

**A CASE STUDY OF THREE PETROLEUM REMEDIATION TECHNIQUES**  
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**OCTOBER 2017**

**I. Introduction**

There are over one million underground storage tanks (USTs) in the United States that contain petroleum or other hazardous substances. According to the Environmental Protection Agency (EPA), there are up to 535,000 UST releases as of March 2017. Of those, approximately 465,000 have been remediated. Leaking USTs can be a threat to both the environment and human health. Fumes and vapors can migrate through the subsurface and accumulate in structures (buildings, parking garages, and utility vaults) where they pose a threat of explosion, asphyxiation, and other health effects. Releases from USTs are one of the most common causes of groundwater contamination (Cleaning Up USTs 2017). Groundwater contamination can impact sources drinking water, causing municipal and private wells to be shut down. Direct exposure through soil or groundwater to compounds found in gasoline can have serious adverse effects to human health. For example, benzene is a carcinogenic and toluene damages the central nervous system (Asghar 2016). There are many remediation options (i.e. biodegradation, thermal treatment, groundwater extraction, volatilization, and excavation) to consider for the impacted site. Each site proposes unique set of challenges based on variables that will affect the remediation process (Cleaning Up USTs 2017). Variables such as the amount and duration of the release, depth to groundwater, and development on the site can affect the timeline and cost of the cleanup.

This paper addresses the remediation and monitoring efforts on a former refueling site located in Puerto Rico. The site was constructed in 1947 and served as a motor pool and vehicle maintenance facility, where petroleum, oil and lubricants were dispensed for military tactical vehicles. Originally, the site contained two 18,927-liter steel USTs. In the 1980's, the two USTs were replaced with three 37,854-liter steel USTs. In 1991, the steel USTs were replaced with two 37,854-liter fiberglass USTs. The site operated as a fueling station for the base until June 2015. The site is currently an undeveloped grass field (Aerostar 2017).

Between December 2003 and July 2007, site assessments were conducted to evaluate soil and groundwater quality. It includes 18 shallow monitor wells (MW-1 through MW-18), one deep monitor well (DW-1), and six temporary monitor wells (SB-1, SB-2, SB-4, SB-5, SB-6, and SB-9). Groundwater analytical results showed benzene, ethylbenzene, methyl tert-butyl ether (MTBE), and naphthalene concentrations above their respective Puerto Rico Environmental Quality Board (PREQB) Water Quality Standards (WQS). Based on the results of the site assessments, interim remedial actions were recommended to address the soil and groundwater impacts at the site (Aerostar 2017).

The purpose of this paper is to examine three different environmental remediation techniques applied to the site. The remediation techniques will be compared in terms of the technology used, how the technology was applied, and overall effectiveness. Effectiveness will be determined by comparing the baseline concentration levels to post-remediation sampling results in relation to applicable regulatory cleanup levels. The regulatory levels for

groundwater are the PREQB WQS UST (Table 1). The Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Levels (GCTLs) will be used when no PREQB WQS is established. The regulatory levels for soil are the Residential and Industrial PREQB UST standards (Table 2).

**Table 1. Groundwater Regulatory Cleanup Levels**

Chemical of Concern	PREQB WQS/UST Regulation (µg/L)	FDEP GCTL (µg/L)
Benzene	5	1
Ethylbenzene	530	30
Toluene	1000	40
Total Xylenes	10000	10000
Methyl tert-butyl ether (MTBE)	12	20
Naphthalene	Not Established	14

(PREQB 2010 and FDEP 2005)

**Table 2. Soil Regulatory Cleanup Levels**

Chemical of Concern	PREQB UST Residential Regulation (mg/kg)	PREQB UST Industrial Regulation (mg/kg)
Ethylbenzene	5.8	25
Naphthalene	3.8	17
Benzene	1.2	5.1

(Aerostar 2017)

In May 2011 and February 2012, two separate rounds of baseline groundwater samples were collected to evaluate groundwater quality. A summary of the groundwater analyses is included in Table 3 (Aerostar 2013). For the purpose of this report, only wells showing concentrations above regulatory levels will be discussed. Laboratory analysis was performed by a National Environmental Laboratory Accreditation Program (NELAP) certified laboratory. Laboratory method detection limits (MDLs) and reporting limits (RLs) were set by the laboratory based on each analytical method.

**Table 3. Baseline Groundwater Analytical Method Summary**

Date	Wells Sampled	Analytical Method
May 2011	MW-1 through MW-3, MW-5, MW-6, MW-9 through MW-11, MW-13 through MW-18	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B
February 2012	MW-1 through MW-3, MW-5, MW-6, MW-9 through MW-11, MW-12, MW-13, MW-15 through MW-18, DW-1, SB-1, SB-2, and SB-4	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B

EPA Method 8260B = Volatile Organic Compounds

EPA Method 8270C = Semi-volatile Organic Compounds

EPA Method 80150B = Gasoline Range Organics and Diesel Range Organics

Laboratory analytical results of the groundwater samples collected from monitor wells MW-3, MW-5, MW-9, and SB-1 showed concentrations of benzene, methyl tert-butyl ether (MTBE), and naphthalene above regulatory levels (Table 3). The remaining monitor wells showed no concentrations above PREQB WQS or FDEP GCTLs

The complete laboratory analytical results for the baseline sampling events in wells showing concentrations above regulatory levels are summarized in Supplemental Material S-1. A Site Map showing the monitor well location is included in Supplemental Material S-2.

**Table 4. Baseline Groundwater Laboratory Analytical Results**

Sample Location	Date	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	Naphthalene
<b>PREQB WQS</b>		<b>5</b>	<b>1000</b>	<b>530</b>	<b>10000</b>	<b>12</b>	<b>NE</b>
<b>FDEP GCTL</b>		<b>1</b>	<b>40</b>	<b>30</b>	<b>20</b>	<b>20</b>	<b>14</b>
MW-3	5/24/11	11.5	4.30	130	3.5	5 U	472
	2/13/12	13.2	3.30	110	0.7 U	1.80	747
MW-5	5/24/11	22.5	3.90	200	5.00	1.0 U	46.4
	2/13/12	66.6	8.20	215	4.3	20.8	177
MW-9	5/25/11	1.40	0.7	1.20	0.4	2.10	2.00
	2/14/12	0.3 U	0.2 U	0.2 U	0.7 U	2.90	23.2
SB-1	2/13/12	0.3 U	0.2 U	0.2 U	0.7 U	1.0 U	19.3

(Aerostar 2013)

All concentrations are in µg/L, concentrations in red are above primary regulatory level

NE = Not Established

MTBE = Methyl tert-butyl ether

U = Not detected at reported value

## II. Methods and Materials

### 2.1 Method One – In-Situ Chemical Oxidation

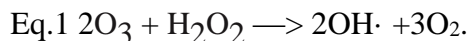
#### 2.1.1 Review of Remediation Technology

The initial remediation technology selected for this site was an in-situ chemical oxidation (ISCO) system consisting of a combination of liquid hydrogen peroxide and ozone gas. Chemical oxidation is a process in which the oxidation state of a substance is increased. The oxidant is reduced by accepting electrons released from the oxidation of target and non-target reactive species. The main objective of chemical oxidation is to transform undesirable chemical species into harmless ones (Huling 2006).

In-situ chemical oxidation involves the introduction of a chemical oxidant into the subsurface for the purpose of transforming groundwater or soil contaminants into less harmful chemical species. There are several different forms of oxidants that have been used for ISCO; however, hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and ozone (O<sub>3</sub>) are the focus of this report. Hydrogen peroxide and ozone have high oxidation potential, which cause them to react rapidly when introduced into the environment. Radical intermediates formed using hydrogen peroxide and ozone also

react very quickly and remains for very short periods of time (Oxidation Potential 1991).

For this project, the combination of hydrogen peroxide and ozone was injected into the subsurface using the Perozone System (Kerfoot Technologies, Inc., Mashpee, MA). The Perozone System utilizes an ozone sparging process (C-Sparger), which generates nano- to micro-sized bubbles of air-encapsulated ozone, created by forcing an air/ozone mixture through specialized delivery points (Spargepoints), to treat subsurface impacts in soil or groundwater. The microbubbles are pulsed through the soil and groundwater. After reacting, ozone and hydrogen peroxide decompose into beneficial oxygen and hydroxyl radicals (Equation 1) (Aerostar 2015).



Hydroxyl radicals are strong, nonspecific oxidants can rapidly degrade a variety of organic compounds. They are highly reactive which can cause the oxidation of most organic compounds until they are fully mineralized as carbon dioxide and water. The hydroxyl radical has a much higher oxidation potential than ozone or hydrogen peroxide, which leads to a shorter contact time and footprint (Huling 2006).

The process can also release oxygen as a byproduct that may be used by microorganisms to oxidize substrate (e.g. a source of carbon) in soil and groundwater through aerobic biodegradation.

### **2.1.2 Implementation of Remediation Technology**

Between December 2011 and May 2014, Perozone system installation and operation activities occurred. Details of the installation and operation of the Perozone system is included in Table 5. The Perozone system layout is illustrated on Supplemental Material S-3 (Aerostar 2015).

**Table 5. Perozone System Installation and Operation Summary**

<b>Event</b>	<b>Dates</b>	<b>Activities</b>
System Installation	December 8 to 16, 2012	Install 12 injection wells (IW-1 through 12)
System Operation	February to September 2012	Perozone injection into IW-1 through 12
System Addition	May 2014	Install 4 additional wells (IW-13 through 16)
System Operation	June to December 2014	Perozone injection into IW-1 through 16

(Aerostar 2013 and 2015)

### **2.1.3 Monitoring the Effect of Remediation Technology**

Between April 2012 and February 2015, groundwater samples were collected prior to, during, and after the Perozone injection to monitor the effectiveness of the system. Details of the groundwater monitoring events are summarized in Table 6.

**Table 6. Perozone System Groundwater Monitoring Summary**

<b>Date</b>	<b>Analytical Method</b>	<b>Wells Sampled</b>
April 18, 2012 During 1 <sup>st</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4
June 20, 2012 During 1 <sup>st</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4
September 26, 2012 Post 1 <sup>st</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4.
December 12, 2012 Post 1 <sup>st</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4
March 11, 2014 Pre-2 <sup>nd</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4
August 28, 2014 During 2 <sup>nd</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4
December 12 2014 During 2 <sup>nd</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4
February 24, 2015 Post 2 <sup>nd</sup> Injection	EPA Method 8260B, EPA Method 8270C, and EPA Method 8015B	MW-1, MW-2, MW-3, MW-5, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, DW-1, SB-1, SB-2, and SB-4

(Aerostar 2013 and 2015)

## **2.2 Method Two - Source Removal and Enhanced Aerobic Biodegradation**

### **2.2.1 Review of Remediation Technology**

The second remediation technology chosen was a combination of source removal and enhanced aerobic biodegradation. Source removal is commonly used with a wider range and level of compounds. It is a mechanical process of physically removing contaminated soil and transporting it offsite.

Enhanced aerobic biodegradation is typically used to treat low to moderate levels of contamination. The most commonly treated compounds with enhanced aerobic bioremediation are petroleum hydrocarbon constituents and related compounds (Advanced Oxygen Release Compound 2017).

This method adds oxygen to saturated soil and groundwater to increase the number and vitality of indigenous aerobic microorganisms able to perform biodegradation. Oxygen is considered by many to be the primary growth-limiting factor for hydrocarbon degrading bacteria. Adding oxygen into the subsurface can accelerate naturally occurring aerobic biodegradation. Whereas, adding petroleum hydrocarbons into the subsurface, leads to a quickly depleted oxygen-depleted aquifers (Advanced Oxygen Release Compound 2017).

Enhanced aerobic biodegradation was accomplished by applying ORC Advanced (ORC-A) (Regenesis, San Clemente, CA). ORC-A is an engineered, oxygen release compound designed specifically for enhanced, in situ aerobic bioremediation of petroleum hydrocarbons in groundwater and saturated soils. Upon contact with groundwater, the calcium oxy-hydroxide based material becomes hydrated producing a controlled-release of molecular oxygen (17% by weight) for periods of up to 12 months on a single application. The oxygen produced by ORC Advanced accelerates aerobic biodegradation processes up to 100 times faster than natural degradation rates (Advanced Oxygen Release Compound 2017).

ORC uses a controlled release technology which slows the reaction that yields oxygen within the crystal. This can minimize the waste of oxygen through the release of big bursts which can cause undesirable foaming and produce unwanted preferential flow paths in the subsurface (CRT 2017).

### **2.2.2 Implementation of Remediation Technology**

Between November 2015 and May 2016, source removal activities were conducted in three stages. These activities included removal the USTs, canopy, dispensers and associated underground fuel lines. Soils in the area of the UST system were screened with a calibrated organic vapor analyzer equipped with a photoionization detector (RAE Systems, San Jose, CA) to evaluate soil quality during removal of the USTs. Inspection of the soils revealing hydrocarbon sheens, odors and hydrocarbon vapors above 100 parts per million (ppm) were excavated. Soils were excavated to a depth of approximately ten feet BLS in the USTs pit, and three feet BLS along the fuel lines and dispensers. The water level inside the tank pit was measured at 2.5 feet BLS (Aerostar 2017). Details of each excavation event is included in Table 4.

**Table 7. Excavation Event Summary Table**

<b>Event</b>	<b>Volume Removed</b>	<b>Additional Activities</b>
First Excavation (November to December 2015)	153 m <sup>3</sup>	Removal of USTs, fuel lines, canopy, and dispensers. 11,356-gallons of petroleum impacted water removed from tank pit
Second Excavation (April 2016)	199 m <sup>3</sup>	Addition of 200 kilograms of Regenesis ORC-A into the excavation

Third Excavation (May 2016) (Aerostar 2017)	83 m <sup>3</sup>	Removal of additional fuel lines
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### ***2.2.3 Monitoring Effects if the Remediation Technology***

Between November and December, 2015 four new permanent monitor wells were installed. Two monitor wells (MW-19 and MW-20) were installed to evaluate groundwater in the area of the tank pit, and two monitor wells (MW-3R and MW-5R) were installed to replace wells destroyed during the excavation.

During the soil excavation events, confirmatory soil samples were collected to confirm petroleum impacted soil. Additional soil was excavated until confirmatory soil results showed all concentrations below regulatory levels (Aerostar 2017).

## **2.3 Method Three - Sorption and Enhanced Aerobic Biodegradation**

### ***2.3.1 Review of Remediation Technology***

The third remediation technology chosen was a combination of sorption and enhanced aerobic biodegradation. Sorption is the chemical and physical process in which one substance becomes attached to another. This was accomplished by injecting PlumeStop Liquid Activated Carbon (PlumeStop) (Regenesis, San Clemente, CA) and ORC-A (Plumestop Technical Bulletin 3.1 2016).

