix injection, and these particles can cause a persistent problem for groundwater sampling. Being mobilized by the typical well purging and sampling processes, these fine silts can carry contaminants into the monitoring well, otherwise not present in the dissolved phase groundwater remediation with PlumeStop. For the scenario just described, well rehabilitation may be the solution.

Surge blocks, well pumps, and vac-trucks are all equipment options for well rehabilitation. Whether a well pump or vac truck is used is up to the prescriber. The process to rehabilitate a well can take between 1-4 hours, depending upon the severity of the problem and the size of the well. Each of these methods and their effectiveness are discussed below.

A vac truck is ideal where a significant amount of silt and sediment is present on the bottom of a well. Vac trucks can place a stinger tube down the well and rapidly remove the silt and sediment, along with purge water. Vac trucks are limited in subsurface reach and, depending upon barometric conditions, generally struggle to draw water/sediment from deeper than 35 feet.

A downhole well development pump can be used for deeper wells or where a vac truck is not suitable. Not all downhole pumps effectively remove sediments at the base of a well, and the process can damage some. It's best to make sure to know how much sediment might be present at the bottom of the well and select the right pump for the job.

Along with extracting purge water and sediments, surging the well with a surge block is highly recommended because it will enhance the quality of the well rehabilitation. The surging process quickly moves water in and out of the well screen, reordering and recompacting the filter pack. Surge blocks for shallow 2" diameter wells can be easily operated by hand. A well development truck with a lift might be needed for deeper wells or larger diameter wells to work the surge block. It's ideal to alternate the surging process with purging using the development pump or vac truck. Adding clear potable water down the well will also help enhance the well rehabilitation process, especially at sites where the hydraulic conductivity may be low, and the wells don't naturally produce much water.

As described in Over Purging methods, using a clear glass 40 ml vial to view the water quality changes during well rehabilitation is highly recommended. Upon completing the well rehabilitation process, it is advisable to flush the well with a $CaCl_2$ solution (see next section for specific recommendations). The $CaCl_2$ flush will help the residual colloidal carbon flocculate and remain in the aquifer.

In Situ Flocculation for Aquifer Clarification

Some practitioners wish to prevent colloidal suspensions near key wells because they know they want to sample soon after an injection or increase the likelihood that groundwater will be in a safe sampling range at any point post-injection. With extra work, practitioners can "park" PlumeStop or PetroFix colloidal suspensions through chemical flocculation techniques. The primary infield flocculation technique that we recommend is the injection or flooding of Calcium Chloride ($CaCl_2$) **separate from the PetroFix application.** $CaCl_2$ can flocculate and destabilize PlumeStop or PetroFix which results in improved aquifer clarification within a few days to weeks.

Here are usage examples of parking:

- Flood $CaCl_2$ into monitoring wells and a very limited distance from those wells immediately after PetroFix applications to "park" colloidal carbon. This accelerates the clarification of the aquifer near those wells and aids in sampling.
- Inject $CaCl_2$ post-injection into the formation in critical sampling areas or areas where one wishes to minimize the initial flux of PetroFix.

PLEASE NOTE: the use of $CaCl_2$ should only be used post-injection and carefully.

DO NOT CO-MIX or CO-INJECT $CaCl_2$ with PlumeStop or PetroFix and only apply in a separate application.

Site-wide parking of PlumeStop or PetroFix will deleteriously affect the distribution of the product. One should decide if they want to use, or have the option, of using $CaCl_2$ so that it can be included in the Underground Injection Control (UIC) application.

Calcium Chloride ($CaCl_2$) Parking

Health and Safety

Figure 5 - Example of 83% $CaCl_2$ flakes.

$CaCl_2$ is non-toxic and, generally, is safe to use when handled properly. However, $CaCl_2$ can generate enough heat to cause burns and equipment damage when mixed in water at high concentrations. This section is intended to give technical and safety guidance on $CaCl_2$ use as a PlumeStop or PetroFix parking agent. To that end, the following mixing threshold is established, which will alleviate most safety concerns.

- **$CaCl_2$ should never be mixed at a concentration above 1 lb $CaCl_2$/ gal water.**
- **$CaCl_2$ should always be added to the total volume of water to minimize heat generation and ensure higher concentrations are not created.**
- **Please read and follow all material handling and safety instructions on supplier packaging**.

Calcium Chloride Mixing

Standard Calcium Chloride Solution:

- 0.5 lb $CaCl_2$/gallon of water equivalent to 150 lb per 300-gallon mix tank.
- The purity of the calcium chloride should be 85% or higher.
- Calcium chloride flakes are recommended over pellets because they will dissolve faster.
- The volume of calcium chloride solution to be injected should be equivalent to 4 saturated well volumes.

Recommended Procedure for Applying Calcium Chloride Well Flush

Figure 6 - Client performing a well flush.

1. Calculate the saturated well volume:

   $V = \pi r^2$ saturated length where "r" is the radius of the borehole.

2. Multiply this volume by 4. Four well volumes will provide a good flush of the surrounding aquifer material.
3. Use a 55-gallon drum or supplementary poly tank if available and fill it with the requisite volume.
4. Slowly add the $CaCl_2$ amount calculated above and mix with a drill mixer. Mix until all $CaCl_2$ is dissolved.
5. Secure expansion plug with bypass (see table and links below) to well and attach hosing and pump. Expansion plugs with bypass are the simplest way to pump with pressure into wells of various sizes.
6. Make sure hosing and fittings match and are rated for appropriate psi tolerance. Rating should be greater than the max PSI of the pump.
7. Pump recommendations: pool pump, trash pump, air diaphragm pump, Hydracell, Moyno.
8. See expansion plug information and links below.
9. Pump the required amount of $CaCl_2$ mixture into the well.

