



**New Jersey Department of Environmental Protection**  
**Site Remediation Program**

**Report Certifications for RCRA GPRA 2020, CERCLA, and Federal Facility Sites**

These certifications are to be used for reports submitted for RCRA GPRA 2020, CERCLA, and Federal Facility Sites. The Department has developed guidance for report certifications for RCRA GPRA 2020, CERCLA, and Federal Facility Sites under traditional oversight. The "Person Responsible for Conducting the Remediation Information and Certification" is required to be submitted with each report. For those sites that are required or opt to use a Licensed Site Remediation Professional (LSRP) the report must also be certified by the LSRP using the "Licensed Site Remediation Professional Information and Statement". For additional guidance regarding the requirement for LSRPs at RCRA GPRA 2020, CERCLA and Federal Facility Sites see [http://www.nj.gov/dep/srp/srra/training/matrix/quick\\_ref/rcra\\_cercla\\_fed\\_facility\\_sites.pdf](http://www.nj.gov/dep/srp/srra/training/matrix/quick_ref/rcra_cercla_fed_facility_sites.pdf).

Document: "Discharge to Groundwater Notification and Request for Concurrence, Pilot Test of RegenOx™ Injection in and Around Building 700 (FTMM-68), Fort Monmouth, New Jersey"

**PERSON RESPONSIBLE FOR CONDUCTING THE REMEDIATION INFORMATION AND CERTIFICATION**

Full Legal Name of the Person Responsible for Conducting the Remediation: William R. Colvin

Representative First Name: William

Representative Last Name: Colvin

Title: BRAC Environmental Coordinator

Phone Number: (732) 380-7064

Ext:

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State: NJ

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This certification shall be signed by the person responsible for conducting the remediation who is submitting this notification in accordance with Administrative Requirements for the Remediation of Contaminated Sites rule at N.J.A.C. 7:26C-1.5(a).

*I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, including all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, to the best of my knowledge, I believe that the submitted information is true, accurate and complete. I am aware that there are significant civil penalties for knowingly submitting false, inaccurate or incomplete information and that I am committing a crime of the fourth degree if I make a written false statement which I do not believe to be true. I am also aware that if I knowingly direct or authorize the violation of any statute, I am personally liable for the penalties.*

Signature:

Date: 06/14/2017

Name/Title: William R. Colvin / BRAC Environmental Coordinator



## DEPARTMENT OF THE ARMY

OFFICE OF ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT  
U.S. ARMY FORT MONMOUTH  
P.O. 148  
OCEANPORT, NEW JERSEY 07757

14 June 2017

Ms. Linda S. Range  
New Jersey Department of Environmental Protection  
Bureau of Case Management  
401 East State Street  
PO Box 420/Mail Code 401-05F  
Trenton, NJ 08625-0028

**SUBJECT: Discharge to Groundwater Notification and Request for Concurrence  
Pilot Test of RegenOx™ Injection in and Around Building 700 (FTMM-68)  
Fort Monmouth, New Jersey  
PI G000000032**

Attachments:

Figure 1 – In Situ Chemical Oxidation Treatment Locations  
Attachment 1 - Regenesis RegenOx Installation Instructions

Dear Ms. Range:

The Fort Monmouth Team is requesting the subject concurrence pursuant to the New Jersey Pollutant Discharge Elimination System (NJPDES), N.J.A.C. 7:14A-1 *et seq.* to proceed with the injection of RegenOx to pilot test and remediate organic Contaminants of Concern (COCs) detected in groundwater in and around Building 700.

### **Background**

The site is located within the Main Post portion of Fort Monmouth (FTMM). In April 2011, FTMM excavated a 500-gallon solvent underground storage tank (UST), which was heavily corroded and leaking in several places; the UST released an unknown volume of tetrachloroethene (PCE).