PlumeStop is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of patented organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix binding to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation (PlumeStop Technical Bulletin 4.1 2016).

Activated carbon is primarily composed of any organic material with a high carbon content. The carbon-based material is converted to activated carbon through physical modification and thermal decomposition in a furnace, under a controlled atmosphere and temperature. The finished product has a large surface area per unit volume and a network of submicroscopic pores where adsorption takes place (Activated Carbon Basics 2017). Activated carbon primarily removes contaminants from liquid by physical adsorption. Carbon's large surface area per unit volume allows for contaminants to adhere to the activated carbon media. The large internal surface area of carbon has several attractive forces that work to attract other molecules. Physical adsorption occurs because all molecules exert attractive forces, especially molecules at the surface of a solid (pore walls of carbon), and these surface molecules seek to adhere to other molecules (PlumeStop Liquid Activated Carbon 2017).

The dissolved adsorbate migrates from the solution through the pore channels to reach the area where the strongest attractive forces are located. Contaminants adsorb because the attraction of the carbon surface for them is stronger than the attractive forces that keep them dissolved in solution. Those compounds that exhibit this preference to adsorb are able to do so when there is enough energy on the surface of the carbon to overcome the energy needed to adsorb the contaminant (Activated Carbon Basics 2017).

Once the contaminants are captured within the high surface area biodegradation can take place. The PlumeStop technology creates a favorable geochemical environment that enhances biodegradation, which in turn can result in the reactivation of the carbon itself (PlumeStop Liquid Activated Carbon 2017).

A description ORC-A included in 2.2.1, while details of its application is included in Section 2.3.2

### ***2.3.2 Implementation of Remediation Technology***

On April 25, 2015, prior to commencing injecting activities, Aerostar abandoned temporary monitor well SB-1 and replaced it by drilling and installing a new two-inch diameter monitor well (MW-21) (Aerostar 2017).

On May 17, 2016, a total of 24 injection points were advanced for the PlumeStop injections and an additional 20 injection points for the ORC-A injections. The injection points were located around monitor wells MW-3R, MW-5R, and MW-21 (Aerostar 2017).

Between May 17 and 20, 2016, Aerostar injected a total of 2,725 liters (2,722 kilograms) of PlumeStop and 121 liters (327 kilograms) of ORC-A into to ground. The injection locations are presented in Supplemental Material S-5 (Aerostar 2017).

### ***2.3.3 Monitoring Effects of the Remediation Technology***

On July 19, 2016, the first round of post remediation groundwater sampling was conducted. Groundwater samples were collected from five monitor wells (MW-3R, MW-5R, and MW-19, MW-20, and MW-21) to monitor the effectiveness of the injections (Aerostar 2017).

On October 26, 2016, Aerostar collected the second round of post remediation groundwater sampling. Aerostar collected groundwater samples from twenty monitor wells (MW-1, MW-2, MW-3R, MW-5R, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-21, and SB-2 (Aerostar 2017).

## **III Results**

### **3.1 Method One**

From April 2012 to February 2015, groundwater samples were collected to monitor water quality throughout the remediation activities. Details of the groundwater laboratory analytical results are included in Supplemental Material S-1. Results are referenced from Aerostar Remedial Implementation Reports 2013 through 2017.

#### ***3.1.1 First Round of Injection***

On April 18, 2012, during the Perozone<sup>®</sup> system injection, one round of groundwater samples were collected to monitor the effectiveness of the injection. Laboratory analytical results for the groundwater samples collected from monitor well MW-3 showed a naphthalene concentration of 49.8 µg/L, above the respective FDEP GCTL of 14 µg/L. Results showed a decrease in hydrocarbon concentrations as compared with the baseline sampling conducted in May 2011 and February 2012. Laboratory analytical results for the groundwater samples



collected from monitor well MW-5 showed benzene and MTBE concentrations of 38.3 µg/L and 19.3 µg/L, above their respective PREQB WQS of 5 µg/L and 12 µg/L. Results showed a decrease in hydrocarbon concentrations compared to the baseline sampling conducted in February 2012. Laboratory analytical results for the groundwater samples collected from monitor well MW-9 showed a naphthalene concentration of 16.9 µg/L, above the FDEP GCTL of 14 µg/L. The naphthalene concentration decreased compared to the baseline sampling conducted in February 2012.

On June 18 and 20, 2012, during the Perozone<sup>®</sup> system injection, a second round of groundwater samples were collected to monitor the effectiveness of the injection. Laboratory analytical results for the groundwater samples collected from monitor well MW-3 showed a naphthalene concentration of 47.7 µg/L, above the FDEP GCTL of 14 µg/L. In general, hydrocarbon concentrations continued decreasing as compared with the previous sampling event. Laboratory analytical results for the groundwater samples collected from monitor well MW-5 showed benzene and MTBE concentrations of 25.6 µg/L and 22.3 µg/L, above their respective PREQB WQS of 5 µg/L and 12 µg/L. Except for an increase in benzene concentrations, concentrations of chemicals of concern continued decreasing as compared with the previous sampling event. Laboratory analytical results for the groundwater samples collected from monitor well SB-2 showed a benzene concentration of 10.3 µg/L, above the PREQB WQS of 5 µg/L. Results showed an increase in benzene concentrations as compared with the previous sampling event.

On September 24 and 25, 2012, the first round of post remediation samples were collected. Laboratory analytical results of the groundwater samples collected from monitor well MW-2 showed a naphthalene concentration of 19.3 µg/L, above the FDEP GCTL of 14 µg/L. The naphthalene concentration increased since the June 2012 sampling event. Laboratory analytical results of the groundwater samples collected from monitor well MW-3 showed a naphthalene, concentration of 213 µg/L, above the FDEP GCTL of 14 µg/L. The naphthalene concentration increased since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well MW-5 showed a benzene concentration of 20.1 µg/L, above the PREQB WQS of 5 µg/L; and a naphthalene concentration of 80.8 µg/L, above the FDEP GCTLs of 14 µg/L. The benzene concentration decreased since the previous sampling event. The naphthalene concentration increased since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well SB-1 showed a naphthalene concentration of 71.8 µg/L, above the FDEP GCTL of 14 µg/L. The naphthalene concentration increased since the June 2012 sampling event.

On December 11 and 12, 2012, a second round of post remediation groundwater sampling were collected. Laboratory analytical results of the groundwater samples collected from monitor well MW-3 showed a naphthalene concentrations of 276 µg/L, above the FDEP GCTL of 14 µg/L. The CoC concentrations increased slightly or remained relatively the same since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well MW-5 showed a benzene concentration of 14.3 µg/L, above the PREQB WQS of 5 µg/L; and a naphthalene concentration of 49.5 µg/L, above the FDEP GCTL of 14 µg/L. The benzene and naphthalene concentrations decreased since the September 2012 sampling event.

### **3.1.2 Second Round of Injection**

Based on the analytical results, Aerostar recommended a second round of Perozone<sup>®</sup> system injection.

On March 11, 2014, prior to initiating the second round of Perozone<sup>®</sup> system injection, a round of groundwater samples were collected to establish a new baseline before the second injection. Laboratory analytical results of the groundwater samples collected from monitor well MW-3 showed a naphthalene, concentration of 216 µg/L, above the FDEP GCTLs of 14 µg/L. The naphthalene concentration decreased from since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well MW-5 showed a benzene concentration of 32.1 µg/L, above the PREQB WQS of 5 µg/L; and a naphthalene concentration of 109 µg/L, above the FDEP GCTL of 14 µg/L. The benzene and naphthalene concentrations increased since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well SB-1 showed a naphthalene concentration of 48.9 µg /L. The naphthalene concentration has increased since the last sampling event.

On August 28, 2014, during the Perozone<sup>®</sup> system injection, one round of groundwater samples were collected to monitor the effectiveness of the injection. Laboratory analytical results of the groundwater samples collected from MW-3 showed a benzene concentration of 5.31 ug/L, above the PREQB WQS of 5 µg/L. The benzene concentration is a slight increase from the last sampling event. Laboratory analytical results of the groundwater samples collected from MW-5 showed a benzene concentration of 15.5 ug/L, above the PREQB WQS of 5 µg/L. The benzene concentration is a decrease from the last sampling event.

On December 12 2014, during the Perozone<sup>®</sup> system injection, a second round of groundwater samples were collected to monitor the effectiveness of the injection. Laboratory analytical results of the groundwater samples collected from MW-3 showed benzene and TPH-GRO concentrations of 6.33 µg/L and 55.42 mg/L, above their respective PREQB WQS of 5 µg/L and 50 mg/L. The benzene concentration is a slight increase from the August 2014, while the exceedance in TPH-DRO is the first exceedance recorded.

On February 24, 2015, after six months of injection, Aerostar collected a round of post injection groundwater sampling. Laboratory analytical results of the groundwater samples collected from monitor well MW-3 showed a naphthalene, concentration of 252 µg/L, above the FDEP GCTLs of 14 µg/L. The naphthalene concentration increased from since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well MW-5 showed a benzene concentration of 24.64 µg/L, above the PREQB WQS of 5 µg/L; and a naphthalene concentration of 97.3 µg/L, above the FDEP GCTL of 14 µg/L. The benzene and naphthalene concentrations increased since the previous sampling event. Laboratory analytical results of the groundwater samples collected from monitor well SB-1 showed a naphthalene concentration of 48.8 µg/L. The naphthalene concentration has remained steady since the last sampling event.

### **3.1.3 Results April 2012 to February 2015**

The remediation system reduced the dissolved hydrocarbon concentrations in monitor wells MW-9, and SB-2 to below regulatory levels. Laboratory analytical results of monitor well SB-1 showed a steady concentration of naphthalene above the FDEP GCTL throughout the remediation process.

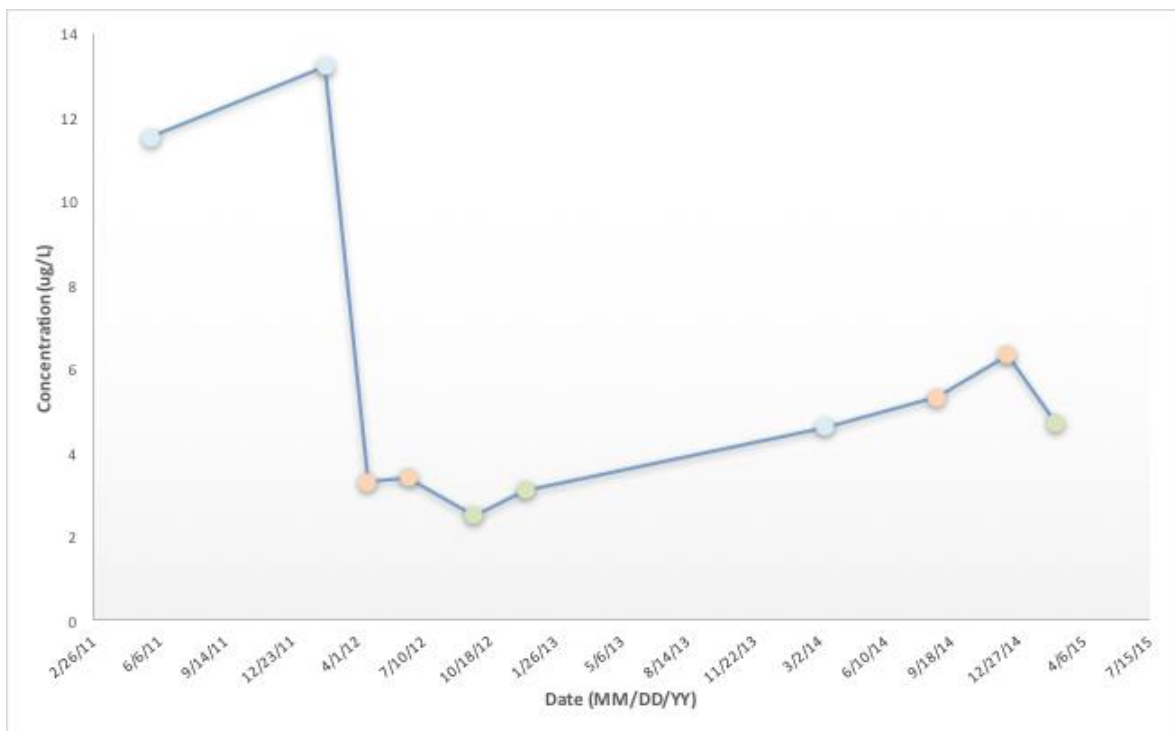


Figure 1: Benzene concentration levels in µg/L at monitor well MW3 from May 2011 to February 2015. The base line, remediation and post remediation are represented by Blue, Orange and Green circles, respectively.

Monitor well MW-3 showed a sharp decrease in benzene concentration after the injection started. Benzene concentrations rebounded, but settled below the PREQB UST WQS of 5 µg/L (Figure 1).

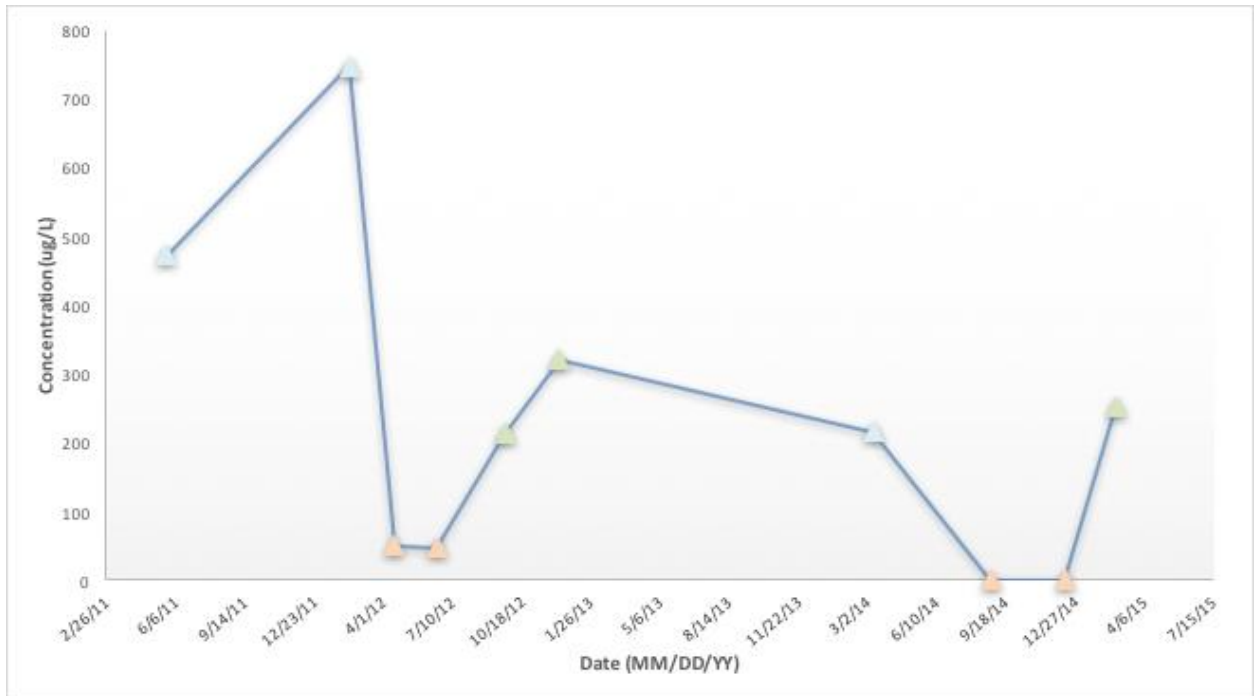


Figure 2: Naphthalene concentration levels in µg/L at monitor well MW3 from May 2011 to February 2015. The base line, remediation and post remediation are represented by Blue, Orange and Green triangles, respectively.