REGENESIS recommends flushing the well at 3-5 gallons per minute or higher without going above a pressure equivalent to 1 psi per foot of well depth.

Expansion Plugs with Bypass

C

Use the bypass tube on these plugs to add air, water, and other fluid to your pipeline or to relieve pressure while testing. Maximum air back pressure is the amount of pressure a plug can withstand without moving. Maximum water back pressure refers to the pressure resulting from the height of the water above the plug.

For Pipe		Max. Back Pressure				Material		Bypass				
Size	ID	Air, psi	Water, ft. of head	O'all Ht.	Temp. Range, °F	Seal	Bypass Cap	Pipe Size	Thread Type	Gender		Each
Style C Iron Stem												
1/2	0.47"-0.50"	Not Rated	46	4 1/4"	30° to 150°	Natural Rubber	Metal	1/16	NPT	Male	2644K15	$18.37
3/4	0.72"-0.75"	Not Rated	46	5 1/8"	30° to 150°	Natural Rubber	Metal	1/8	NPT	Male	2644K16	21.13
1	0.97"-1.00"	Not Rated	46	5"	30° to 150°	Natural Rubber	Metal	1/4	NPT	Male	2644K18	22.70
2	1.75"-2.00"	Not Rated	34	10 3/8"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K21	18.37
3	2.75"-3.00"	Not Rated	34	10 1/2"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K22	23.87
4	3.63"-4.00"	Not Rated	23	10 1/8"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K23	27.60
5	4.50"-5.00"	Not Rated	23	12 5/8"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K24	57.74
6	5.50"-6.00"	Not Rated	23	12 1/2"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K25	40.69
8	7.50"-8.00"	Not Rated	4	14 3/4"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K26	91.31
10	9.50"-10.00"	Not Rated	4	14 7/8"	30° to 150°	Natural Rubber	Metal	1/2	NPT	Male	2644K31	132.05
12	11.50"-12.00"	Not Rated	4	14 5/8"	30° to 150°	Natural Rubber	Metal	1	NPT	Male	2644K32	232.86

Expansion plug link: https://www.mcmaster.com/expansion-plugs-with-bypass/expansion-plugs-with-bypass/
Adapter link: https://www.mcmaster.com/pipe-fittings/thick-wall-plastic-pipe-fittings-for-water/

Passive Diffusion Bags

Figure 7 – Example passive diffusion sampler.

Passive diffusion bag (PDB) samplers can sample groundwater where PlumeStop or PetroFix is present because it cannot diffuse through these bags, so the groundwater collected will be free of PlumeStop or PetroFix.

The significant advantage of PDBs is the confidence that you can sample groundwater for VOCs at any time post-injection based on your desired sampling time frames and without interference from any suspended PlumeStop or PetroFix. Furthermore, according to the Interstate Technology Regulatory Council (ITRC), PDB sampling is cost-effective and a viable alternative to standard or low-flow purge and sample techniques for collecting volatile organic compound (VOC) data at monitoring wells. PDB samplers, typically low-density polyethylene bags filled with water, have been shown in multiple studies to provide accurate groundwater VOC measurements.

PDBs come in 1-to-4-foot lengths and are filled with clean water and hung into a well for a minimum of two weeks. PBD sampling is achieved as VOCs in groundwater diffuse through the wall of the bag and into the bag water, which eventually comes to equilibrium with the surrounding well water.

Figure 8 - Sample pulled from a PDB bag and free of suspended carbon.

PDB Implementation Tips

- **Take Baseline PDB samples before injection.** State regulatory agencies might ask you to compare PDB's to standard groundwater samples (i.e., low-flow sampling or bailing) to prove that they correlate. With this in mind, **we recommend you take baseline samples alongside PDB samples before any PlumeStop or PetroFix application, where time-critical monitoring will begin shortly afterward.**
- **Hang PDBs from the same vertical interval that you have historically sampled from.** To get accurate groundwater VOC values compared to past or present results, it is critical to hang a PDB from the same vertical sampling interval in a monitoring well used from other sampling efforts. This is because groundwater contamination can stratify in an aquifer, and a plume may have different vertical groundwater concentrations intersecting a monitoring well screen. Those differences can be detected by PDBs hanging in a well. This phenomenon also is true for standard low-flow sampling. For example, at a hydrocarbon site, it is common for higher groundwater concentrations to be present in the aquifer near the surface of the aquifer where the smear zone resides versus at the bottom of a well where it is not likely present. However, multiple studies show that when PDBs are hung in the same zone that you usually collect standard or low-flow purge samples, they will correlate and provide accurate VOC concentrations.

PDB Analyte Limitations

Please note that PDBs are unsuitable for monitoring certain organic compounds (MTBE, TBA) or ionic species (nitrate, sulfate). They are currently only effective for early VOC measurements and not the entire suite of parameters you may use need to sample. Non-VOC parameters may need to be measured using standard sampling techniques after the PlumeStop or PetroFix suspension has mostly been clarified from groundwater. We recommend you become familiar with available resources on PDBs (the first ITRC FAQ listed left) and guidelines from the suppliers of PDBs.