During sampling events performed from November 2016 to January 2017, PCE was identified as the primary contaminant detected at the highest concentrations in soil and groundwater. PCE concentrations in source area soil adjacent to the former UST in 2015 ranged up to 360,000 micrograms per kilogram ( $\mu\text{g/kg}$ ) at a depth of 12.5-13.0 feet below ground surface (ft bgs) and remained elevated in the deepest soil sampling interval (15,000  $\mu\text{g/kg}$  at 24.0-24.5 ft bgs). In November 2015, the highest PCE concentration in groundwater (3,800 micrograms per liter [ $\mu\text{g/L}$ ]) occurred in the deeper of the two source area wells (565MW01D, screened 18-23 feet bgs). In January 2017, PCE was detected in source area soil samples at concentrations ranging up to

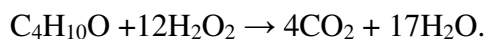
6,900 µg/kg (20-20.5 ft bgs) with elevated PCE concentrations being detected in samples ranging from 18 to 27 ft bgs.

### **Discharge to Groundwater Proposal**

To reduce PCE concentrations in groundwater in and around Building 700, the FTMM Team proposes to inject RegenOx proximate to the source near Building 700. RegenOx, a product manufactured by Regenesis, is an advanced chemical oxidation technology that chemically destroys contaminants *in-situ* through a powerful, but controlled chemical reaction. RegenOx product maximizes *in-situ* performance while using a solid alkaline oxidant that employs a sodium percarbonate complex with a multi-part catalytic formula. RegenOx directly oxidizes contaminants while its unique catalytic component generates a range of reactive oxidizing free radicals that rapidly and effectively destroy a range of target contaminants including chlorinated hydrocarbons (aliphatic ethenes and ethanes), including PCE.

RegenOx is delivered as two parts that are combined prior to injection into the subsurface. Following injection into the subsurface, the RegenOx solution produces an effective oxidation reaction that is more effective than Fenton's reaction in treating chlorinated hydrocarbons without the dangers of forming a highly exothermic reaction. The RegenOx injections will be limited to the area in and around Building 700. The FTMM Team proposes to inject RegenOx to a maximum depth of 30 feet below grade surface (bgs). The assumed thickness of groundwater requiring treatment is approximately 18 feet. According to Regenesis, the calculated rate of solution injection will be approximately 18 gallons/vertical foot.

The FTMM Team proposes to use RegenOx as the primary oxidant to treat volatile organic compounds (VOCs) *in-situ*. After injection, the RegenOx solution forms an activator complex containing a highly-reactive catalytic surface. The contaminant and the oxidizer complex react with the activator complex via an oxidation pathway. The overall stoichiometric pathway for the reaction of RegenOx (hydrogen peroxide, H<sub>2</sub>O<sub>2</sub>) and PCE is:



Complete reaction of PCE yields non-hazardous end products of carbon dioxide and water. These two end products are also formed when RegenOx reacts with other VOCs including substituted hydrocarbons (e.g., ethylbenzene, toluene, xylenes).

Additional information on RegenOx can be found at the following website: [http://www.clean.com.br/PDFs\\_Zips\\_Flashs/RegenOx%20Guide/Regensis\\_Content.pdf](http://www.clean.com.br/PDFs_Zips_Flashs/RegenOx%20Guide/Regensis_Content.pdf).

The FTMM Team proposes to pilot test the injection of RegenOx to treat VOCs detected in groundwater. After treatment with RegenOx, if PCE or other VOC concentrations exceed the applicable NJDEP Ground Water Quality Criteria (GWQC), the FTMM Team may opt to continue injections using RegenOx.

### **RegenOx Injection Technology Descriptions**

RegenOx is an advanced chemical oxidation technology that destroys contaminants through controlled chemical reactions. RegenOx maximizes *in-situ* performance by using a solid alkaline

oxidant containing a sodium percarbonate complex with a multi-part catalytic formula. RegenOx directly oxidizes contaminants while its unique catalytic component generates a range of highly-oxidizing free radicals that rapidly and effectively destroy a range of target contaminants including petroleum hydrocarbons, and chlorinated compounds found at FTMM-68.

The proposed RegenOx treatment program will be implemented for the remediation of VOCs in and around Building 700. The preparation of RegenOx solutions to be injected will be prepared consistent with Regenesys Installation Instructions (Attachment 2). The proposed injections will utilize approximately 85 temporary injection point locations using a direct push rig within an area encompassing approximately 5,000 square feet, as shown on Figure 1. The exact locations of the temporary injection points will be based on access of the Geoprobe-equipped truck, overhead building obstructions, and locations of subsurface and overhead utilities.