Naphthalene initially showed a sharp decrease after injection started, followed by an initial rebound, but showing a concentration below PREQB UST WQS during the end of injection. However, the naphthalene concentration rebounded during post remediation sampling to 252 µg/L, above the FDEP GCTL of 14 µg/L (Figure 2). Although the naphthalene concentration remained above FDEP GCTLs, it was reduced approximately by 64%.

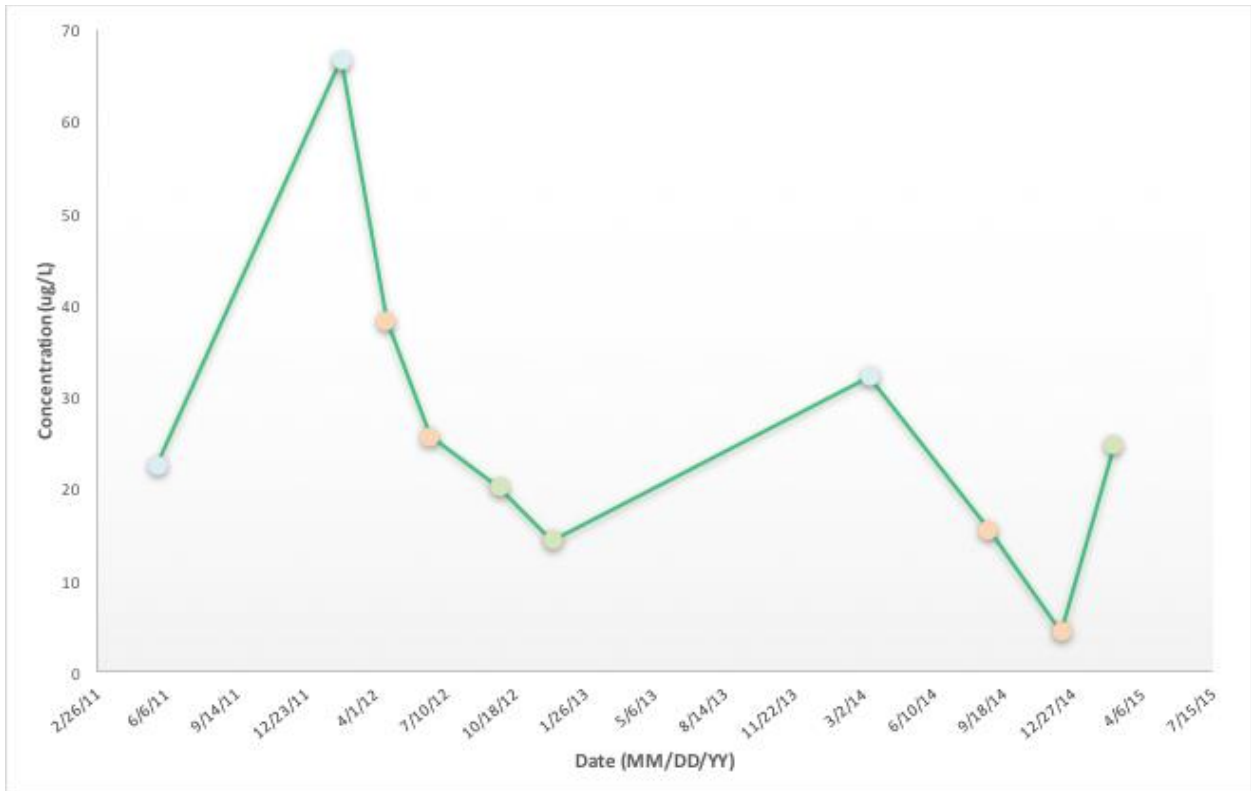


Figure 3: Benzene concentration levels in µg/L at monitor well MW5 from May 2011 to February 2015. The base line, remediation and post remediation are represented by Blue, Orange and Green circles, respectively.

Monitor well MW-5 showed a sharp decrease in benzene concentration after the injection started. The benzene concentration fell below the PREQB UST WQS during the end of injection. However, the benzene concentration rebounded during post remediation sampling to 24.64 µg/L, above the PREQB UST WQS of 5 µg/L (Figure 3). Although the benzene concentration remained above PREQB UST WQS, it was reduced approximately 63%.

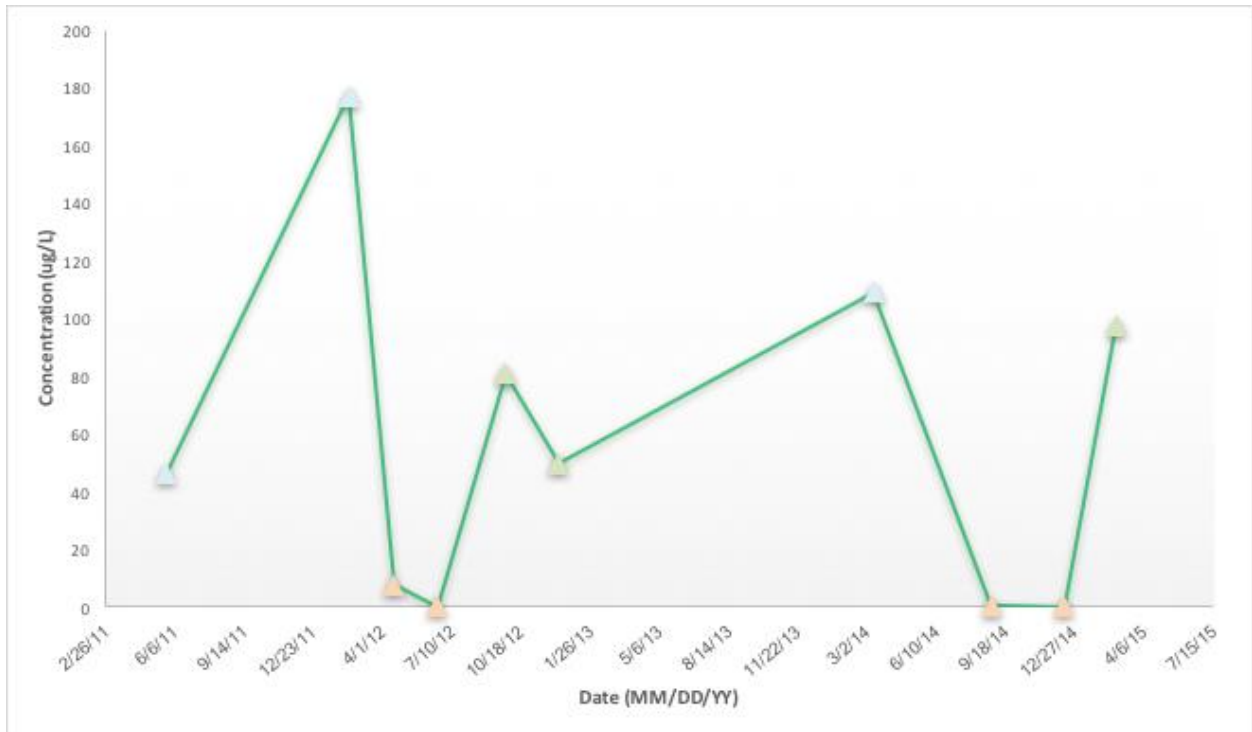


Figure 4: Naphthalene concentration levels in µg/L at monitor well MW-5 from May 2011 to February 2015. The base line, remediation and post remediation are represented by Blue, Orange and Green triangles, respectively.

Monitor well MW-5 initially showed a sharp increase after injection started. The naphthalene concentration fluctuated before falling below PREQB UST WQS during the end of injection. However, the naphthalene concentration rebounded during post remediation sampling to 97.3 µg/L, above the FDEP GCTL of 14 µg/L (Figure 4). Although the naphthalene concentration remained above FDEP GCTLs, it was reduced approximately 45%.

### 3.2 Method Two

On November 24, 2015, confirmatory soil samples (SS-01 through SS-14) were collected from the walls and floors of the excavation for laboratory analysis. Laboratory analytical results of the soil sample collected from the excavation wall, north of the former tank pit (SS-01-4'), the excavation wall, west of the former tank pit (SS-02-4), and at the former dispenser area (SS-08-2.5, SS-11-1.5', and SS-12-1.5), showed concentrations of benzene, ethylbenzene, benzo(a)pyrene, and naphthalene above their respective PREQB protection of groundwater screening levels.

The laboratory analytical results for the remaining soil samples (see Supplemental Material S-6) showed no concentrations above PREQB cleanup screening level (Aerostar 2017).

#### *Second Excavation*

On April 28, 2016, confirmatory soil samples (SS-15 through SS-22) were collected to ensure all of the impacted soil was excavated. Laboratory analytical results of the soil sample collected along the northwestern wall along Howard Drive (SS-16-3.5'), and the southern wall

of the extended excavation (SS-18-3.5') showed ethylbenzene and naphthalene concentrations above their PREQB UST residential screening level. The ethylbenzene concentration was also above the PREQB UST industrial screening level.

During the May 2016 excavations, additional soil was excavated and backfilled along the wall where soil sample SS-18-3.5' was collected; however, at the time of the May 2016 excavation, a confirmatory soil sample was not collected. In October 2016, during the second round of groundwater sampling, a confirmatory soil sample (SS-28) was collected at the 3.5 foot depth along the wall of the extended excavation near soil sample SS-18-3.5'. The laboratory analytical results for confirmatory soil sample SS-28 showed no concentrations above PREQB UST cleanup screening levels.

A soil sample (SS-19-3.5) was collected along the western wall of the dispenser excavation. Laboratory analytical results for soil sample SS-19-3.5' showed a naphthalene concentration above the PREQB UST residential screening level. The excavation was extended on May 3, 2016, along the western wall to remove the fiberglass fuel lines and impacted soil. Soil samples SS-23 and SS-24 were collected to confirm removal of impacted soil. The laboratory analytical results for confirmatory soil sample SS-23 and SS-24 showed no concentrations above PREQB UST cleanup screening levels.

The laboratory analytical results for the remaining confirmatory soil samples showed no concentrations above PREQB UST cleanup screening levels (Supplemental Material S-6) (Aerostar 2017).

### **3.3 Method Three**

On July 19, 2016, the first round of post remediation groundwater sampling was conducted. Groundwater samples were collected from five monitor wells (MW-3R, MW-5R, and MW-19, MW-20, and MW-21) to monitor the effectiveness of the injections. Laboratory analytical results of the groundwater samples collected from monitor well MW-3R showed a naphthalene concentration of 114 µg/L, above the FDEP GCTLs of 14 µg/L. The naphthalene concentration increased from since the February 2015 sampling event. The laboratory analytical results for the remaining monitor wells showed no concentrations above 2014 PREQB UST WQS or FDEP GCTLs.

On October 26, 2016, Aerostar collected the second round of post remediation groundwater sampling. Aerostar collected groundwater samples from twenty monitor wells (MW-1, MW-2, MW-3R, MW-5R, MW-6, MW-9, MW-10, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-21, and SB-2). Laboratory analytical results for groundwater sample MW-5R, showed benzene and naphthalene concentrations of 7.5 µg/L and 14.6 µg/L, respectively, above their respective PREQB UST WQS of 5 µg/L and 14 µg/L. The benzene and naphthalene concentrations increased slightly above PREQB UST WQS. The laboratory analytical results for the remaining monitor wells showed no concentrations above 2014 PREQB WQS or FDEP GCTLs.

Overall, the dissolved hydrocarbon concentrations decreased in the target monitor wells. Monitor well MW-3R continued with the decreasing trend of benzene concentrations below the PREQB UST WQS. Monitor well MW-3R also showed a decrease in naphthalene concentration from 252 µg/L prior to remediation to 12.8 µg/L, an overall reduction of approximately 95%. Monitor well MW-5R initially showed a decrease in benzene concentration to below the PREQB UST WQS; however, the benzene concentration slightly rebounded to 7.5 µg/L. Although the benzene concentration remains above the PREQB UST WQS, it showed an overall decrease of approximately 70% since the February 2015 sampling event. Monitor well MW-5R also initially showed a decrease in naphthalene concentration to below the PREQB UST WQS; however, the naphthalene concentration slightly rebounded to 14.6 µg/L. Although the benzene concentration remains above the PREQB UST WQS, it showed an overall decrease of approximately 85% since the February 2015 sampling event. The concentration of naphthalene in monitor well MW-21 decreased to show two consecutive results below the PREQB UST screening level, for an overall decrease of approximately 86% since the 2015 sampling event (Aerostar 2017).

### **3.4 Overall Results**

The initial remediation and monitoring took place between May 2011 and October 2016. Between February and August 2012, groundwater remediation was conducted using in-situ chemical oxidation consisting of a combination of liquid hydrogen peroxide and ozone gas (Perozone) injected into the subsurface to remediate the petroleum impacted groundwater and soil. Between June and December 2014, a second round of groundwater remediation was conducted using Perozone. The Perozone system reduced the dissolved hydrocarbon concentrations in monitor wells MW-9, and SB-2 to below regulatory levels. Laboratory analytical results of monitor well SB-1 showed steady concentrations above the FDEP GCTL throughout the remediation process. Monitor well MW-3 showed a decrease in benzene to below regulatory levels, and a reduction in naphthalene by 64%. Monitor well MW-5 showed a decrease in benzene and naphthalene by approximately 63% and 45%, respectively.