Here are some helpful links:

PDB References

- ITRC FAQ On PDBs And List Of VOC's Showing Good Sample Correlation: https://www.itrcweb.org/Documents/PDBFAQs2.pdf
- Users Guide for Polyethylene-Based PDBs: https://www.itrcweb.org/GuidanceDocuments/DSP-1a.pdf
- USEPA Clu-In.org Guidance On Diffusion Samplers: https://clu-in.org/characterization/technologies/default.focus/sec/Passive(nopurge)Samplers/cat/DiffusionSamplers/

PDB Suppliers

- ALS: https://www.alsglobal.com/en-us/services-and-products/environmental/sampling/passive-diffusion-bags-pdbs
- EON Products Incorporated: https://store.eonpro.com/store/c/71-Water-Sampling-Pumping.aspx

Compounds Showing Good Correlation in Laboratory Tests

(Average differences in concentration of 11 percent or less between diffusion sampler water and test vessel water)

Benzene	1,3-Dichlorobenzene	Napthalene
Bromodichloromethane	1,4-Dichlorobenzene	1,1,2,2-Tetrachloroethane
Bromoform	Dichlorodifluoromethane	Tetrachloroethene
Chlorobenzen	1,2-Dichloroethane	Toluene
Carbon tetrachloride	1,1-Dichloroethene	1,1,1-Trichloroethane
Chloroethane	*cis*-1,2-Dichloroethene	1,1,2-Trichloroethane
Chloroform	*trans*-1,2-Dichloroethene	Trichloroethene
Chloromethane	1,2-Dichloropropane	Trichlorofluoromethane
2-Chlorovinyl ether	cis-Dichloropropene	1,2,3-Trichloropropane
Dibromochloromethane	Dibromochloromethane	Vinyl chloride
Dibromomethane	*trans*-1,3-dichloropropene	Total xylenes
1,2-Dichlorobenzene	Ethyl benzene	

Compounds Showing Poor Correlation in Laboratory Tests

(average differences in concentration greater than 20 percent between diffusion sampler water and test vessel water)

Acetone*	Methyl-*tert*-butyl ether	MIBK*	Styrene

Source: Compounds tested under laboratory conditions for use with passive diffusion bag samplers (Vroblesky and Campbell, 2001).

*T.M. Sivavec and S. S. Baghel, 2000, General Electric Company, written communication.

Table 3 - ITRC FAQ document on passive diffusion bags analytes showing good correlation with PDBs

Install and Develop Sentinel Piezometers

Sentinel piezometers can be installed to detect the spread of PlumeStop or PetroFix before reaching a monitoring well or another sensitive receptor. By performing real-time observations of the sentinel well, the remediation practitioner should have sufficient time for a response to be implemented during the injection to maximize or minimize the appearance of PlumeStop or PetroFix at that well or receptor. The main reasons for using sentinel wells are to fine-tune PlumeStop or PetroFix dilutions to achieve proper ROI when there are not enough nearby monitoring wells for the same observations, to detect that lateral or vertical spread to unwanted zones or receptors, and finally, in some circumstances to aid in the minimization of PlumeStop or PetroFix in nearby wells to aid in early sampling.

The location of the piezometer is determined based on the existing grid or barrier injection layout, the groundwater flow direction and the groundwater flow velocity, and the need for the sentinel well. If sentinel piezometers are installed, we recommend that multiple units be installed to measure spread at different locations. For example, multiple piezometers can help document sufficient distribution at the site while also helping to minimize spread at other sensitive areas.

Sentinel Wells to Monitor Distribution

If sentinel wells are used within a grid to manage and monitor the spread of PlumeStop or PetroFix, we recommend placing them equidistant within the grid and where monitoring well coverage is insufficient. While injections are being performed, these piezometers should be monitored for PlumeStop or PetroFix. Ideally, CAC concentrations of several hundred to several thousand mg/L should be observed if distribution and injection overlap is achieved. If such concentrations are not observed during the injection, the remediation practitioners should re-evaluate injection volumes (by increasing injection dilutions), boost pressure, re-evaluate injection tooling used, adjust the spacing, or a combination of all. More on this subject is discussed in the direct push application instructions for PetroFix www.petrofix.com/resources

Sentinel Wells to Minimize Distribution to a Critical Receptor

The remediation practitioner may seek to minimize suspended carbon's impact at a critical well or receptor. In the case of the monitoring well, groundwater results may be needed relatively soon after injection and it is essential to minimize the concentration of CAC flowing through and around that monitoring well. As a cautionary note, minimizing the spread of PlumeStop or PetroFix by using sentinel wells may interfere with the performance by limiting the beneficial spread of CAC at densities that would offer better performance. Please use sentinel wells and concentration adjustments judiciously.

We recommend that sentinel wells be placed 1 to 2 feet directly between injection points and the monitoring well where you want to minimize impact, or at least 5 feet from a critical receptor (i.e., water body). By monitoring real-time, the pumping of CAC can be stopped or slowed once the sentinel piezometers show detections of materials. We feel that it is appropriate to allow the sentinel piezometer to reach concentrations of up to a few hundred mg/L, which would attenuate in concentration to the nearby well or receptor.

Sentinel wells can be effectively used with $CaCl_2$ parking efforts by verifying parking zones.

Wait and Sample When CAC <100 PPM

Figure 9 - Client periodically sampled wells and used field concentration test kit (next section) to evaluate when sampling was safe. In this case, groundwater sampling was delayed.

If a well is impacted, the best solution is to delay sampling and analysis until PlumeStop or PetroFix has had more time to deposit onto the soil, resulting in clarified groundwater samples. **Two to three months is enough at many sites, although it can take longer at some sites.** The time to equilibrate in the subsurface is correlated with soil clay and silt content. Generally, increased clay and silt content will decrease the time for PlumeStop or PetroFix to sorb and equilibrate. Divalent cations (ex. calcium or magnesium) in groundwater also speed up the clarification process.

If PlumeStop or PetroFix is observed in a groundwater well during the application, the well can be flushed with clear water (i.e., no reagent). The "PetroFix Well Flushing" Technical Bulletin provides more information on clear water well flushing. If sampling at least four weeks post-PlumeStop or PetroFix application, extended low flow purging of the monitoring well may improve the water clarity.