The RegenOx injection rates and pressure will not exceed 18 gallons/vertical foot and 5 pounds/vertical foot, respectively using direct push technology (e.g. Geoprobe Model 5400) beginning at a bottom depth of approximately 30 feet bgs. At each injection point, a high-pressure pump will be used to inject the RegenOx solution to facilitate lateral distribution in groundwater. After the RegenOx solution is injected (from the bottom of the hole up), the injection point will be raised one foot for the next injection. This process will be repeated until the shallow target interval depth is reached, which varies from 6 to 16 feet bgs depending on location. The top depth of the treatment interval will be shallower near the former UST based on test boring results. Injection of RegenOx solution at this shallow depth interval will ensure that the primary mass of VOCs entrained below the vadose zone-water table interface is targeted for this remedial effort.

The following conditions will be met during each of the two RegenOx injection event:

- Surface run-off will be prevented;
- RegenOx application will not result, directly or indirectly, in a discharge to surface water;
- Application(s) will not affect water supplies or cause vapor hazards in subsurface structures (e.g., utility lines) nor will it adversely impact the dissolved VOCs, causing contaminant migration;
- All results from the RegenOx application will be incorporated into an appropriate deliverable to the NJDEP (e.g., *Remedial Action Progress Report*); and
- The first injection event will be made at approximately 85 locations on 10 ft centers with a follow-up round of 5 ft offsets.
- The second injection event will be made at about 85 locations on 10 ft centers with a follow-up round of 5 ft offsets.

### **Performance Monitoring**

To assess the impacts of the injection activities and subsurface response to the **RegenOx** application, existing groundwater monitoring wells within and hydraulically downgradient of the injection area at Building 700 will be monitored immediately prior to injections and approximately 1 week after the last injection event for the media and parameters indicated below:

- Water Column:

- Depth from top of inner well casing
- Analyze Immediately Parameters (AIP): Temperature, pH, Oxidation-Reduction Potential (ORP), Dissolved oxygen (DO), Specific conductance
- Headspace:
  - VOCs using a Photoionization Detector (PID)
  - Oxygen

### **Performance Sampling**

In order to evaluate the performance of the injection treatments, a total of three groundwater sampling events will be performed before and after the injection events. FTMM Team proposes to collect groundwater samples from existing monitoring wells in and around Building 700 (see Figure 1) immediately prior to the first injection event to establish baseline concentrations for comparisons. Approximately one week following the first injection event, groundwater samples will be collected to evaluate the concentrations of dissolved-phase VOCs plus 15 tentatively identified compounds (TICs) (VOC+15) in the treatment area and to determine the effectiveness of the injection. A second round of post-injection sampling will be performed in wells around Building 700 one week after the second injection event. All groundwater samples collected will be analyzed by a NJDEP certified laboratory. A summary of the performance monitoring and sampling is provided as follows:

**Table A. Summary of Performance Monitoring and Sampling Parameters and Frequencies**

| <b>Elapsed Time After RegenOx Injection</b>       | <b>Comments</b>                                                                           |
|---------------------------------------------------|-------------------------------------------------------------------------------------------|
| 0 (Baseline)                                      | Measure AIPs at monitoring wells and collect groundwater samples from 6 wells for VOC+15. |
| 1 week after first injections (Post-Injection 1)  | Measure AIPs and collect groundwater samples from 6 wells for VOC+15.                     |
| 1 week after second injections (Post-Injection 2) | Measure AIPs and collect groundwater samples from 6 wells for VOC+15.                     |

The following parameters will also be determined in groundwater during the above schedule: iron, manganese, and hydrogen peroxide alkalinity. Prior to injection, alkalinity (as calcium carbonate), major anions, major cations, and hexavalent chromium will be determined via U.S. Environmental Protection Agency approved test methods.