The second remediation and monitoring event took place between November 2015 and May 2016, and involved removing the USTs, dispensers, fuel lines, and associated contaminated soil. The source removal was conducted until soil samples confirmed all accessible impacted soil was removed. Soil impacts shown in soil sample SS-16-3.5' was not removed due to the proximity to Howard Drive.

The third remediation and monitoring event took place between May 2016 and October 2016, and involved the injection of Plumestop and ORC-A. Monitor well MW-3R continued with the decreasing trend of benzene concentrations below the PREQB UST WQS. Monitor well MW-3R also showed a decrease in naphthalene concentration of approximately 95%. Monitor well MW-5R showed an overall decrease of approximately 70%. Monitor well MW-5R also showed an overall decrease of approximately 85%. The concentration of naphthalene in monitor well MW-21 decreased to show two consecutive results below the PREQB UST screening level, for an overall decrease of approximately 86%.

At the conclusion of the remediation and monitoring events, concentrations above regulatory levels still exist in monitor wells MW-3R (naphthalene) and MW-5R (benzene and



naphthalene). Figure 5 is a graphical representation of the benzene concentration reported in monitor wells MW-3/3R and MW-5/5R at baseline, during remediation, and post remediation. We compared three models, a linear, exponential, second degree polynomial to fit the benzene concentrations. The linear and exponential models were the best model to describe the decreasing trend of benzene in monitor wells MW-3/3R and MW-5/5R, respectively. However, the percentage of variability explained by these models remained low (25% and 53%, respectively) and therefore must be used with caution when it comes to projections for future level of contamination. Figure 6 is a graphical representation of the naphthalene concentration reported in monitor wells MW-3/3R and MW-5/5R at baseline, during remediation, and post remediation. The second degree polynomial trend line fits the naphthalene the best in monitor wells MW-3/3R and MW-5/5R. With the trend being positive then negative for wells MW-3/3R and positive then negative for well MW-5/5R.

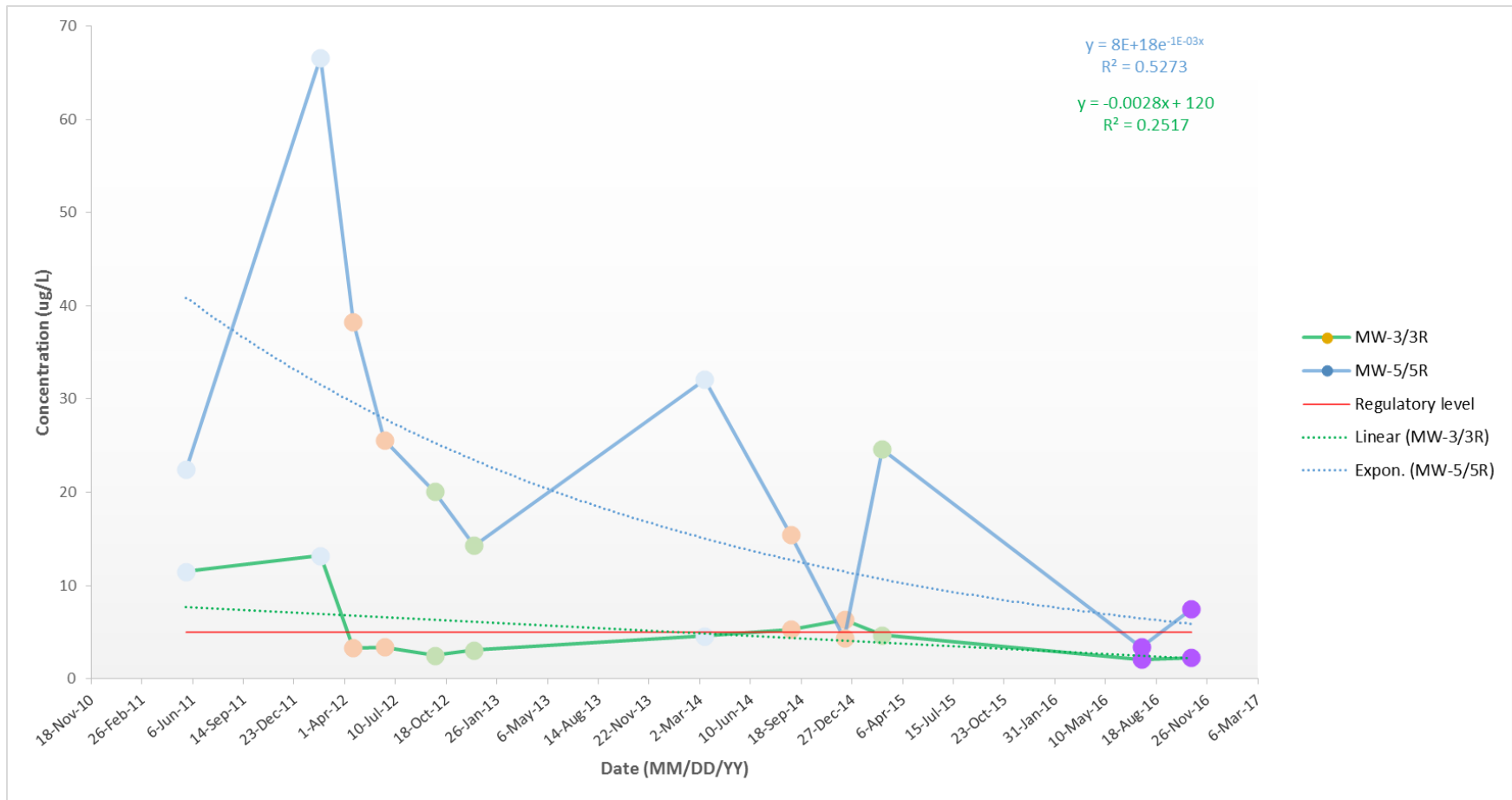


Figure 5: Trend in Benzene concentration (µg/L) in MW-3 (Blue) and MW-5 (Green). Base line concentrations (Blue circle), during remediation concentration (Orange circle), Method 1 post remediation concentration (Green circle), Method 2 and 3 post remediation (purple circle) from May 2011 to October 2016.

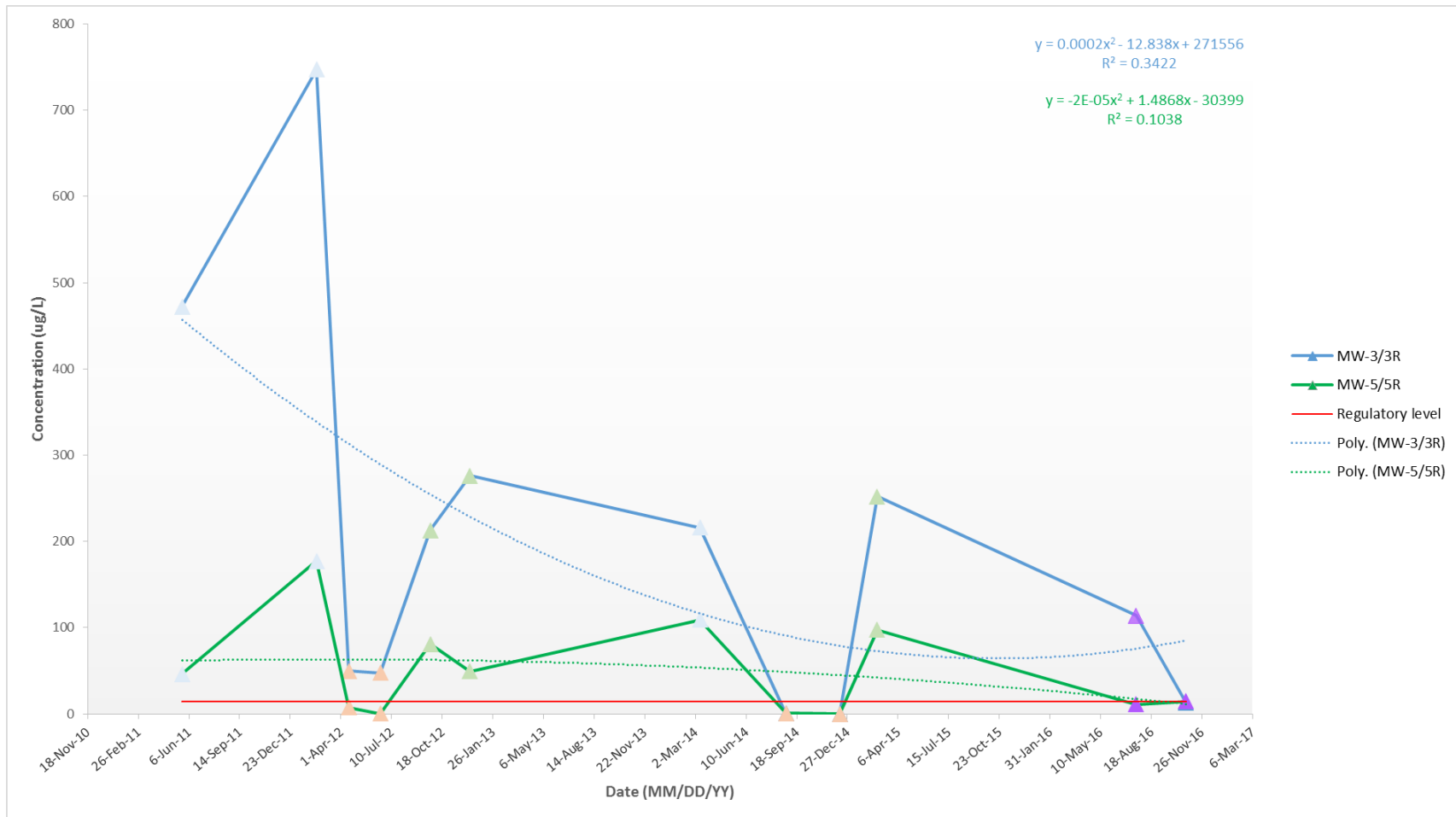


Figure 6: Trend in Naphthalene concentration (µg/L) in MW-3 (Blue) and MW5 (Green). Base line concentrations (Blue triangle), during remediation concentration (Orange triangle), Method 1 post remediation concentration (Green triangle), Method 2 and 3 post remediation (purple triangle) from May 2011 to October 2016.



## IV Discussion

Remediation and monitoring activities took place between May 2011 and October 2016. Three main methods (in situ chemical oxidation, source removal/enhanced biodegradation, and sorption/enhanced biodegradation) of remediation were applied in an attempt to lower hydrocarbon concentration in the soil and groundwater below regulatory levels.

In situ chemical oxidation was effective in removing high concentrations of contaminants in the wells onsite. Laboratory analytical results generally showed dissolved hydrocarbon concentrations decrease significantly from samples collected while the remediation system was still active. However, after the remediation system was shut down, concentrations rebounded back to above regulatory levels. This pattern implies that a source remained onsite contributing to reemergence of the dissolved hydrocarbon concentrations. This source could be a contaminated soil onsite, or an UST system that is continuing to leak. Information concerning soil samples collected before the remediation was implemented and records of integrity tests on the UST system were unavailable for review.

Petroleum impacted soil was encountered during the removal of the UST, fuel lines, and dispensers. The presence of the petroleum impacted soil supports the idea that a source of contamination remained onsite during the chemical oxidation injection and contributed to the concentration increase after the injection system was shut down.

The combination of Plumstop and ORC-A introduced into the groundwater have further decreased dissolved hydrocarbons onsite. As of the last sampling event, the only concentrations that remain above regulatory levels are naphthalene for MW-3R, and benzene and naphthalene for MW-5R.

Concentrations of benzene and naphthalene for monitor wells MW-3/3R and MW-5/5R were plotted to reveal trends in the data. The benzene concentrations in monitor well MW-3/3R showed a linear trend with a slightly negative slope, the model explained 25% of the variability present in the data. This implies that the benzene concentration will probably remain stable around a mean at or below regulatory levels. The benzene concentrations in monitor well MW-5/5R showed exponential trend with a negative slope and the model explained 53% of the variability present in the data. This indicates that the benzene will decrease to below regulatory levels without further remediation efforts. The naphthalene concentrations in monitor well MW-3/3R showed a polynomial trend with negative trend followed by a positive trend. Here 34% of the variability present in the data was explained by this model. This suggests that the naphthalene concentration has a possibility to increase and may need further remediation even though laboratory analytical results after the last remediation event showed a sharp decrease in concentration levels. Additional groundwater samples will be needed to confirm the effectiveness of the remediation. The naphthalene concentrations in monitor well MW-5/5R showed a polynomial trend with a positive slope followed by a negative slope with 10% of variability explained. This implies that the naphthalene concentration will decrease to below regulatory levels without further remediation efforts. The high variance in the data set attributes to the lower R-square value.

In conclusion, remediation at the site has been overall effective. The efficiency of the remediation efforts seemed to be limited early on a continuing source of contamination, and the site being an active fueling station. Although additional groundwater sampling is needed to confirm the effectiveness of the remediation efforts, the outlook is positive for closure of the site in the near future.