As a rule of thumb, if a sample is placed in a 40-mL VOA vial and you can see through the vial, it is probably safe to sample. The inability to effectively see through a vial is approximately 100 mg/L of PlumeStop or PetroFix (see the following figure of various PlumeStop or PetroFix concentrations for reference).

If you are interested in independent research on showing when suspended carbon from PlumeStop or PetroFix interferes with laboratory samples, please view the webinar entitled "*Remediation of Chlorinated Solvents in Groundwater with PlumeStop: Analytical Challenges and Solutions*" which was given by Heather Lord, Ph.D., who at the time was the Environmental Research and Development Manager for Maxxam Labs (now Bureau Veritas Labs). At roughly 15 minutes, Heather begins discussing the ranges where PlumeStop (or PetroFix) does not cause significant lab interference (around 100 mg/L) and positive results from passive diffusion bag samplers.

Unfortunately, no commercial laboratory prep procedures can easily remove PlumeStop or PetroFix from samples before analysis without deviating from standard methods. Filtering the 1 to 2-micrometer diameter particles from suspension is possible (see later section), although difficult and not always an accepted approach by every regulatory agency.

While centrifuging is possible, commercial labs typically do not have the necessary centrifuges to separate PlumeStop or PetroFix effectively.

If you need further technical assistance addressing the interference of PlumeStop or PetroFix when sampling, please get in touch with REGENESIS at info@REGENESIS.com or info@petrofix.com.

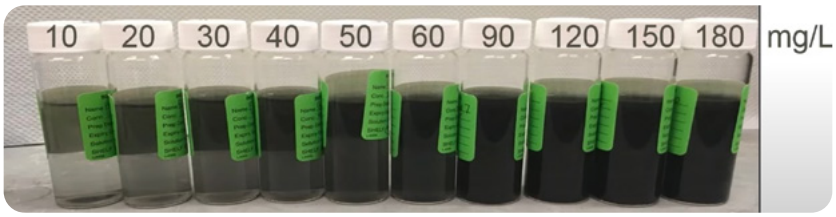


Figure 10 - PlumeStop or PetroFix concentrations in 40 mL VOA vials. If a vial can be seen through (~<100 mg/L), sending the sample to the lab is safe.

CAC Field Concentration Test Kit

Kit Contents:

- 50 mg C/L standard
- Tall test vial
- Small dosing syringe
- Large dilution syringe

NOTE: you will need a source of clean water. Tap or bottled drinking water is acceptable.

REGENESIS does provide simple in-field PlumeStop or PetroFix testing kits to semi-quantitatively determine the activated carbon concentration in groundwater samples following the injection of PlumeStop or PetroFix. The kit is meant to aid in deciding if a well requires flushing, judging the influence of an injection event, and following the change in suspended carbon well over time. Using the kit as described below will resolve activated carbon concentrations of 0-5000 mg C/L.

All PetroFix shipments come with one (1) field concentration test kit taped to the top of a drum or tote in the shipment. For PlumeStop projects which are injected turnkey by REGENESIS, the field crews will have available kits. The instructions in the kit explain how to dilute the sample and how to calculate CAC concentrations. Please contact REGENESIS at info@REGENESIS.com or 949-366-8000 if you need to replace a test kit.

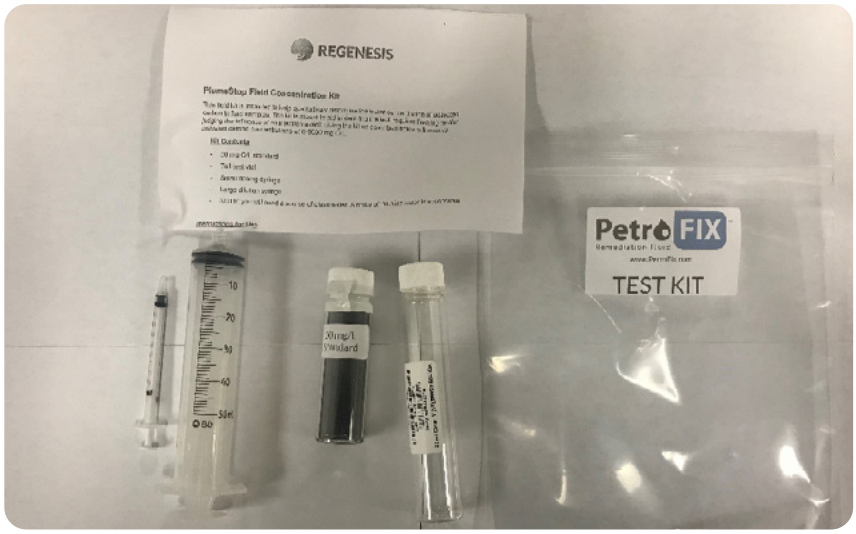


Figure 11 – Image of a field concentration test kit.

Filtering PlumeStop or PetroFix From Samples

In some instances, filtration as a step to remove low levels of CAC may be considered. Of the various methods available to remove CAC from water samples, filtration is the least recommended and most likely to receive pushback from regulators. Filtration is difficult because the filters rapidly become clogged by the CAC at higher concentrations, 300 mg/L or above. This filter cake build-up can also bias low concentration aqueous analytical results because of the high CAC layer that filtered water must travel through as it reaches the filter membrane. Additional issues with filtration include sorption of target analytes to the filter membrane and potential volatilization of lighter organic compounds such as BTEX.