Proposed performance monitoring wells and rationale include the following:

- 565MW01, 565MW01D for monitoring within the injection treatment area;
- FTMM-68-MW-07 for monitoring below the injection treatment area; and

Linda S. Range, NJDEP

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- FTMM-68-MW-01, FTMM-53-MW-02, and FTMM-68-MW-08 for monitoring 50 ft downgradient of the treatment area

**Groundwater Sampling Procedures**

The FTMM Team will measure AIPs and depth to water at each monitoring well at the frequencies noted in **Table A**. Groundwater samples will be collected from the monitoring wells in accordance with NJDEP *Field Sampling Procedures Manual*.

Applicable protocols regarding sampling, handling, storage, preservation, reporting, decontamination of field equipment and other procedures will comply with NJDEP *Field Sampling Procedures Manual* dated August 2005.

The FTMM Team respectfully requests the NJDEP's concurrence of the RegenOx injection as described herein without an expiration date. This will allow the FTMM Team to conduct additional RegenOx injections without the requirement to request additional concurrence from the NJDEP, thus avoiding time delays. The FTMM Team will provide written notification to NJDEP at least two weeks prior to initiating the RegenOx injection event.

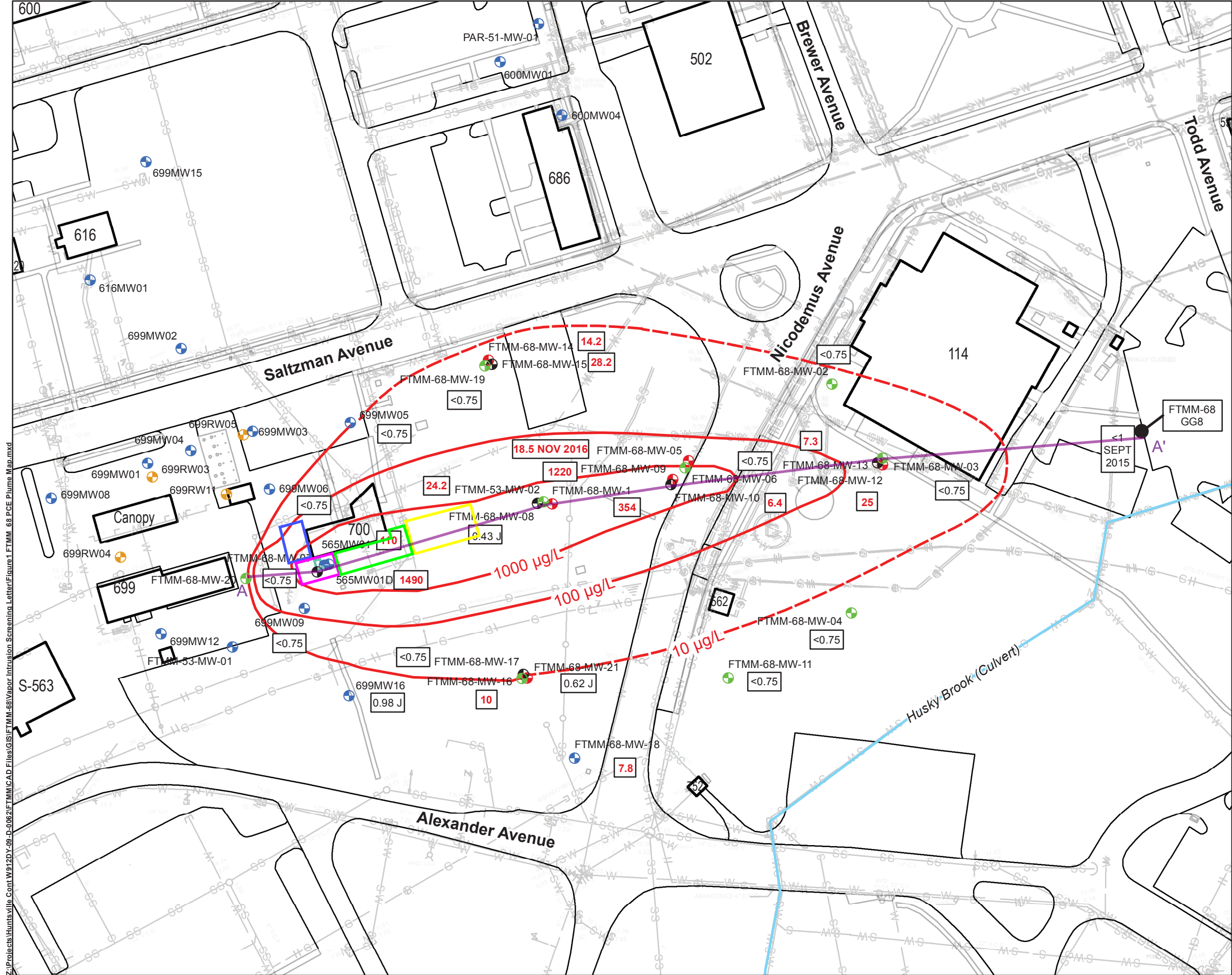
The FTMM Team will await NJDEP's concurrence prior to implementation of the injection(s). If you have any questions or require additional information, please contact me at 732-380-7064 or via email at [william.r.colvin18.civ@mail.mil](mailto:william.r.colvin18.civ@mail.mil).