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## **SUPPLEMENTAL MATERIAL**



Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID		MW-2											35273096010	
				Lab ID		1710476	1828775	1861944	1861941 (DUP-01)	1883633	1936072	1975388	2178106	AT-14-7869	AT-14-11641	AT-15-1936		
				Sample Date	7/18/2005	2/27/2007	5/24/2011	2/14/2012	4/16/2012	4/16/2012	6/18/2012	9/24/2012	12/11/2012	3/11/2014	8/26/2014	12/11/2014		2/24/2015
				PREVIOUS INVESTIGATION		BASELINE		DURING REMEDIATION			POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION	10/26/2016	
<b>VOC - Method 5035/8260B</b>																		
Benzene	5	1	ug/L		0.23 J	0.54 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	2.0 U	2.0 U	2.0 U	0.10 U
Toluene	1000	40	ug/L		0.20 U	0.62 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.1 U	2.1 U	2.1 U	0.50 U
Ethylbenzene	530	30	ug/L		0.20 U	0.62 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.7	0.2 U	0.2 U	2.4 U	2.4 U	2.4 U	0.50 U
Xylenes (Total)	10000+	10000	ug/L		0.35 U	1.3 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	4.5 U	2.6 U	2.6 U	1.0 U
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L		0.20 U	NA	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.60 U	0.60 U	0.60 U	0.50 U
<b>SVOC - Method 3541/8270C</b>																		
Acenaphthene	670	20	ug/L		0.33 U	0.0015 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.52 U	0.081 U	0.20 U	0.025 U
Anthracene	8300	2100	ug/L		0.22 U	0.011 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.3 U	0.15 U	0.80 U	0.025 U
Benzo(a)anthracene	0.038	0.05	ug/L		0.16 U	0.013 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.70 U	0.20 U	0.20 U	0.025 U
Benzo(a)pyrene	0.038	0.2	ug/L		0.098 U	0.015 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.1 U	0.10 U	0.20 U	0.025 U
Benzo(b)fluoranthene	0.038	0.05	ug/L		0.11 U	0.039 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.6 U	0.20 U	0.20 U	0.025 U
Benzo(g,h,i)perylene	NE	210	ug/L		0.078 U	0.022 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.5 U	0.13 U	0.20 U	0.028 U
Benzo(k)fluoranthene	0.038	0.5	ug/L		0.16 U	0.034 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.0 U	0.22 U	0.20 U	0.025 U
Chrysene	0.038	4.8	ug/L		0.14 U	0.014 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.68 U	0.17 U	0.80 U	0.025 U
Fluoranthene	130	280	ug/L		0.17 U	0.0082 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.48 U	0.062 U	0.20 U	0.025 U
Fluorene	1100	280	ug/L		0.28 U	0.012 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.85 U	0.090 U	0.20 U	0.025 U
Naphthalene	NE	14	ug/L		0.27 U	0.0091 U	0.2 U	0.2 U	0.2 U	0.2 U	2.80	19.3	1.50	0.2 U	0.52 U	0.026 U	0.20 U	1.0 U
Phenanthrene	NE	210	ug/L		0.20 U	0.0082 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4 U	0.16 U	0.20 U	NA
Pyrene	830	210	ug/L		0.17 U	0.0083 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.32 U	0.051 U	0.20 U	0.025 U
<b>TPH - Method 8015 B</b>																		
DRO (C10-C28)	50	5	mg/L		0.93	0.67	4 U	0.13 U	0.13 U	0.13 U	1.12	2.31	1.28	0.125 U	0.261 U	0.25 U	0.25 U	
GRO (C6-C10)	50	5	mg/L		0.025 J	0.0079 U	0.044	0.169	0.0705	0.0583	0.719	0.234	0.0765	0.050 U	0.167 U	0.1672 U	0.17 U	

UST Removal, Soil Remediation, and PlumeStop/ORC-A Injection

**Data Qualifiers:**

U - Not detected at the Reporting Limit (RL)  
J - The result is an estimate concentration that is < RL but ≥ MDL

**Units:**

ug/L - micrograms per liter (ppb)  
mg/L - milligrams per liter (ppm)

**Notes:**

NA - Not Analyzed  
NE - No screening level established  
PREQB Water Quality Standard - March 2010  
FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)  
**BOLD** - detections  
Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL  
+ PREQB UST Standard

Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID	MW-3												MW-3R	
				Lab ID			1710477	1827481	1861945	1883634	1936062	1976325	2178923	AT-14-7948	AT-14-11654	AT-15-1937	35255742002	35273096017
				Sample Date	7/19/2005	2/23/2007	5/24/2011	2/13/2012	4/17/2012	6/18/2012	9/25/2012	12/12/2012	3/11/2014	8/28/2014	12/12/2014	2/24/2015	7/19/2016	10/26/2016
				PREVIOUS INVESTIGATION	BASELINE		DURING REMEDIATION		POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION	First Round POST REMEDIATION	Second Round POST REMEDIATION		
<b>VOC - Method 5035/8260B</b>																		
Benzene	5	1	ug/L	2.9	28	11.5	13.2	3.30	3.40	2.50	3.10	4.60	5.31	6.33	4.69	2.1	2.3	
Toluene	1000	40	ug/L	0.53 J	12 U	4.30	3.30	0.8	0.2 U	1.10	1.0 U	1.00	2.1 U	2.1 U	2.1 U	0.50 U	0.50 U	
Ethylbenzene	530	30	ug/L	20	190	130	110	22.8	44.0	31.3	37.2	38.7	31.7	36.92	2.4 U	10.7	0.56 I	
Xylenes (Total)	10000+	10000	ug/L	0.40 J	26 U	3.5 U	0.7 U	0.2	0.7 U	1.60	3.5 U	1.10	4.5 U	2.6 U	<2.62	1.0 U	1.0 U	
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L	1.3	NA	5 U	1.80	1.0 U	1.0 U	1.0 U	5.0 U	1.0 U	0.60 U	0.60 U	0.60 U	0.50 U	0.93 I	
<b>SVOC - Method 3541/8270C</b>																		
Acenaphthene	670	20	ug/L	1.7 L	1.3 J	1.20	1.10	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.49 U	0.081 U	0.20 U	0.31 I	0.14 I	
Anthracene	8300	2100	ug/L	1.3 J	0.10 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.2 U	0.15 U	0.80 U	0.032 I	0.025 U	
Benzo(a)anthracene	0.038	0.05	ug/L	0.16 U	0.13 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.67 U	0.20 U	0.20 U	0.025 U	0.025 U	
Benzo(a)pyrene	0.038	0.2	ug/L	0.098 U	0.15 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.1 U	0.10 U	0.20 U	0.025 U	0.025 U	
Benzo(b)fluoranthene	0.038	0.05	ug/L	0.11 U	0.39 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.4 U	0.20 U	0.20 U	0.025 U	0.025 U	
Benzo(g,h,i)perylene	NE	210	ug/L	0.078 U	0.22 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4 U	0.13 U	0.20 U	0.028 U	0.028 U	
Benzo(k)fluoranthene	0.038	0.5	ug/L	0.16 U	0.34 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.97 U	0.22 U	0.20 U	0.025 U	0.025 U	
Chrysene	0.038	4.8	ug/L	0.14 U	0.14 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.65 U	0.17 U	0.80 U	0.025 U	0.025 U	
Fluoranthene	130	280	ug/L	0.17 U	0.080 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.46 U	0.062 U	0.20 U	0.025 U	0.025 U	
Fluorene	1100	280	ug/L	5.6 J	3.3	3.70	3.00	0.2 U	0.2 U	1.40	0.8	0.2 U	0.81 U	0.090 U	0.20 U	0.83	0.20 I	
Naphthalene	NE	14	ug/L	1200	670	472	747	49.8	47.7	213	276	216	0.49 U	0.026 U	252	114	12.8	
Phenanthrene	NE	210	ug/L	1.5 J	0.86 J	1.10	0.9	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4 U	0.16 U	0.20 U	0.24 I	NA	
Pyrene	830	210	ug/L	0.17 U	0.081 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.30 U	0.051 U	0.20 U	0.025 U	0.025 U	
<b>TPH - Method 8015 B</b>																		
DRO (C10-C28)	50	5	mg/L	11	7.6	4 U	5.92	2.07	1.99	3.73	4.57	3.57	5.00	7.44	3.88	NA	NA	
GRO (C6-C10)	50	5	mg/L	13	2.2	2.6	2.98	1.336	1.127	1.608	1.568	2.164	4.070	55.42	0.17 U	NA	NA	

UST Removal, Soil Remediation, and PlumeStop/ORC-A Injection

**Data Qualifiers:**  
U - Not detected at the Reporting Limit (RL)  
J - The result is an estimate concentration that is < RL but ≥ MDL

**Units:**  
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**Notes:**  
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NE - No screening level established  
PREQB Water Quality Standard - March 2010  
FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)

**BOLD** - detections  
Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL  
+ PREQB UST Standard

Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID	MW-5											MW-5R		
				Lab ID			1710478	1827482	1861946	1883635	1936064	1975389	2178924	AT-14-7945	AT-14-11643	AT-15-1938	35255742003	35273096019
				Sample Date	7/19/2005	2/23/2007	5/24/2011	2/13/2012	4/17/2012	6/18/2012	9/25/2012	12/11/2012	3/11/2014	8/28/2014	12/11/2014	2/24/2015	7/19/2016	10/26/2016
				PREVIOUS INVESTIGATION	BASELINE		DURING REMEDIATION		POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION	First Round POST REMEDIATION	Second Round POST REMEDIATION		
<b>VOC - Method 5035/8260B</b>																		
Benzene	5	1	ug/L		1200	140	22.5	66.6	38.3	25.6	20.1	14.3	32.1	15.5	4.34	24.64		
Toluene	1000	40	ug/L		31 J	17 J	3.90	8.20	3.7	1.70	3.00	1.0 U	3.70	2.1 U	2.1 U	2.1 U		
Ethylbenzene	530	30	ug/L		760	290	200	215	20.9	12.9	55.3	61.1	10.1	18.9	8.17	2.4 U		
Xylenes (Total)	10000+	10000	ug/L		29 J	26 U	5.00	4.3	2.2	1.50	3.50	3.5 U	1.60	4.5 U	2.6 U	3.06		
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L		70	NA	1.0 U	20.8	19.3	22.3	10.8	7.80	4.80	0.60 U	0.60 U	0.60 U		
<b>SVOC - Method 3541/8270C</b>																		
Acenaphthene	670	20	ug/L		0.53 J	0.42 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.59 U	0.081 U	0.20 U		
Anthracene	8300	2100	ug/L		0.22 U	0.10 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.4 U	0.15 U	0.80 U		
Benzo(a)anthracene	0.038	0.05	ug/L		0.16 U	0.13 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.79 U	0.20 U	0.20 U		
Benzo(a)pyrene	0.038	0.2	ug/L		0.098 U	0.15 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.3 U	0.10 U	0.20 U		
Benzo(b)fluoranthene	0.038	0.05	ug/L		0.11 U	0.39 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.9 U	0.20 U	0.20 U		
Benzo(g,h,i)perylene	NE	210	ug/L		0.078 U	0.22 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.7 U	0.13 U	0.20 U		
Benzo(k)fluoranthene	0.038	0.5	ug/L		0.16 U	0.34 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.1 U	0.22 U	0.20 U		
Chrysene	0.038	4.8	ug/L		0.14 U	0.14 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.77 U	0.17 U	0.80 U		
Fluoranthene	130	280	ug/L		0.17 U	0.080 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.54 U	0.062 U	0.20 U		
Fluorene	1100	280	ug/L		0.81 J	0.69 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.3	0.2 U	0.96 U	0.090 U	0.20 U		
Naphthalene	NE	14	ug/L		780	610	46.4	177	7.60	0.2 U	80.8	49.5	109	0.59 U	0.026 U	97.3		
Phenanthrene	NE	210	ug/L		0.51 J	0.31 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.6 U	0.16 U	0.20 U		
Pyrene	830	210	ug/L		0.17 U	0.081 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.36 U	0.051 U	0.20 U		
<b>TPH - Method 8015 B</b>																		
DRO (C10-C28)	50	5	mg/L		7	6.2	4 U	2.61	1.32	8.07	9.97	8.74	3.45	6.21	2.55	5.2		
GRO (C6-C10)	50	5	mg/L		12	3.7	0.781	2.530	1.627	2.089	1.779	0.902	1.819	3.560	2.29	4.01		

UST Removal, Soil Remediation, and PlumeStop/ORC-A Injection

**Data Qualifiers:**  
 U - Not detected at the Reporting Limit (RL)  
 J - The result is an estimate concentration that is < RL but ≥ MDL

**Units:**  
 ug/L - micrograms per liter (ppb)  
 mg/L - milligrams per liter (ppm)

**Notes:**  
 NA - Not Analyzed  
 NE - No screening level established  
 PREQB Water Quality Standard - March 2010  
 FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)  
**BOLD** - detections  
 Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL  
 + PREQB UST Standard

Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID	MW-9										UST Removal, Soil Remediation, and PlumeStop/ORC-A Injection	35273096004
				Lab ID	1711508	1828776	1862768	1883637	1936797	1976327	2178109	AT-14-7870	AT-14-11644	AT-15-1939		
				Sample Date	5/25/2011	2/14/2012	4/18/2012	6/20/2012	9/26/2012	12/12/2012	3/10/2014	8/26/2014	12/11/2014	2/25/2015		
				BASELINE		DURING REMEDIATION		POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION			
<b>VOC - Method 5035/8260B</b>																
Benzene	5	1	ug/L		1.40	0.3 U	1.20	1.00	1.70	1.5 U	0.3 U	2.0 U	2.0 U	2.0 U	0.62 I	
Toluene	1000	40	ug/L		0.7	0.2 U	0.7	0.2 U	0.2 U	1.0 U	0.2 U	2.1 U	2.1 U	2.1 U	0.50 U	
Ethylbenzene	530	30	ug/L		1.20	0.2 U	0.8	0.2 U	0.2 U	1.0 U	0.6	2.4 J	<2.3551	<2.36	0.69 I	
Xylenes (Total)	10000+	10000	ug/L		0.4	0.7 U	0.6	0.7 U	0.7 U	3.5 U	0.5	4.5 U	2.6 U	2.6 U	1.0 U	
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L		2.10	2.90	3.20	1.0 U	1.0 U	5.50	1.0 U	0.60 U	0.60 U	0.60 U	0.50 U	
<b>SVOC - Method 3541/8270C</b>																
Acenaphthene	670	20	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.47 U	0.081 U	0.20 U	0.093 I	
Anthracene	8300	2100	ug/L		0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.1 U	0.15 U	0.80 U	0.025 U	
Benzo(a)anthracene	0.038	0.05	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.63 U	0.20 U	0.20 U	0.025 U	
Benzo(a)pyrene	0.038	0.2	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.0 U	0.10 U	0.20 U	0.025 U	
Benzo(b)fluoranthene	0.038	0.05	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.3 U	0.20 U	0.20 U	0.025 U	
Benzo(g,h,i)perylene	NE	210	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.3 U	0.13 U	0.20 U	0.028 U	
Benzo(k)fluoranthene	0.038	0.5	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.92 U	0.22 U	0.20 U	0.025 U	
Chrysene	0.038	4.8	ug/L		0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.61 U	0.17 U	0.80 U	0.025 U	
Fluoranthene	130	280	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.43 U	0.062 U	0.20 U	0.025 U	
Fluorene	1100	280	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.77 U	0.090 U	0.20 U	0.18 I	
Naphthalene	NE	14	ug/L		2.00	23.2	16.9	0.2 U	2.80	9.90	13.7	0.48 U	0.026 U	0.20 U	7.2	
Phenanthrene	NE	210	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.3 U	0.16 U	0.20 U	NA	
Pyrene	830	210	ug/L		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.29 U	0.051 U	0.20 U	0.025 U	
<b>TPH - Method 8015 B</b>																
DRO (C10-C28)	50	5	mg/L		4 U	0.91	2.28	1.86	0.13 U	0.85	2.44	0.813	1.31	2.2	NA	
GRO (C6-C10)	50	5	mg/L		0.165	0.556	1.031	1.308	0.0885	0.373	0.278	0.448	1.14	1.16	NA	