Notes on best practices when filtering:

- Only attempt filtration to remove low levels of CAC (approximately 300 mg/L or lower)
- To avoid sorption of analytes to the filter, use glass fiber filter membranes (GFF) or other polar, low-affinity type materials.
- Minimize the headspace on both sides of a filtration setup. Volatilization of many VOCs is rapid and will bias the results

If filtration is being considered, it is strongly recommended to first consult with the regulating agency receiving the data to decide if the proposed sampling method will be acceptable.

In VOA Sample Clarification With Alum

A final option to obtain groundwater samples if additional fieldwork, waiting, or other methods are not desired or otherwise not successful, then groundwater samples can be safely sampled when treated with a powerful flocculant known as aluminum sulfate (alum). Field treatment of VOA samples with alum will remove CAC from the water matrix within hours while maintaining the integrity of any desired analysis. As stated throughout this document the presence of CAC above approximately 100 mg/L can have a negative impact on the methods and instruments used to quantify volatile organic compounds (VOCs) in water by standard methods like EPA 8260. This method is compatible with analytical methods used to measure VOCs, cVOCs, TPH-G and TPH-D.

Note, given this new approach clients or regulators may have questions about adding alum to samples and the potential to affect results. REGENESIS has confirmed with our own labs and through independent, outside lab testing that the use of alum does not bias results. Additional information on the subject can be found in a separate technical bulletin at www.REGENESIS.com or www.PetroFix.com website and doing a keyword search for **"CAC Alum Flocculation Method Validation"** which will identify the latest copy of this document which we anticipate may be updated in the future.

Alum Approach

For standard volatile organic carbon analysis by EPA 8260, this is achievable by adding a small amount (approx. 1 g/L) of alum (potassium aluminum sulfate, a food additive) to the sample at the time of collection. The addition of alum will promote the flocculation and settling of the suspended CAC, thus clarifying the sample, and allowing a clear aliquot to be taken for workup and analysis by the standard purge and trap method commonly performed as a part of EPA 8260. Because the carbon and water have reached equilibrium by the time of collection, there is slight to no bias between the before and after contaminant groundwater concentration following removal of the suspended CAC from the sample. Alum is commonly used in municipal water supplies to reduce turbidity before distribution in public water utilities.

Alum Settling Agent Kit

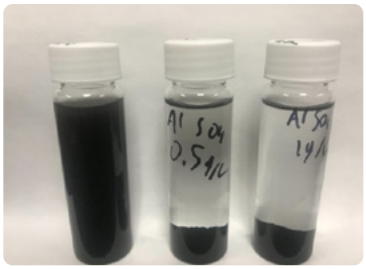


Figure 12 - Before and after alum treatment of suspended CAC in VOA vials.

Settling Agent Dosing Guide

Sample Volume	40 mL
Settling agent	40 mg
Settling agent	2 scoops

Alum kits are provided by request and are used for settling suspended colloidal activated carbon (CAC) in 40mL VOA vials so that the remaining clear solution (supernatant) can be analyzed for contaminants by instrumental methods. Once the settling agent is added to the sample of black water, the carbon will begin to settle rapidly and be ready for analysis in roughly an hour. This method is appropriate for water samples containing around 5000 mg/L of CAC or less.

The lab receiving an alum-treated sample must allow the vials to stand undisturbed after receipt until the CAC has settled by an acceptable amount. If vials are set aside immediately after receipt by the lab, there will be adequate time for settling to occur within the method hold time. The lab requires no other special action.

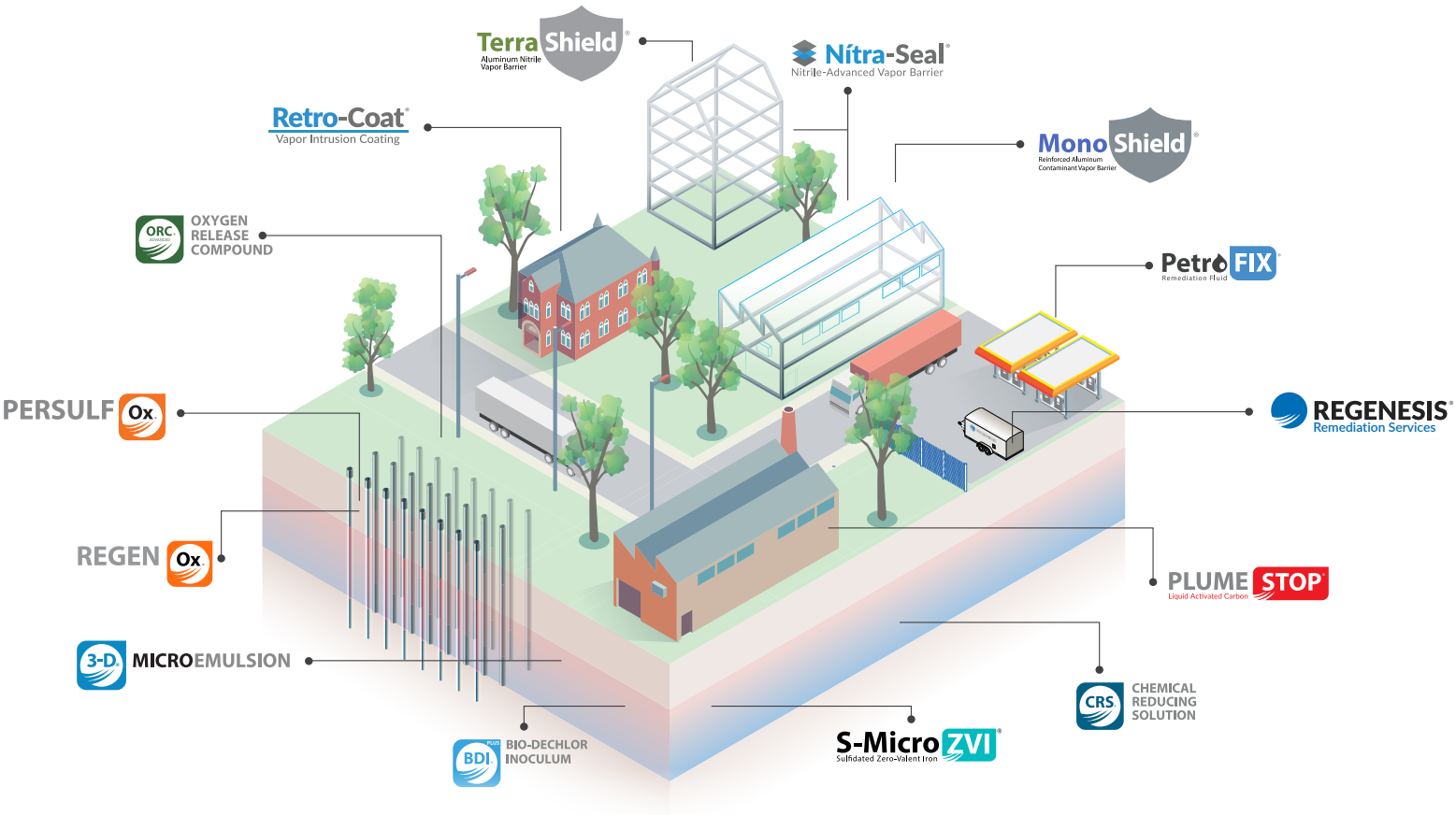
Kits can be obtained by emailing info@REGENESIS.com or info@petrofix.com and referencing your project. Alum can be sourced separately as well and applied per the kit directions below.