Sincerely,



William R. Colvin, PMP, CHMM, PG  
BRAC Environmental Coordinator  
Fort Monmouth

cc: Linda Range, NJDEP (2 hard copies)  
William Colvin, FTMM-BEC (e-mail)  
Joseph Pearson, Calibre (e-mail)  
James Moore, USACE (e-mail)  
Jim Kelly, USACE (e-mail)  
Cris Grill, Parsons (e-mail)



**LEGEND:**

- Monitoring Well Screened in QCM2
- Monitoring Well Screened across QCM2/Tht Contact
- Monitoring Well Screened in Kt
- Monitoring Well Screened in Tht
- Recovery Well
- W- Water Line
- SS Sanitary Sewer Line
- SW- Storm Sewer Line
- G- Gas Line
- UST Excavation Footprint
- Cross Section A-A'
- PCE Isoconcentration Contour
- PCE Isoconcentration Contour Inferred
- Grab Groundwater Sample Location
- <0.75 PCE Well Concentration, March/April 2017 - unless otherwise noted.
- Area 1 - Injection depth 6 - 30 feet bgs
- Area 2 - Injection depth 15 - 32 feet bgs
- Area 3 - Injection depth 16 - 30 feet bgs
- Area 4 - Injection depth 16 - 30 feet bgs

**NOTES:**

All results in micrograms per liter (µg/L).  
Bold red indicates value exceeds NJ Ground Water Quality Criteria for PCE (1 µg/L).  
QCM2 - Cape May Formation, Unit 2 (surficial deposits).  
Tht - Hornerstown Formation.  
Kt - Tinton Formation.  
Maximum PCE concentration at each well cluster was used for contouring.

1 inch = 100 feet

0 50 100 200 Feet

Source: FTMM Supplied CAD

|                                                           |                                            |
|-----------------------------------------------------------|--------------------------------------------|
| <b>PARSONS</b><br>401 Diamond Drive NW,<br>Huntsville AL  | <b>Fort Monmouth</b><br><b>New Jersey</b>  |
| <b>In-Situ Chemical Oxidation<br/>Treatment Locations</b> |                                            |
| CREATED BY:<br><b>AM</b>                                  | REVIEWED BY:<br><b>KW</b>                  |
| DATE:<br><b>MAY. 2017</b>                                 | FIGURE NUMBER:<br><b>FIGURE 1</b>          |
| PROJECT NUMBER:<br><b>748810-02180</b>                    | FILE:<br>Figure1 FTMM_68 PCE Plume Map.mxd |

Z:\Projects\Huntsville Cont W912DY-09-D-0062\FTMM\CAD Files\GIS\FTMM-68\Vapor Intrusion Screening Letter\Figure1 FTMM\_68 PCE Plume Map.mxd

## **Attachment 1**

### **Regenesis RegenOx Installation Instructions**

# RegenOx® Installation Instructions: Direct-Push Injection

## General Guidelines

One of the best methods to deliver RegenOx® into the subsurface is to inject the material through direct push rods using hydraulic equipment. This approach increases the spreading and mixing of RegenOx into the aquifer. This set of instructions is specific to direct push equipment. For advice on other injections methods such as soil mixing, hydraulic and pneumatic fracturing, and vertical injection, please contact Technical Services directly.