**Data Qualifiers:**

U - Not detected at the Reporting Limit (RL)

J - The result is an estimate concentration that is < RL but ≥ MDL

**Units:**

ug/L - micrograms per liter (ppb)

mg/L - milligrams per liter (ppm)

**Notes:**

NA - Not Analyzed

NE - No screening level established

PREQB Water Quality Standard - March 2010

FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)

**BOLD** - detections

Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL

+ PREQB UST Standard

Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID	MW-12									UST Removal, Soil Remediation, and PlumeStop/ORC-A Injection	35273096011
				Lab ID	1830678	1883626	1936793	1976318	2178925	AT-14-7862	AT-14-11646	AT-15-1942			
				Sample Date	7/19/2005	2/17/2012	6/19/2012	9/25/2012	12/12/2012	3/12/2014	8/27/2014	12/11/2014	2/24/2015		
				PREVIOUS INVESTIGATION	DURING REMEDIATION		POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION			
<b>VOC - Method 5035/8260B</b>															
Benzene	5	1	ug/L	<b>830</b>	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	2.0 U	2.0 U	2.0 U	0.10 U		
Toluene	1000	40	ug/L	<b>22 J</b>	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.1 U	2.1 U	2.1 U	0.50 U		
Ethylbenzene	530	30	ug/L	<b>1100</b>	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.4 U	2.4 U	2.4 U	0.50 U		
Xylenes (Total)	10000+	10000	ug/L	<b>22 J</b>	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	4.5 U	2.6 U	2.6 U	1.0 U		
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L	<b>55</b>	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.60 U	0.60 U	0.60 U	0.50 U		
<b>SVOC - Method 3541/8270C</b>															
Acenaphthene	670	20	ug/L	<b>0.54 J</b>	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.58 U	0.081 U	0.20 U	0.025 U		
Anthracene	8300	2100	ug/L	0.22 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.4 U	0.15 U	0.80 U	0.025 U		
Benzo(a)anthracene	0.038	0.05	ug/L	0.16 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.78 U	0.20 U	0.20 U	0.025 U		
Benzo(a)pyrene	0.038	0.2	ug/L	0.098 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.2 U	0.10 U	0.20 U	0.025 U		
Benzo(b)fluoranthene	0.038	0.05	ug/L	0.11 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.9 U	0.20 U	0.20 U	0.025 U		
Benzo(g,h,i)perylene	NE	210	ug/L	0.078 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.6 U	0.13 U	0.20 U	0.028 U		
Benzo(k)fluoranthene	0.038	0.5	ug/L	0.16 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.1 U	0.22 U	0.20 U	0.025 U		
Chrysene	0.038	4.8	ug/L	0.14 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.76 U	0.17 U	0.80 U	0.025 U		
Fluoranthene	130	280	ug/L	0.17 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.54 U	0.062 U	0.20 U	0.025 U		
Fluorene	1100	280	ug/L	<b>0.88 J</b>	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.95 U	0.090 U	0.20 U	0.025 U		
Naphthalene	NE	14	ug/L	<b>850</b>	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.58 U	0.026 U	0.20 U	1.0 U		
Phenanthrene	NE	210	ug/L	<b>0.47 J</b>	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.6 U	0.16 U	0.20 U	NA		
Pyrene	830	210	ug/L	0.17 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.36 U	0.051 U	0.20 U	0.025 U		
<b>TPH - Method 8015 B</b>															
DRO (C10-C28)	50	5	mg/L	<b>6.9</b>	0.13 U	0.13 U	0.13 U	0.13 U	0.125 U	0.261 U	0.26 U	0.24 U	NA		
GRO (C6-C10)	50	5	mg/L	<b>15</b>	<b>0.0324</b>	0.025 U	0.025 U	0.025 U	0.050 U	0.1672 U	0.17 U	0.17 U	NA		

**Data Qualifiers:**

U - Not detected at the Reporting Limit (RL)

J - The result is an estimate concentration that is < RL but ≥ MDL

**Units:**

ug/L - micrograms per liter (ppb)

mg/L - milligrams per liter (ppm)

**Notes:**

NA - Not Analyzed

NE - No screening level established

PREQB Water Quality Standard - March 2010

FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)

**BOLD** - detections

Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL

+ PREQB UST Standard

Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID	SB-1										MW-21		
				Lab ID			1827484	1861948	1883639	1936792	1975391	2180076	AT-14-7950	AT-14-11649	AT-15-1958	35255742001	35273096015
				Sample Date	7/19/2005	2/26/2007	2/13/2012	4/17/2012	6/20/2012	9/25/2012	12/11/2012	3/12/2014	8/28/2014	12/11/2014	2/26/2015	7/19/2016	10/26/2016
				PREVIOUS INVESTIGATION	BASELINE	DURING REMEDIATION		POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION	First Round POST REMEDIATION	Second Round POST REMEDIATION		
<b>VOC - Method 5035/8260B</b>																	
Benzene	5	1	ug/L		3.6	7.5	0.3 U	0.3 U	3.70	1.10	0.3 U	1.10	2.0 U	2.0 U	2.0 U		
Toluene	1000	40	ug/L		0.47 J	1.6 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.1 U	2.1 U	2.1 U		
Ethylbenzene	530	30	ug/L		8.2	14	0.2 U	0.2 U	3.50	0.5	0.2 U	3.30	2.4 U	2.4 U	2.4 U		
Xylenes (Total)	10000+	10000	ug/L		0.48 J	1.6 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	4.5 U	2.6 U	2.6 U		
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L		0.20 U	NA	1.0 U	1.0 U	10.2	4.30	1.0 U	7.10	0.60 U	0.60 U	0.60 U		
<b>SVOC - Method 3541/8270C</b>																	
Acenaphthene	670	20	ug/L		0.33 U	0.10 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.49 U	0.081 U	0.20 U		
Anthracene	8300	2100	ug/L		0.22 U	0.011 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.2 U	0.15 U	0.80 U		
Benzo(a)anthracene	0.038	0.05	ug/L		0.16 U	0.014 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.66 U	0.20 U	0.20 U		
Benzo(a)pyrene	0.038	0.2	ug/L		0.098 U	0.016 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.0 U	0.10 U	0.20 U		
Benzo(b)fluoranthene	0.038	0.05	ug/L		0.11 U	0.042 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.4 U	0.20 U	0.20 U		
Benzo(g,h,i)perylene	NE	210	ug/L		0.078 U	0.023 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4 U	0.13 U	0.20 U		
Benzo(k)fluoranthene	0.038	0.5	ug/L		0.16 U	0.037 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.96 U	0.22 U	0.20 U		
Chrysene	0.038	4.8	ug/L		0.14 U	0.15 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.64 U	0.17 U	0.80 U		
Fluoranthene	130	280	ug/L		0.17 U	0.0087 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.45 U	0.062 U	0.20 U		
Fluorene	1100	280	ug/L		0.70 J	1.2 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.8	0.80 U	0.090 U		
Naphthalene	NE	14	ug/L		110	120	19.3	3.40	13.6	71.8	6.30	48.9	0.49 U	0.026 U	48.8		
Phenanthrene	NE	210	ug/L		0.20 U	0.097 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.3 U	0.16 U	0.20 U		
Pyrene	830	210	ug/L		0.17 U	0.0088 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.30 U	0.051 U	0.20 U		
<b>TPH - Method 8015 B</b>																	
DRO (C10-C28)	50	5	mg/L		1.3	NA	0.45	0.13 U	0.13 U	0.97	2.28	0.849	0.204 U	0.264 U	1.0		
GRO (C6-C10)	50	5	mg/L		1.600	NA	0.313	0.025 U	0.382	0.229	0.025 U	0.269	0.321	1.300	1.57		

UST Removal, Soil Remediation, and PlumesStop/ORC-A Injection

**Data Qualifiers:**  
 U - Not detected at the Reporting Limit (RL)  
 J - The result is an estimate concentration that is < RL but ≥ MDL  
**Units:**  
 ug/L - micrograms per liter (ppb)  
 mg/L - milligrams per liter (ppm)  
**Notes:**  
 NA - Not Analyzed  
 NE - No screening level established  
 PREQB Water Quality Standard - March 2010  
 FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)  
**BOLD** - detections  
 Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL  
 + PREQB UST Standard

Analyte	PREQB Water Quality Standard (March 2010)	FDEP Groundwater Cleanup Target Levels (GCTL)	Units	Sample ID		SB-2										UST Removal, Soil Remediation, and PlumeStop/ORC-A Injection	35273096014
				Lab ID		1827485	1861949	1883640	1936066	1975392	2180077	AT-14-7949	AT-14-11651	AT-15-1959			
				Sample Date	7/20/2005	2/26/2007	2/13/2012	4/17/2012	6/20/2012	9/25/2012	12/11/2012	3/12/2014	8/28/2014	12/11/2014	2/26/2015		
				PREVIOUS INVESTIGATION	BASELINE	DURING REMEDIATION		POST REMEDIATION		BASELINE	DURING REMEDIATION		POST REMEDIATION				
<b>VOC - Method 5035/8260B</b>																	
Benzene	5	1	ug/L		5.7	11	0.3 U	1.40	10.3	2.10	1.10	0.3 U	2.0 U	2.0 U	2.0 U		
Toluene	1000	40	ug/L		0.41 J	0.80 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.1 U	2.1 U	2.1 U		
Ethylbenzene	530	30	ug/L		8.2	5.1	0.2 U	1.00	1.50	0.9	0.6	0.2 U	2.4 U	2.4 U	2.4 U		
Xylenes (Total)	10000+	10000	ug/L		0.37 J	1.3 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	4.5 U	2.6 U	2.6 U		
Methyl tert-Butyl Ether (MTBE)	12+	20	ug/L		0.20 U	NA	1.0 U	1.0 U	2.40	1.0 U	1.0 U	1.0 U	0.60 U	0.60 U	0.60 U		
<b>SVOC - Method 3541/8270C</b>																	
Acenaphthene	670	20	ug/L		0.33 U	0.015 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.51 U	0.081 U	0.20 U		
Anthracene	8300	2100	ug/L		0.22 U	0.011 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	1.2 U	0.15 U	0.80 U		
Benzo(a)anthracene	0.038	0.05	ug/L		0.16 U	0.013 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.69 U	0.20 U	0.20 U		
Benzo(a)pyrene	0.038	0.2	ug/L		0.098 U	0.015 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.1 U	0.10 U	0.20 U		
Benzo(b)fluoranthene	0.038	0.05	ug/L		0.16 J	0.039 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.5 U	0.20 U	0.20 U		
Benzo(g,h,i)perylene	NE	210	ug/L		0.078 U	0.022 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4 U	0.13 U	0.20 U		
Benzo(k)fluoranthene	0.038	0.5	ug/L		0.16 U	0.035 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.0 U	0.22 U	0.20 U		
Chrysene	0.038	4.8	ug/L		0.14 U	0.014 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.67 U	0.17 U	0.80 U		
Fluoranthene	130	280	ug/L		0.17 U	0.0082 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.47 U	0.062 U	0.20 U		
Fluorene	1100	280	ug/L		0.28 U	0.012 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.84 U	0.090 U	0.20 U		
Naphthalene	NE	14	ug/L		29	7.1	2.70	4.20	0.2 U	6.00	8.20	0.2 U	0.51 U	0.026 U	1.00		
Phenanthrene	NE	210	ug/L		0.20 U	0.020 J	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4 U	0.16 U	0.20 U		
Pyrene	830	210	ug/L		0.17 U	0.0083 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.31 U	0.051 U	0.20 U		
<b>TPH - Method 8015 B</b>																	
DRO (C10-C28)	50	5	mg/L		0.670	0.650	0.13 U	0.13 U	0.13 U	0.98	0.50	0.125 U	0.204 U	0.26 U	0.28		
GRO (C6-C10)	50	5	mg/L		0.850	NA	0.231	0.145	0.359	0.224	0.183	0.156	0.344	0.229	0.17 U		

**Data Qualifiers:**

U - Not detected at the Reporting Limit (RL)  
J - The result is an estimate concentration that is < RL but ≥ MDL

**Units:**

ug/L - micrograms per liter (ppb)  
mg/L - milligrams per liter (ppm)

**Notes:**

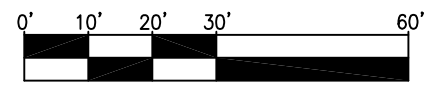
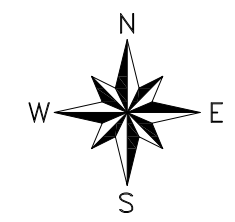
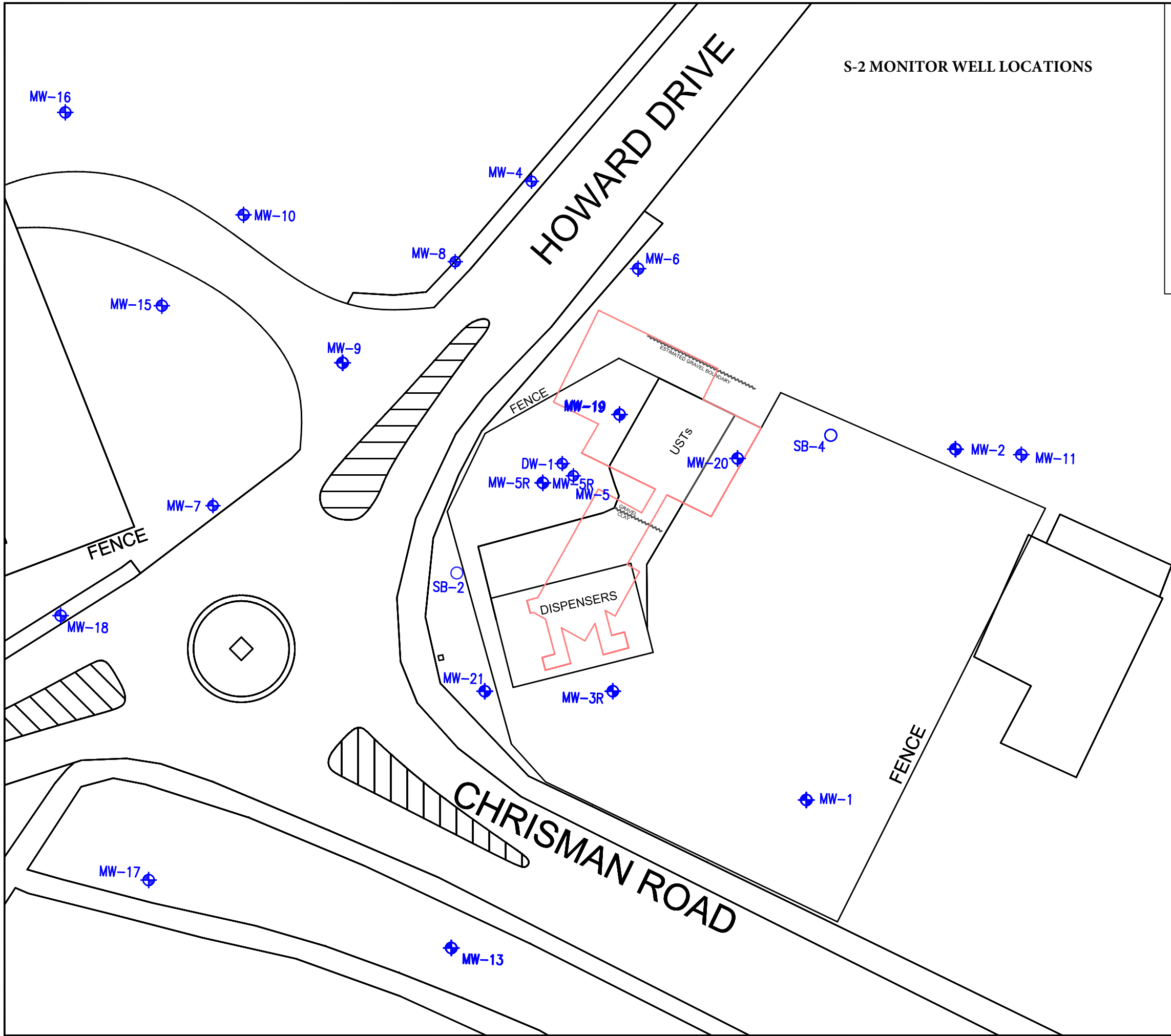
NA - Not Analyzed  
NE - No screening level established  
PREQB Water Quality Standard - March 2010  
FDEP Groundwater Cleanup Target Levels (GCTL) - 62-777 FAC Table 1 (April 2005)  
**BOLD** - detections  
Highlighted Yellow - detected above the PREQB WQS of FDEP GCTL  
+ PREQB UST Standard