Contents:

- 1x Vial of 10 g settling agent (aluminum sulfate hydrate, alum)
- Dosing spoon to deliver 20-40 mg of alum

Procedure:

1. Obtain 40 mL of water to be tested in a 40 mL VOA vial.
2. Deposit 2 scoops of the settling agent into the vial.
3. Shake the vial for 30 seconds.
4. Allow at least 1 hour for carbon to completely settle before testing clear water



About REGENESIS

At REGENESIS we value innovation, technology, expertise and people which together form the unique framework we operate in as an organization. We see innovation and technology as inseparably linked with one being born out of the other.

Inherently, innovation imparts new and better ways of thinking and doing. For us this means delivering expert environmental solutions in the form of the most advanced and effective technologies and services available today.

We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems there is a high potential for success including savings in time, resources and cost.

At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking time to understand the people we work with and their circumstances. We believe this is a key factor in achieving successful project outcomes.

We believe that by acting under this set of values, we can work with our customers to achieve a cleaner, healthier, and more prosperous world.

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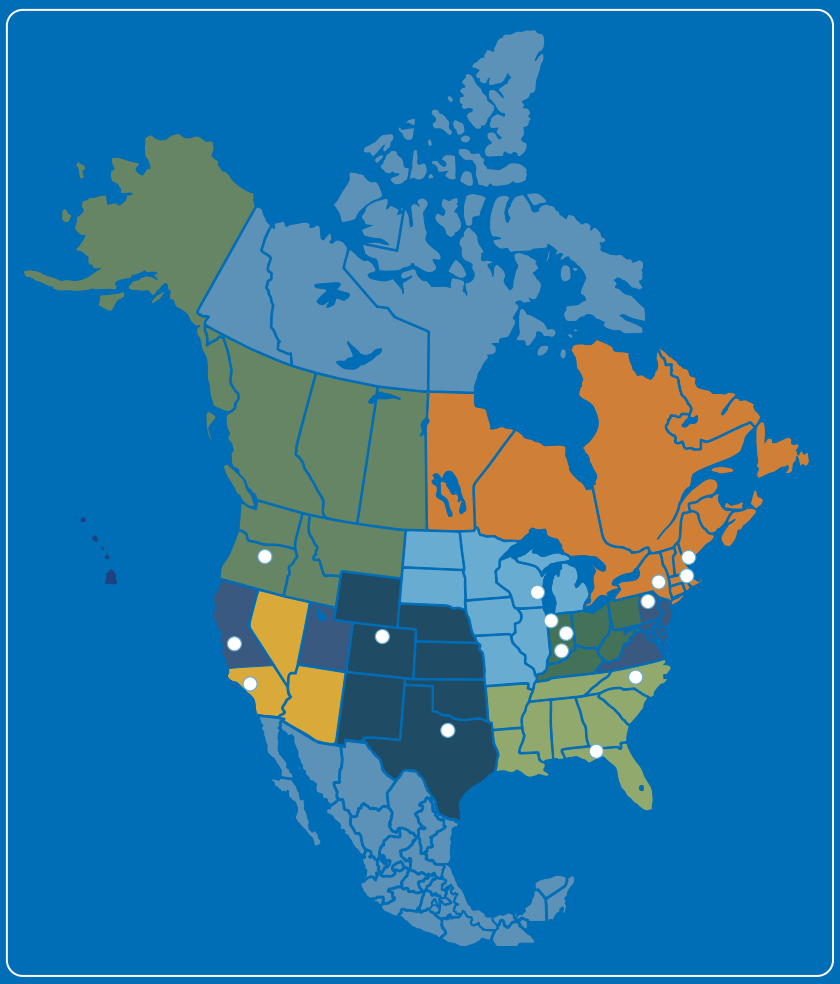