The installation of RegenOx should span the entire vertical contaminated saturated thickness, or in the case of vadose zone treatment the entire affected vadose zone targeted for treatment.

## Typical Installation Equipment

- Direct push rig
- Drive Rods (typically 1 ½-inch O.D.) & Injection Tooling with fluid deliver sub-assembly
- Injection Pump rated for 5 gpm @ 200 psi for sandy formations and 800 psi for silt and clay formations (Geoprobe DP-800, Yamada, Moyno, Rupe Models 9-1500 and 9-1600, Wilden, etc.)
- Injection hosing and a pressure relief valve with a bypass
- Clear hosing between mixing tank/drum and pump
- Pressure gauges
- Power drill paint stirrer (3-inch diameter or smaller propeller tip)
- Plastic bucket lid puller tool/opener tool
- 5-amp sump pump (such as Little Giant) and hose
- Three to four 55-gallon drums or similarly sized mixing tanks for RegenOx mixing
- Sand, bentonite chips, granular bentonite, cement, hydraulic cement, and quick-set concrete for closing and sealing temporary injection holes
- Wood plugs or similar for temporarily sealing injection holes prior to grout sealing
- Access to water
- Access to electricity

## Personal Protective Equipment (PPE)

Personnel working with or in areas of potential contact with RegenOx should be required at a minimum to be fitted with modified Level D personal protective equipment:

- Eye protection – Wear well sealed goggles or a face shield (recommended for full face protection)
- Head – Hard hat when required
- Respiratory – Use dust respirator approved by NIOSH/MSA
- Hands – Wear neoprene gloves
- Feet – Wear steel toe shoes with chemical resistant soles or neoprene boots
- Clothing – Wear long sleeve shirts and long pant legs. Consider using a Tyvek® body suit, Carhartt® coverall or splash gear

## Material Overview, Handling, and Safety

RegenOx is packaged in two parts. RegenOx Part A Oxidizer complex and RegenOx Part B Activator complex. Part A is shipped in a 40 pound bag and Part B is shipped in separate 5-gallon buckets and has a gross weight of approximately 42 pounds (net weight of RegenOx material in each bucket is 40 pounds). The RegenOx Oxidizer complex is shipped as a fine white powder and the RegenOx Activator complex is shipped as a liquid gel. The Activator has a viscosity roughly equivalent to honey. It is common for stored RegenOx Activator to settle somewhat in a container, so it is imperative to adequately pre-mix the RegenOx Activator prior to mixing it with the RegenOx Oxidizer. Mixing the RegenOx Part B Activator with water at a ratio of roughly 1 gallon water per bucket of Activator makes the activator pourable and easier to work with. A Material Safety Data Sheet for Part A (RegenOx Oxidizer) and for Part B (RegenOx Activator) is provided with each shipment. Personnel who operate field equipment during the installation process should have appropriate training, supervision, and experience.

## Installation Procedures

1. Prior to the installation of RegenOx, any surface or overhead impediments should be identified as well as the location of all underground structures. Underground structures include but are not limited to: utility lines; tanks; distribution piping; sewers; drains; and landscape irrigation systems.
2. The planned installation locations should be adjusted to account for all impediments and obstacles.
3. Pre-mark the installation locations, noting any points that may have different vertical application requirements or total depth.
4. Set up the direct push unit over each specific point and follow the manufacturer standard operating procedures (SOP) for the direct push equipment. Care should be taken to assure that probe holes remain in the vertical.
5. For most applications, REGENESIS suggests using 1.5-inch O.D./0.625-inch I.D drive rods. However, some applications may require the use of 2.125-inch O.D./1.5-inch I.D. or larger drive rods.
6. Advance drive rods through the surface pavement, as necessary, following SOP.
7. Push the drive rod assembly with an expendable tip to the desired maximum depth. REGENESIS suggests pre-counting the number of drive rods needed to reach depth prior to starting injection activities.
8. After the drive rods have been pushed to the desired depth, the rod assembly should be withdrawn three to six inches. Then the expendable tip can be dropped from the drive rods,
9. following SOP. If an injection tool was used instead of an expendable tip, the application of material can take place without any preliminary withdrawal of the rods.
10. In some cases, introduction of a large column of air prior to RegenOx application may be problematic. This is particularly the case in deep injections (>50 ft) with large diameter rods (>1.5-inch O.D.). To prevent the injection of air into the aquifer during RegenOx application, as well as to prevent problems associated with heaving sands, fill the drive rods with water, or the RegenOx mixture prior dropping the expendable tip or exposing the injection tool.
11. Open one of the buckets of RegenOx Part B Activator and pour/spoon the entire bucket of Activator into a small mixing bucket or tank, making sure that any Activator that settled in the bottom of the bucket was scraped out of the Activator bucket and into the mixing tank. Stir the Activator with the power drill mixer for roughly 2 to 3 minutes. Add roughly one gallon of water to the activator, and stir again for at least 2 to 3 minutes. The net weight of Activator in a bucket is 40