LEGEND

- MONITOR WELL LOCATION
- PIEZOMETER
- GROUNDWATER SAMPLE LOCATIONS (TANK PIT WATER)

S-2 MONITOR WELL LOCATIONS

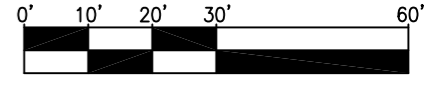
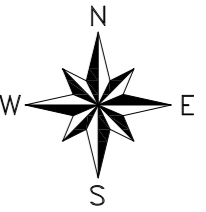
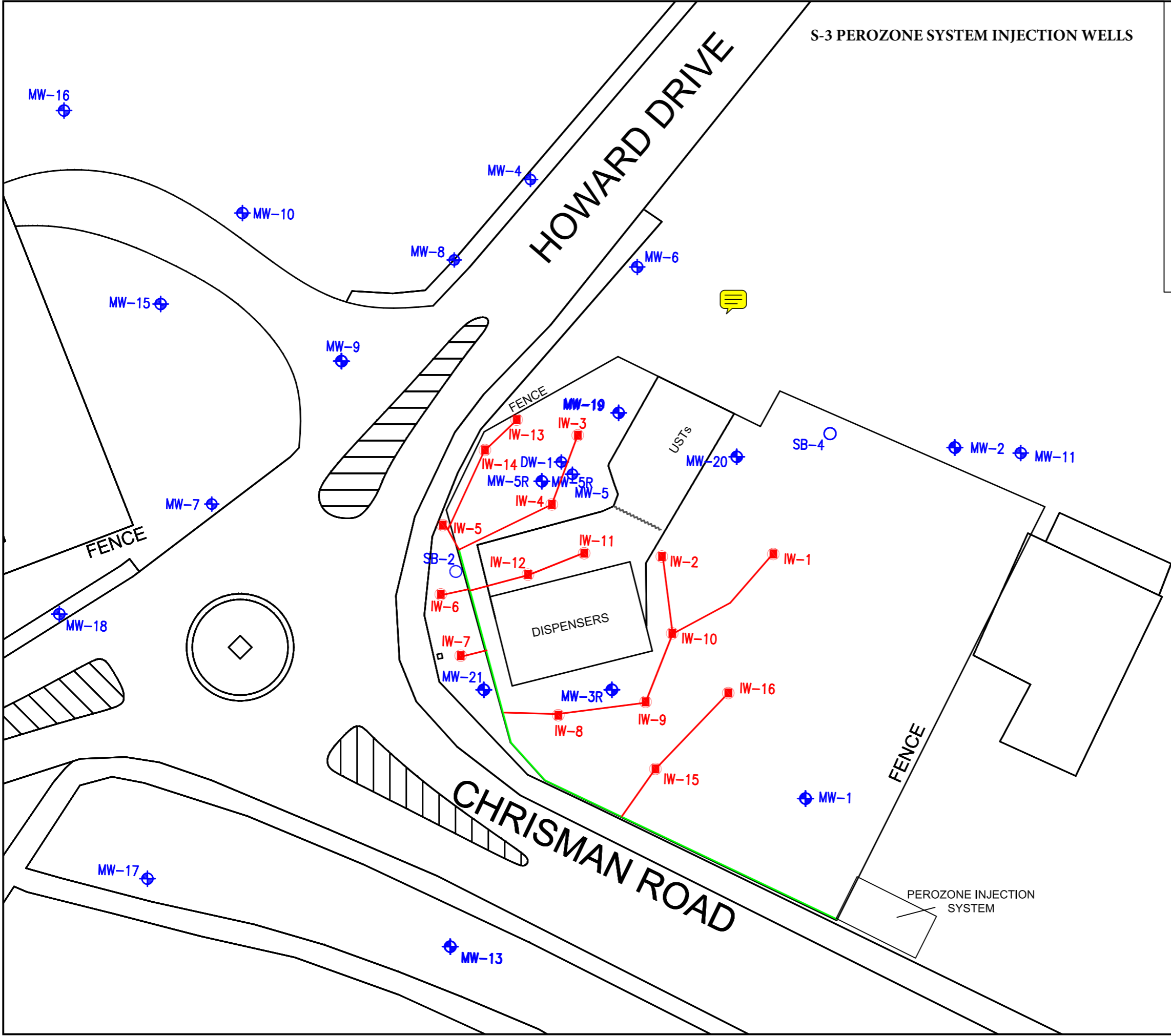




S-3 PEROZONE SYSTEM INJECTION WELLS

LEGEND

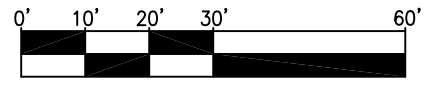
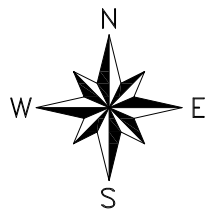
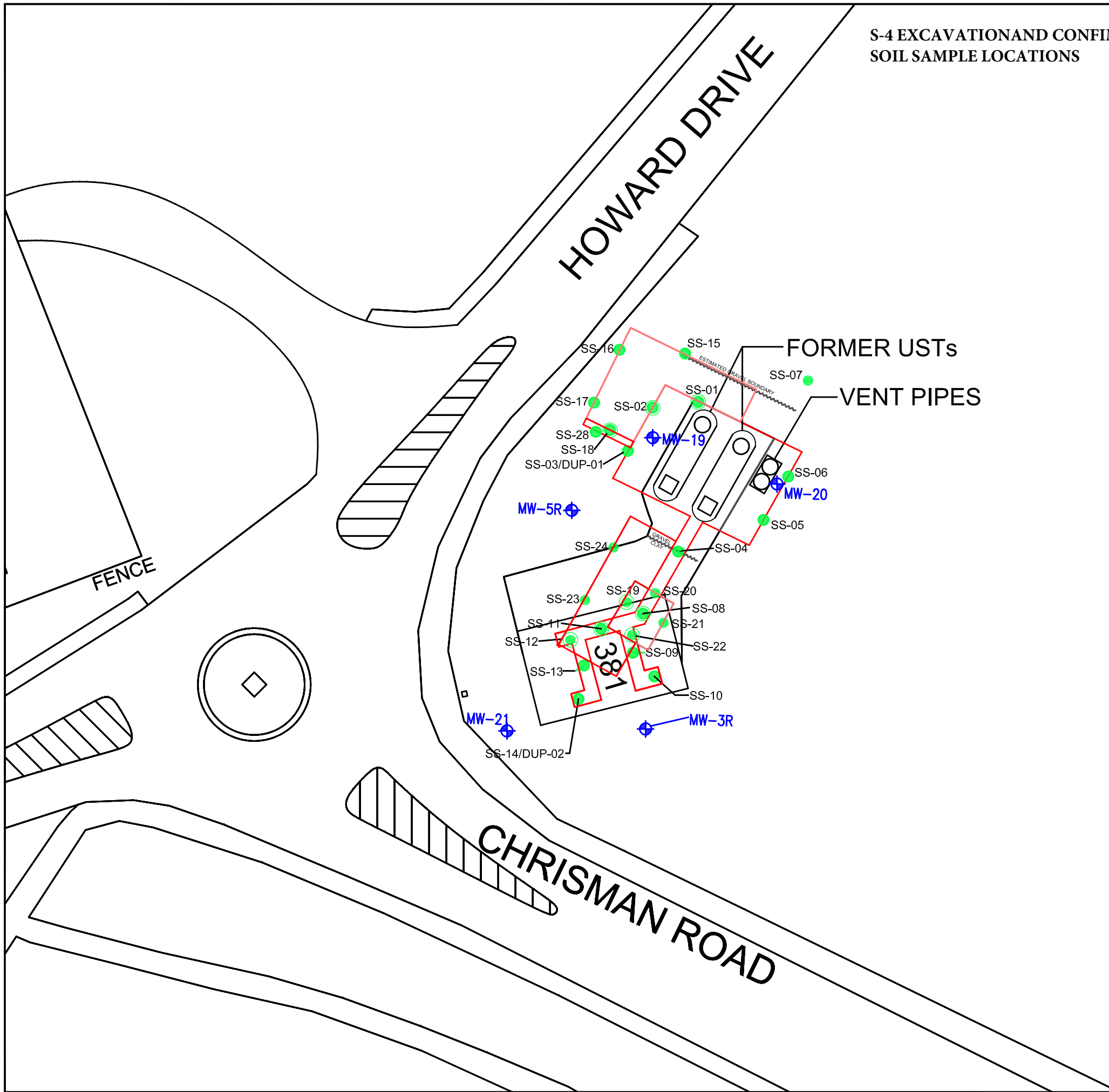
- MONITOR WELL LOCATION
- PIEZOMETER
- PEROZONE INJECTION WELL
- ABOVEGROUND PIPING
- UNDERGROUND PIPING







S-4 EXCAVATION AND CONFIRMATORY SOIL SAMPLE LOCATIONS

LEGEND

- MONITOR WELL LOCATION
- UST REMOVAL AND REMEDIATION EXCAVATIONS
- SOIL SAMPLE LOCATIONS
- IMPACTED SOIL SAMPLES (EXCAVATED)



**LEGEND**

-  MONITOR WELL LOCATION
-  UST REMOVAL AND REMEDIATION EXCAVATIONS
-  PLUMESTOP INJECTION POINT
-  ORC-A INJECTION POINT

**S-5 PLUME STOP AND ORC-A INJECTION POINT LOCATIONS**

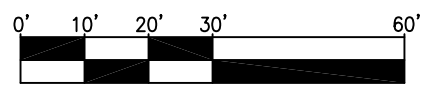
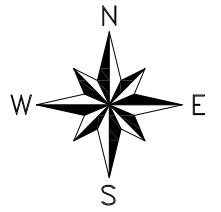
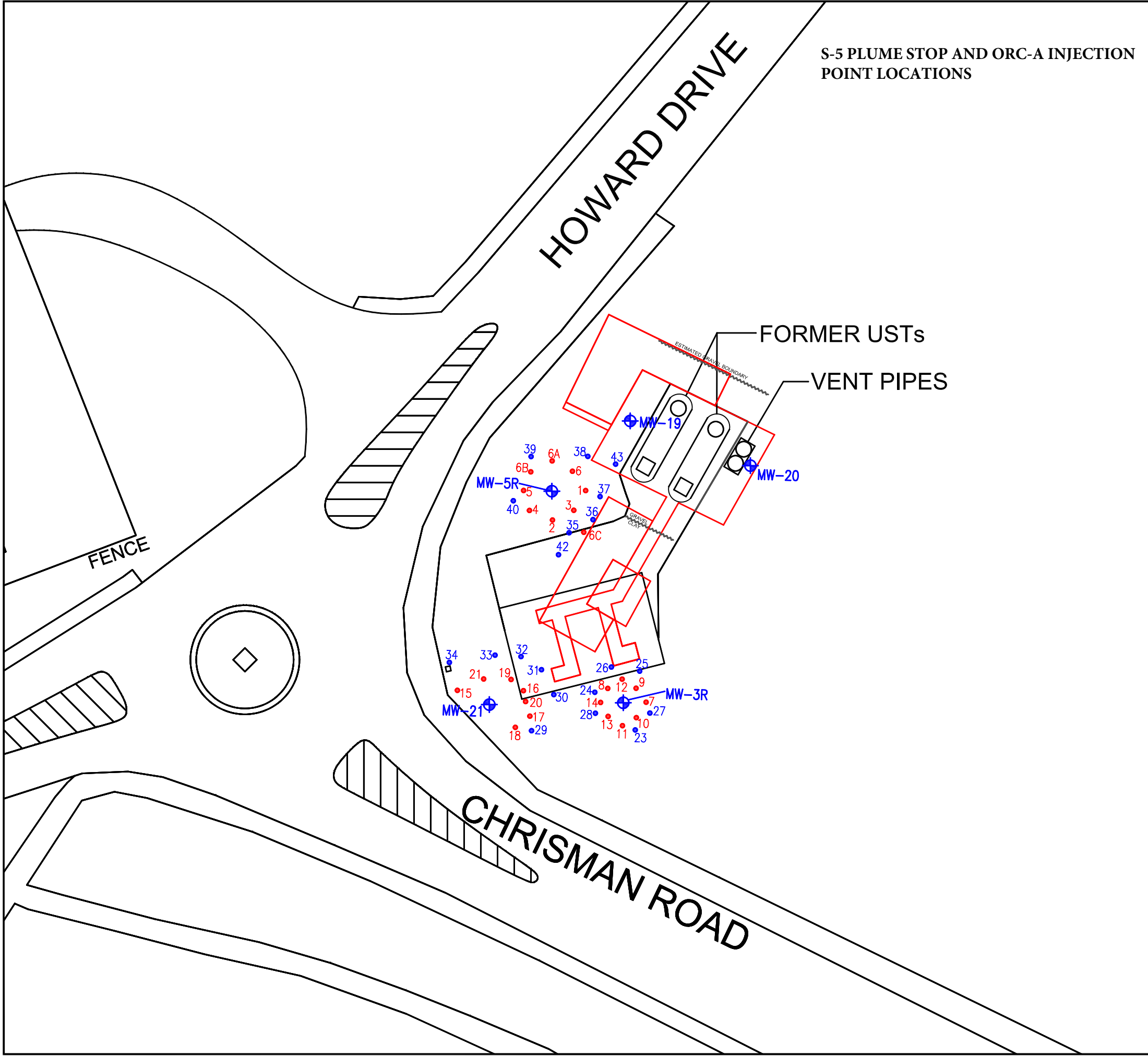
HOWARD DRIVE