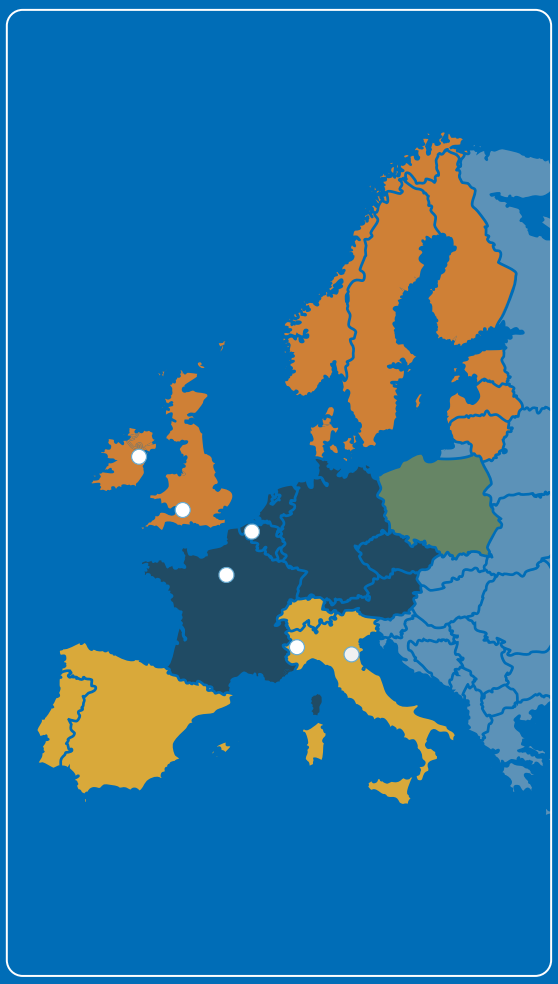

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APPENDIX D – PHOTOGRAPHS

GeoProbe® 7720DT Rig Used to Inject PetroFix®

Direct Push Rods

Top-Down Rectractable Injection Tool

Top-Down Non-Retractable Injection Tool

Support Truck and Trailer

PetroFix® Mixing Vessel

Water Holding Tank

Injection Pump, Pressure Gauge, and Shut-Off Valve

Totalizing Flowmeter

PetroFix® Drums

MW-8 Area

MW-9 Area

VP-5 Area

Borehole Patched with Asphalt

APPENDIX D – FIELD RECORDS

Barela's Bridge, 800 Bridge Boulevard, SW, Albuquerque, NM

Contractor (company): Enviro Drill

Contractor Personnel: Ryan, Rigo

List of Contractor Equipment:

Before starting, take photos of pre-existing conditions of the site

Take photos of each piece of equipment, instrumentation, materials, overall setup and anything of importance

Drill Rig (manufacturer, model) Geo Probe 7720 DT

Rods (diameter, run length) 1" 5'

Injection Tool (diameter, length, injection interval length) 1" diameter, ~~2~~ 1', 1' interval (4x4)

Support Truck (manufacturer, model) Chevy 3500

Injection Pump (manufacturer, model) grout Pump

Mixer (volume, type) 30 grout mixer

Water Tank (volume, type) Poly 500 gal Snyder

PetroFix (volume, concentration) 2 55 gal Drums Activated Carbon, > 30%

Electron Acceptor (volume, composition) 2 2040 Bags Sodium Nitrate/Ammonium Sulfate

Water Source Spigot in yard

Bentonite (type, mass, volume, container) ~~D~~ Quick Grout

Flowmeter (type, manufacturer, model, location) badger meter, on hose from mixer.

Pressure (type, scale, resolution, location) Bar, PSI, 0-300

Sorbent (type, volume, mass) white rags

VR-5

INJECTION FORM
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW, ALBUQUERQUE, NEW MEXICO

Date and Time:	9-23-2022 0845
EA Personnel:	D. OBrien
Subcontractor Personnel and Equipment:	Enviro drill Ryan, Rigo, chris Geoprobe
Project Manager/PE: Vener Mustafin	505-296-1070 vmustafin@eaest.com

6381201

Batch Mix Recipe

Volume of PetroFix, gallons	2.1
Mass of Amendments, pounds	1
Volume of Water, gal	27.9

Injection

Borehole ID	Time - Start/End	Interval, ft bgs	Pressure, psi	Injected Volume, gal	Flow	Notes
2	0916	8-9	75	26.7	6 gpm	
2	0919	9-10	60	26.7	6 gpm	
2	0933	10-11	50	26.7	6 gpm	
2	0952	11-12	50	26.7	6 gpm	
2	1008	12-13	50	26.7	6 gpm	
1	1051	8-9	60	26.7	6 gpm	
1	1109	9-10	60	26.7	6 gpm	
1	1125	10-11	60	26.7	6 gpm	
1	1138	11-12	60	26.7	6 gpm	
1	1146	12-13	60	26.7	6 gpm	
3	1333	8-9	100	26.7	6 gpm	
3	1339	9-10	75	26.7	6 gpm	
3	1347	10-11	60	26.7	6 gpm	
3	1353	11-12	60	26.7	6 gpm	
3	1401	12-13	60	26.7	6 gpm	

Notes: DTW: well vault is filled with water - Before Drilling

mw-8

INJECTION FORM
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW, ALBUQUERQUE, NEW MEXICO

Date and Time:	9-22-2017 1111	6381201
EA Personnel:	D. OBrien	
Subcontractor Personnel and Equipment:	Enviro Drill Ryan, Rizo, Chris Geoprobe	
Project Manager/PE: Vener Mustafin		505-296-1070 vmustafin@eaest.com

Batch Mix Recipe

Volume of PetroFix, gallons	2.1
Mass of Amendments, pounds	1
Volume of Water, gal	27.9