pounds. The pounds of Activator required for one vertical foot of injection can be divided by 40.

Pour the stirred/mixed Activator into empty buckets based on that fraction. (For example, if 5 pounds of activator are required per foot, pour 5/40 or 1/8 of the contents into each of six empty buckets.)

12. Measure the appropriate quantity of RegenOx Oxidizer for each vertical foot of injection.
13. RegenOx % oxidizer in solution should typically range between 4% to 8%. Solutions up to 10% can be used, but flocculation of the solution prior to injection may result. Solutions with greater than 10% oxidizer in solution will result in excess reaction and flocculation prior to injection and are not normally recommended. Into a 55-gallon drum or mixing tank, pour the required amount of water for one to four vertical feet of injection. The volume of water per injection location can be calculated from the following equation:

**Volume of water (gallons/vertical foot of injection):**

$$\frac{\text{RegenOx Oxidizer lbs/foot}}{(8.34 \text{ lbs/gal water})(\% \text{ RegenOx\_Oxidizer solids})} \left[ \frac{1}{\% \text{ RegenOx\_Oxidizer solids}} \right]$$

Tighter formations (clays and silts), and even some fine sand formations will likely require higher oxidant percentages since less volume can be injected per location. The following are guides to various RegenOx mixing ratios based on the above equation.

- to make a roughly 5% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx), use 22 gallons of water.
- to make a roughly 8% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx), use 13.5 gallons of water.
- to make a roughly 10% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx), use 11 gallons of water.

14. Pour the pre-measured quantity of RegenOx Oxidizer to make the desired target % oxidant in solution mixture into the mixing drum or tank. Mix the water and oxidant with a power drill paint stirrer to ensure that the Oxidizer has dissolved in the water.
15. Pour the applicable amount of the pre-mixed RegenOx Activator into the oxidant mixing tank or pump hopper. Mix the Oxidant and Activator using a power drill paint stirrer or hand paddle mixer for at least 5 minutes until a homogenous mixture is formed. After mixing the RegenOx mixture should be injected into the subsurface as soon as possible.
16. Do not mix more RegenOx material than will be used over roughly 1 to 4 feet of injection so as to minimize potential above ground reaction/flocculation prior to injection.
17. Transfer the contents of the mixing tank to the pump hopper using a gravity drain or a sump pump.
18. For some types of pumps, it may be desirable to perform a volume check prior to injecting RegenOx. Determining volume displaced per pump stroke can be accomplished in 2 easy steps:
  - a) Determine the number of pump strokes needed to deliver 3 gallons of RegenOx (use a graduated bucket for this).
  - b) Divide 3 gallons by the results from the first step to determine the number of gallons of RegenOx delivered by each pump stroke.
19. Connect the delivery hose to the pump outlet and the delivery sub-assembly. Circulate RegenOx through the hose and the delivery sub-assembly to displace air in the hose.
20. Connect the sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the RegenOx through the delivery system to displace the water/fluid in the rods.

21. Slowly withdraw the drive rods. Commonly, RegenOx injections progress at 1-foot intervals. However, continuous injection while slowly withdrawing single lengths of drive rod (3 or 4 feet) is an acceptable option. The pre-determined volume of RegenOx should be pumped into the aquifer across the desired treatment interval.
22. Remove one section of the drive rod. The drive rod may contain some residual RegenOx. Place the RegenOx-filled rod in a clean, empty bucket and allow the RegenOx to drain. Eventually, the RegenOx should be returned to the RegenOx pump hopper for reuse.
23. Observe any indications of aquifer refusal. This is typically indicated by a high-pitched squeal in the pump's hydraulic system or (in the case of shallow applications) RegenOx "surfacing" around the injection rods or previously installed injection points. At times backpressure caused by gassing will impede pump movement. This can be corrected by bleeding the pressure off using a pressure relief/bypass valve (placed inline between the pump discharge and the delivery sub-assembly) and then resume pumping. If aquifer acceptance appears to be low, allow enough time for the aquifer to equilibrate prior to removing the drive rod.
24. Repeat steps 13-23 until treatment of the entire contaminated vertical zone has been achieved. It is recommended that the procedure extend to the top of the capillary fringe/smear zone, or to the top of the targeted treatment interval.
25. Install an appropriate seal, such as bentonite, above the RegenOx material through the entire vadose zone. Prior to emplacing the borehole seal, we recommend placing clean sand in the hole to the top of the RegenOx treatment zone (especially important in holes that stay open). Bentonite chips or granular bentonite should be placed immediately above the treatment zone, followed by a cement/bentonite grout to roughly 0.5 feet below ground surface. Quick-set concrete should then be used as a surface seal.
26. Remove and clean the drive rods as necessary.
27. Finish the borehole at the surface as appropriate (concrete or asphalt cap, if necessary). We recommend a quick set concrete to provide a good surface seal with minimal set up time.
28. A proper borehole and surface seal assures that RegenOx remains properly placed and prevents contaminant migration from the surface. Each borehole should be sealed immediately following RegenOx application to minimize RegenOx surfacing during the injection process. If RegenOx continues to "surface" up the direct push borehole, an appropriately sized (oversized) disposable drive tip or wood plug/stake can be used to plug the hole until the aquifer equilibrates and the RegenOx stops surfacing. If wells are used for RegenOx injection, the RegenOx injection wells and all nearby groundwater monitoring wells should be tightly capped to reduce potential for surfacing through nearby wells.
29. Periodically compare the pre-and post-injection volumes of RegenOx in the pump hopper using pre-marked volume levels. Volume level indicators are not on all pump hoppers. In this case, volume level markings can be temporarily added using known amounts of water and a carpenter's grease pencil (Kiel crayon). We suggest marking the water levels in 3-gallon increments.
30. Move to the next probe point, repeating steps 8 through 29. We recommend that the next RegenOx injection point be as far a distance as possible within the treatment zone from the previous RegenOx injection point. This will further minimize RegenOx surfacing and short circuiting up an adjacent borehole. When possible, due to the high volumes of liquid being injected, working from the outside of the injection area towards the center will limit expansion of the plume.

## **1) RegenOx Pump Information**

REGENESIS® has evaluated a number of pumps that are capable of delivering RegenOx to the subsurface at a sufficient pressure and volumetric rate. Although a number of pumps may be capable of delivering the RegenOx to the subsurface at adequate pressures and volume, each pump has a set of practical issues that make it difficult to manage in a field setting. In general, REGENESIS strongly recommends using a pump with a minimum pressure rating of 200 pounds per square inch (psi) in sandy formations or 800 psi in silt, clay or weathered bedrock formations, and a minimum delivery rate of 5 gallons per minute (gpm). A lower gpm rated pump can be used; however, they are not recommended due to the amount of time required to inject the volume of liquids typically associated with a RegenOx injection (i.e. 1,000 lbs of RegenOx [500 lbs Oxidant/500 lbs Activator] require roughly 1,100 gallons of water to make a 5% Oxidant solution).

## **2) Pump Cleaning**

For best results, use a hot water pressure washer (150-170 °F or 66-77 °C) to clean equipment and rods periodically throughout the day. Internal pump mechanisms and hoses can be easily cleaned by circulating hot water and a biodegradable cleaner such as Simple Green® through the pump and delivery hose. Further cleaning and decontamination (if necessary due to subsurface conditions) should be performed according to the equipment supplier's standard procedures and local regulatory requirements.

For more information contact REGENESIS at 949.366.8000