FORMER USTs

VENT PIPES

FENCE

CHRISMAN ROAD



S-6 SOIL LABORATORY ANALYTICAL RESULTS

Parameter	CAS Number	PREQB UST Regulation		Soil															
		Residential	Industrial	SS-01-4' *	SS-02-4' *	SS-03-3.5'	DUP-01	SS-04-3.5'	SS-05-3.5'	SS-06-3.5'	SS-07-3.5'	SS-08-2.5' *	SS-09-1.5'	SS-10-1.5'	SS-11-1.5' *	SS-12-1.5' *	SS-13-1.5'	SS-14-1.5'	Dup-02
				11/24/2015	11/24/2015	11/24/2015		11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015	11/24/2015
mg/Kg	mg/Kg	mg/Kg	mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		
Benzene	71-43-2	1.2	5.1	0.0077	0.18 U	0.0037 I	0.17 U	0.0061 U	0.0028 U	0.0024 U	0.0030 U	0.18 U	0.0024 U	0.0025 U	0.0023 U	0.0071 U	0.0029 U	0.0035 U	0.0031 U
Toluene	108-88-3	490	4,700	0.0030 U	0.19 U	0.0031 U	0.18 U	0.0065 U	0.0030 U	0.0026 U	0.0031 U	0.19 U	0.0025 U	0.0026 U	0.0024 U	0.0075 U	0.0031 U	0.0037 U	0.0033 U
Ethylbenzene	100-41-4	5.8	25	1.5	4.3	0.15	0.43	0.037	0.019	0.0028 I	0.0033 U	3.6	0.0027 U	0.0028 U	0.0025 U	0.0078 U	0.0032 U	0.0039 U	0.0051 I
Xylene (Total)	1330-20-7	58	250	0.0057 U	0.36 U	0.0059 U	0.34 U	0.012 U	0.0056 U	0.0049 U	0.0060 U	4.8	0.0049 U	0.0050 U	0.0046 U	0.014 U	0.0059 U	0.0071 U	0.0062 U
Ethylene Dibromide (EDB)	106-93-4	0.036	0.16	0.0028 U	0.18 U	0.0029 U	0.16 U	0.0060 U	0.0027 U	0.0024 U	0.0029 U	0.18 U	0.0024 U	0.0024 U	0.0022 U	0.0069 U	0.0028 U	0.0035 U	0.0030 U
cis-1,2-Dichloroethylene	156-59-2	16	230	0.0028 U	0.18 U	0.0029 U	0.16 U	0.0060 U	0.0027 U	0.0024 U	0.0029 U	0.18 U	0.0024 U	0.0024 U	0.0022 U	0.0069 U	0.0028 U	0.0035 U	0.0030 U
trans-1,2-Dichloroethylene	156-60-5	160	2,300	0.0034 U	0.21 U	0.0035 U	0.20 U	0.0073 U	0.0034 U	0.0029 U	0.0035 U	0.22 U	0.0029 U	0.0030 U	0.0027 U	0.0084 U	0.0035 U	0.0042 U	0.0037 U
Methyl-tert-Butyl Ether (MTBE)	1634-04-4	47	210	0.0041 I	0.18 U	0.0029 U	0.16 U	0.021	0.0027 U	0.0024 U	0.0029 U	0.18 U	0.0024 U	0.0024 U	0.0022 U	0.0069 U	0.0028 U	0.0035 U	0.0030 U
Acenaphthene	83-32-9	350	4,500	0.039 U	0.045 U	0.043 U	0.042 U	0.043 U	0.010 U	0.011 U	0.042 U	0.16 U	0.018 U	0.011 U	0.036 U	0.041 U	0.041 U	0.044 U	0.042 U
Anthracene	120-12-7	1,700	23,000	0.036 U	0.042 U	0.040 U	0.040 U	0.040 U	0.0098 U	0.0099 U	0.040 U	0.50 I	0.017 U	0.011 U	0.034 U	0.039 U	0.038 U	0.041 U	0.039 U
Benzo(a)anthracene	56-55-3	0.15	2.9	0.032 U	0.037 U	0.035 U	0.035 U	0.035 U	0.0086 U	0.0087 U	0.035 U	0.13 U	0.015 U	0.0094 U	0.048 I	0.034 U	0.033 U	0.036 U	0.034 U
Benzo(a)pyrene	50-32-8	0.015	0.029	0.033 I	0.036 U	0.034 U	0.034 U	0.034 U	0.0083 U	0.0084 U	0.034 U	0.13 U	0.014 U	0.0091 U	0.069 I	0.035 I	0.032 U	0.035 U	0.033 U
Benzo(b)fluoranthene	205-99-2	0.15	2.9	0.20 U	0.23 U	0.22 U	0.22 U	0.22 U	0.053 U	0.054 U	0.22 U	0.84 U	0.091 U	0.059 U	0.19 U	0.21 U	0.21 U	0.23 U	0.22 U
Benzo(g,h,i)perylene	191-24-2	---	---	0.062 I	0.040 I	0.034 U	0.033 U	0.033 U	0.0082 U	0.0083 U	0.033 U	0.13 U	0.014 U	0.0090 U	0.11 I	0.087 I	0.049 I	0.035 U	0.033 U
Benzo(k)fluoranthene	207-08-9	1.5	29	0.057 U	0.066 U	0.063 U	0.062 U	0.063 U	0.015 U	0.016 U	0.062 U	0.24 U	0.026 U	0.017 U	0.053 U	0.061 U	0.060 U	0.065 U	0.062 U
Chrysene	218-01-9	15	290	0.032 U	0.036 U	0.035 U	0.034 U	0.035 U	0.0085 U	0.0086 U	0.034 U	0.13 U	0.014 U	0.0093 U	0.029 U	0.033 U	0.033 U	0.036 U	0.034 U
Fluoranthene	206-44-0	230	3,000	0.036 U	0.041 U	0.039 U	0.039 U	0.039 U	0.0096 U	0.0097 U	0.039 U	0.15 U	0.016 U	0.011 U	0.033 U	0.038 U	0.048 I	0.040 U	0.054 I
Fluorene	86-73-7	230	3,000	0.034 U	0.040 U	0.038 U	0.037 U	0.038 U	0.0092 U	0.0093 U	0.037 U	0.97 I	0.016 U	0.010 U	0.032 U	0.036 U	0.036 U	0.039 U	0.037 U
Naphthalene	91-20-3	3.8	17	0.50	1.7	0.094 U	0.093 U	0.18 I	0.023 U	0.023 U	0.093 U	10.9	0.039 U	0.025 U	0.080 U	0.091 U	0.089 U	0.24 I	0.14 I
Phenanthrene	85-01-8	2,100	4,300	0.10 U	0.12 U	0.11 U	0.11 U	0.11 U	0.027 U	0.027 U	0.11 U	1.2	0.046 U	0.029 U	0.093 U	0.11 U	0.10 U	0.11 U	0.11 U
Pyrene	129-00-0	170	2,300	0.028 U	0.032 U	0.031 U	0.030 U	0.031 U	0.0075 U	0.0076 U	0.030 U	0.46 I	0.013 U	0.0083 U	0.026 U	0.030 U	0.043 I	0.032 U	0.044 I
Lead	7439-92-1	400	800	10.4	17.5	5.9	4.8	6.8	5.8	5.9	16.0	16.0	6.2	6.0	32.7	13.9	10.9	5.5	4.3

Parameter	CAS Number	PREQB UST Regulation		Soil											
		Residential	Industrial	SS-15-4	DUP-04	SS-16-3.5	SS-17-3.5	SS-18-3.5 *	SS-19-3.5 *	SS-20-3.5	SS-21-3.5	SS-22-3.5 *	SS-23	SS-24	SS-28
				4/28/2016	4/28/2016	4/28/2016	4/28/2016	4/28/2016	4/28/2016	4/28/2016	4/28/2016	4/28/2016	5/3/2016	5/3/2016	10/27/2016
mg/Kg	mg/Kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
Benzene	71-43-2	1.2	5.1	0.0037 U	0.0034 U	0.89 U	0.0041 U	0.93 U	0.0070	0.0027 U	0.0030 U	0.018	0.0034 U	0.0239	0.0049 U
Toluene	108-88-3	490	4,700	0.0039 U	0.0036 U	0.94 U	0.0043 U	0.98 U	0.0032 I	0.0029 U	0.0032 U	0.0033 U	0.0036 U	0.0033 U	0.0051 U
Ethylbenzene	100-41-4	5.8	25	0.070	0.010	8.5	0.0045 U	118	0.016	0.0044 I	0.0097	0.053	0.0038 U	0.331	0.0054 U
Xylene (Total)	1330-20-7	58	250	0.0073 U	0.0035 U	1.8 U	0.0082 U	1.9 U	0.0057 U	0.0054 U	0.0060 U	0.0063 U	0.0069 U	0.0063 U	0.0098 U
Ethylene Dibromide (EDB)	106-93-4	0.036	0.16	0.0036 U	0.0033 U	0.87 U	0.0040 U	0.90 U	0.0028 U	0.0026 U	0.0029 U	0.0031 U	NA	NA	NA
cis-1,2-Dichloroethylene	156-59-2	16	230	0.0036 U	0.0033 U	0.87 U	0.0040 U	0.90 U	0.0028 U	0.0026 U	0.0029 U	0.0031 U	NA	NA	NA
trans-1,2-Dichloroethylene	156-60-5	160	2,300	0.0044 U	0.0041 U	0.87 U	0.0049 U	1.1 U	0.0034 U	0.0032 U	0.0036 U	0.0038 U	NA	NA	NA
Methyl-tert-Butyl Ether (MTBE)	1634-04-4	47	210	0.0036 U	0.0033U	0.87 U	0.0040 U	0.90 U	0.0028 U	0.0033 I	0.0029 U	0.0059 I	0.0038 I	0.0173	0.0048 U
Acenaphthene	83-32-9	350	4,500	0.038 U	0.040 U	0.038 U	0.041 U	0.040 U	0.035 U	0.037 U	0.039 U	0.040 U	0.043 U	0.038 U	NA
Anthracene	120-12-7	1,700	23,000	0.035 U	0.037 U	0.036 U	0.038 U	0.038 U	0.033 U	0.035 U	0.036 U	0.037 U	0.040 U	0.035 U	NA
Benzo(a)anthracene	56-55-3	0.15	2.9	0.031 U	0.048 I	0.031 U	0.033 U	0.038 I	0.029 U	0.030 U	0.032 U	0.033 U	0.035 U	0.031 U	NA
Benzo(a)pyrene	50-32-8	0.015	0.029	0.030 U	0.031 U	0.030 U	0.032 U	0.032 U	0.028 U	0.030 U	0.031 U	0.032 U	0.034 U	0.030 U	NA
Benzo(b)fluoranthene	205-99-2	0.15	2.9	0.19 U	0.20 U	0.19 U	0.21 U	0.21 U	0.18 U	0.19 U	0.20 U	0.20 U	0.22 U	0.19 U	NA
Benzo(g,h,i)perylene	191-24-2	---	---	0.030 U	0.031 U	0.030 U	0.032 U	0.032 U	0.027 U	0.029 U	0.030 U	0.031 U	0.034 U	0.030 U	NA
Benzo(k)fluoranthene	207-08-9	1.5	29	0.055 U	0.058 U	0.056 U	0.060 U	0.059 U	0.051 U	0.055 U	0.057 U	0.059 U	0.064 U	0.056 U	NA
Chrysene	218-01-9	15	290	0.031 U	0.036 I	0.031 U	0.033 U	0.033 U	0.028 U	0.030 U	0.031 U	0.032 U	0.035 U	0.031 U	NA
Fluoranthene	206-44-0	230	3,000	0.035 U	0.036 U	0.035 U	0.037 U	0.037 U	0.032 U	0.034 U	0.035 U	0.037 U	0.045 U	0.035 U	NA
Fluorene	86-73-7	230	3,000	0.033 U	0.035 U	0.034 U	0.036 U	0.050 I	0.087 I	0.033 U	0.034 U	0.035 U	0.038 U	0.034 U	NA
Naphthalene	91-20-3	3.8	17	0.083 U	0.091 I	2.6	0.090 U	5.5	4.6	0.29	0.16 I	0.29	0.095 U	0.084 U	NA
Phenanthrene	85-01-8	2,100	4,300	0.097 U	0.10 U	0.098 U	0.10 U	0.10 U	0.089 U	0.096 U	0.099 U	0.10 U	0.11 U	0.098 U	NA
Pyrene	129-00-0	170	2,300	0.027 U	0.035 I	0.027 U	0.029 U	0.029 U	0.027 I	0.027 U	0.028 U	0.029 U	0.031 U	0.027 U	NA
Lead	7439-92-1	400	800	6.7	8.5	11.4	5.3	10.6	6.4	5.2	6.6	4.3	2.6	2.7	NA

**Data Qualifiers:**  
 U - Not detected at the Reporting Limit (RL)  
 I - The result is an estimate concentration that is < MRL but ≥ MDL  
**Units:**  
 mg/kg - milligrams per kilogram (ppm)  
**Notes:**  
 NA - Not Analyzed  
 --- - No screening level established  
 PREQB UST Regulations - Guio de Cierre Permanente February 2015  
**BOLD** - detections  
 Highlighted - detected above the PREQB UST Standards  
 \* (shaded in green) Samples over excavated during corrective action for soils in April and May 2016