Injection

Borehole ID	Time - Start/End	Interval, ft bgs	Pressure, psi	Injected Volume, gal	flow	Notes
6	1139	9-10	220	33.3	6 gpm	
6	1147	10-11	150	33.3	6 gpm	
6	1155	11-12	150	33.3	6 gpm	
6	1206	12-13	150	33.3	6 gpm	
5	1356	9-10	200	33.3	6 gpm	
5	1355	10-11	150	33.3	6 gpm	
5	1404	11-12	150	33.3	6 gpm	
5	1416	12-13	150	33.3	6 gpm	
4	1502	9-10	100	33.3	6 gpm	
4	1510	10-11	75	33.3	6 gpm	
4	1519	11-12	75	33.3	6 gpm	
4	1527	12-13	75	33.3	6 gpm	

Notes: inital DTW 9.14
Formal DTW 9.23

INJECTION FORM
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW, ALBUQUERQUE, NEW MEXICO

Date and Time:	9-22-2022 0843
EA Personnel:	D. O'Brien
Subcontractor Personnel and Equipment:	Enviro drill Ryan, Rigo Geo probe
Project Manager/PE: Vener Mustafin	505-296-1070 vmustafin@eaest.com

6381201

Batch Mix Recipe

Volume of PetroFix, gallons	4.1
Mass of Amendments, pounds	1.0
Volume of Water, gal	25.9

Injection

Borehole ID	Time - Start/End	Interval, ft bgs	Pressure, psi	Injected Volume, gal	flow	Notes
7	0942	9-10	50	10	6 gpm	
7	0945	10-11	50	10	6 gpm	
7	0949	11-12	50	10	6 gpm	
7	0952	12-13	50	10	6 gpm	
7	0956	13-14	50	0	6 gpm	Unable to inject - clay loam
7	0959	14-15	50	0	6 gpm	Unable to inject - clay loam
7	1001	15-16	50	30	6 gpm	
7	1005	16-17	50	10	6 gpm	
7	1007	17-18	50	10	6 gpm	
7	1011	18-19	50	10	6 gpm	

Notes: DTW: Unable to access well - stuck closed, even hammer would not open

INJECTION FORM
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW, ALBUQUERQUE, NEW MEXICO

Date and Time:	9-21-2023 14 55
EA Personnel:	D. O Brien
Subcontractor Personnel and Equipment:	Enviro drill Ryan Rig 8 Geo probe
Project Manager/PE: Vener Mustafin	505-296-1070 vmustafin@eaest.com

6381201

Batch Mix Recipe

Volume of PetroFix, gallons	4.1
Mass of Amendments, pounds	1.0
Volume of Water, gal	25.9

Injection

Borehole ID	Time - Start/End	Interval, ft bgs	Pressure, psi	Injected Volume, gal	flow	Notes
8	1518	9-10	100	10	4 gpm	
8	1520	10-11	80	10	4 gpm	
8	1523	11-12	50	10	4 gpm	
8	1526	12-13	50	10	4 gpm	
8	1528	13-14	50	10	4 gpm	
8	1536	14-15	50	10	4 gpm	
8	1542	15-16	50	10	4 gpm	
8	1544	16-17	50	10	4 gpm	
8	1546	17-18	90	10	4 gpm	
8	1551	18-19	50	10	4 gpm	

Notes:

INJECTION FORM
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW, ALBUQUERQUE, NEW MEXICO

Date and Time:	9-21-2022	1356	6381201
EA Personnel:	D O'Brien		
Subcontractor Personnel and Equipment:	Enviro Drill	Ryan Rigo	
Project Manager/PE: Vener Mustafin			505-296-1070 vmustafin@eaest.com

Batch Mix Recipe

Volume of PetroFix, gallons	4.1
Mass of Amendments, pounds	1.0
Volume of Water, gal	29.9

Injection

Borehole ID	Time - Start/End	Interval, ft bgs	Pressure, psi	Injected Volume, gal	flow	Notes
9	1404	9-10	50	10	6 gpm	
9	1410	10-11	120	0	0	could not inject - clay ~~to soil test~~
9	1412	11-12	120	0	0	↓
9	1414	12-13	90	30	6 gpm	injection successful again
9	1420	13-14	80	10	6 gpm	
9	1428	14-15	60	10	6 gpm	
9	1431	15-16	60	10	6 gpm	
9	1433	16-17	60	10	6 gpm	
9	1437	17-18	50	10	6 gpm	
9	1440	18-19	50	10	6 gpm	

Notes:

INJECTION FORM
BARELA'S BRIDGE, 800 BRIDGE BLVD., SW, ALBUQUERQUE, NEW MEXICO

Date and Time:	9-21-2022 1158
EA Personnel:	D. O'Brien
Subcontractor Personnel and Equipment:	Enviro Drill Ryan, Ryno GeoProbe
Project Manager/PE: Vener Mustafin	505-296-1070 vmustafin@eaest.com

6381201

Batch Mix Recipe

Volume of PetroFix, gallons	4.1
Mass of Amendments, pounds	1
Volume of Water, gal	29.9

Injection

Borehole ID	Time - Start/End	Interval, ft bgs	Pressure, psi	Injected Volume, gal		Notes
10	1231	9-10	60	10	8 spm	
10	1237	10-11	50	10	8 spm	
10	1244	11-12	50	10	6 spm	
10	1249	12-13	50	10	6 spm	
10	1251	13-14	50	10	6 spm	
10	1306	14-15	50	10	6 spm	
10	1309	15-16	50	10	6 spm	
10	1324	17-18	50	20	6 spm	Previous intervals slough'd to surface
10	1327	18-19	50	10	6 spm	

Notes: