



Williams Petroleum Services, LLC

One Williams Center
P.O. Box 3483
Tulsa, OK 74101-3483

January 17, 2020

Mr. Don Lininger, CHMM
Chief, Waste Remediation & Permitting
Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219

Re: Quarterly Update – 4th Quarter 2019
Former Augusta Refinery (FAR) RCRA Facility Investigation (RFI)
Williams Petroleum Services (WPS), LLC
Augusta, Kansas – KSD007235138

Dear Mr. Lininger:

This letter is offered as the report of investigation activities at the Former Augusta Refinery (FAR) in accordance with Section X, "Reporting," of the Administrative Order on Consent dated October 24, 2003, Docket No. RCRA-07-2004-0009. This report addresses activities occurring during the period of October 1 through December 31, 2019.

Description of Activities

- In accordance with the August 26, 2015 LNAPL Corrective Measures Study (CMS) Work Plan Addendum, completed routine manual and passive light non-aqueous phase liquid (LNAPL) recovery efforts for the continued evaluation of LNAPL removal efficacy.
- In July 2019, downloaded transducer data and collected water levels as part of the continued Water Balance evaluation through the ongoing monitoring of water level data per the September 11, 2013 scope of work.
- Following the groundwater sampling event initiated in September 2019, initiated data review, data compilation, and figure preparation.
- In correspondence dated October 2, 2019, the 3rd quarter 2019 Quarterly Report was submitted to the USEPA and KDHE.
- On December 12, 2019, completed 3rd quarterly NPDES sampling.
- On December 12, 2019, completed surface water sampling for the Walnut River AOI interim measure performance monitoring.

- In December 2019, completed the semi-annual SWMU 1 and 2 groundwater monitoring event.

Summary of All Findings

- Appendix A presents a summary of the PetroFix™ pilot testing results.
- Appendix B presents a summary of the biosparge pilot testing results.

Summaries of All EPA/KDHE Approved Changes

- None.

Summaries of All Contacts

- See description of activities.

Summaries of Problems Encountered

- While remotely watching the water levels at the USGS gauge on the Walnut River, it was noted that the gauging station was recording flow levels significantly higher than what has been observed at similar stage.

Actions to Rectify Problems

- APTIM has been in contact with USGS and NOAA to note the gauging station issue and attempt to identify when the station will be repaired.

Changes in Key Project Entities

- None.

Projected Work for the Next Reporting Period

The following activities will be performed or initiated during the next reporting period:

- Continue LNAPL monitoring and removal.
- Continue quarterly NPDES monitoring.
- Continue pilot test monitoring activities.
- Submit the NuStar AOC data package.
- Submit the 2019 Groundwater Sampling Event data package.

Other Relevant Documentation

- None

I certify that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to evaluate the information submitted. I certify that the information contained in or accompanying this submittal is true, accurate, and complete. As to those identified portion(s) of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with the procedures designed to ensure that qualified

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personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Please provide all written correspondence regarding this Quarterly Update directly to Mr. Lee Andrews, with Williams Petroleum Services, LLC. If you have any questions, do not hesitate to contact Mr. Andrews at (918) 573-6912.

Sincerely,

Williams Petroleum Services, LLC



Mark A. Gebbia

Vice President, Environmental, Regulatory & Permitting

c: Gary Blackburn, KDHE

Lee Andrews, Williams Petroleum Services, LLC

David Way, Aptim Environmental & Infrastructure, LLC.



Appendix A



PERMEABLE SORPTION BARRIER PILOT TEST

For the CMS, a permeable sorption barrier is being evaluated to limit hydrocarbon plume migration and enhance biodegradation. The preliminary barrier design was for in-situ injection of REGENESIS® PlumeStop® Liquid Activated Carbon in the area located along the east side of US Highway 77 within the highway right-of-way and west of the Walnut River between monitoring wells DG-10 and P-16D (see **Figure A-1** and **A-2**). An application pilot test was completed to evaluate the effectiveness of a sorption contaminant biodegradation barrier technology to reduce contaminant concentrations and migration of those contaminants.

A design verification testing (DVT) was initially completed at the site on October 2018. The DVT consisted of clear water injection (both deep and shallow intervals) and the vertical profiling of contaminant mass in both soil and groundwater in the proposed area of injection. Based on site-specific conditions (contaminant concentrations and aquifer characteristics), Regenesis recommended that PetroFix™ Remediation Fluid technology be used as a better solution for the site rather than the PlumeStop.

PetroFix, like PlumeStop consists of the same micron-scale activated carbon (1 to 2 μm), but contains significantly more carbon (+30%) than PlumeStop formulation. Sulfate is pre-blended in the PetroFix drums of activated carbon and additional electron acceptors are added from 20-pound buckets (sulfate + nitrate blend).

PetroFix adheres quicker to the surface of soil particles than PlumeStop, requiring slightly tighter spacing for injection through the same low-pressure application technique.

Biodegradation is fastest when microbes have an ample supply of oxygen, which is the most favorable electron acceptor from a redox standpoint and is quickly depleted in groundwater impacted by petroleum hydrocarbons. One of the next-best electron acceptors is nitrate, which is also rapidly utilized in groundwater impacted by petroleum hydrocarbons. After oxygen and nitrate are consumed, the next electron acceptors consumed by the microbes include iron and sulfate. As the more favorable electron acceptors are consumed, an aquifer will become methanogenic with a more negative redox potential (ORP reading). Under these conditions the acetate, other small organic compounds, carbon dioxide, and hydrogen that are produced by syntrophic degradation of petroleum hydrocarbons are ultimately converted to methane.

The remediation strategy employed when applying PetroFix is two-part: contaminants are adsorbed to the activated carbon and biodegradation is enhanced through the addition of the sulfate/nitrate blend to stimulate the growth of syntrophic and BTEX-degrading microbes. After the added nitrate and sulfate are exhausted, petroleum degradation continues through syntrophic biodegradation processes, meaning the continuous addition of electron acceptors is not required.



The purpose of the pilot test was to evaluate the effectiveness the sorption contaminant biodegradation barrier technology to reduce contaminant concentrations and migration of those contaminants. Attenuation monitoring performed at the site over a period of many years has demonstrated the subsurface system's natural ability to attenuate hydrocarbons over distance, but enhancements may be appropriate to address hydrocarbons in key locations.

Key objectives for the pilot test data collection include:

- Determine the effective injection parameters for the liquid activated carbon media.
- Determine the ability of activated carbon barrier to limit migration of dissolved hydrocarbons in the subsurface.
- Verify that degradation kinetics are adequate to provide treatment across the barrier.

A.1 Pre-Pilot Test Data Collection

Operating parameters were collected prior to and during the pilot test to evaluate efficacy and construction of a final treatment system. Pre-pilot test data collection consisted of hydraulic injection testing and collection of soil and groundwater samples for laboratory analysis to establish baseline conditions and help determine the contaminant mass and transport zones within the test cells.

A.1.1 Pre-Pilot Hydraulic Injection Testing

The clear water injection test and initial vertical soil profile collection was completed on October 17, 2018. The injection test was used to evaluate injectability of the liquid activated carbon media, verify theoretical radius-of-influence (ROI), and recommended injection tooling, injection flow rates and pressures. Data collected from the injection testing was used to finalize the injection parameters for the pilot test cell.

A direct-push Geoprobe® unit was used for completion of two injection tests located approximately 10 feet from the existing monitoring wells DG-09D and DG-09S to determine in-situ application rates and related injection information. One of the injection tests was completed in the deeper sand and gravel interval at a depth of 35 to 42 feet below ground surface and the second injection test completed within the shallower silts and lean clays. Flow rates, injection pressures, and total volume of water injected were monitored during each of the clear water injection tests. Water levels were also monitored in the adjacent monitoring well cluster.

A.1.2 Pre-Pilot Soil Sampling

One direct-push soil boring was completed and sampled to refusal at a total depth of 42 feet bgs. The borehole location was completed within the pilot test cell at the deep monitoring well location DV-1D.

A direct push rig was used for the completion of the borehole and collection of soil samples using dual tube sampling methods. Five soil samples were collected from the soil boring with soil samples collected



in approximate 2-foot intervals, at depths of 18, 24, 29, 34, and 39 feet bgs. The soil samples were submitted for laboratory analysis of BTEX, TPH GRO, DRO, and ORO.

A.1.3 Pre-Pilot Groundwater Sampling

One shallow, intermediate and deep monitoring well cluster (DV-1) and three additional deep monitoring wells (DV-2, DV-3, and DV-4) were installed within the pilot test cell (see **Figure A-2**). These monitoring wells were used for the collection of groundwater samples to establish a baseline prior to the pilot test and for performance monitoring within and up gradient of the pilot test cell.

A Geoprobe was used for installation of the monitoring wells. The screen intervals for the three monitoring wells in the DV-1 monitoring well cluster are from 10 to 25 feet (DV-1S), 25 to 35 feet (DV-1I), and 35 to 40 feet (DV-1D) bgs. The other three deep monitoring wells were completed with five feet of well screen set at top of bedrock in each of the soil boring locations.

Each monitoring well was constructed using 2-inch diameter PVC riser threaded to 2-inch diameter PVC 0.010-inch slotted well screen. A silica sand filter pack was placed one to two feet above the screen with a bentonite seal placed above the sand filter pack to within one foot of surface. Each monitoring well was completed at surface in a two-foot diameter concrete pad, with an 8-inch diameter flush mount manhole with bolt-down water-rated lid.

An APTIM field geologist was present to oversee the soil sampling and monitoring well installation activities. Specific boring logs and monitoring well completion diagrams are included in the **Appendix Attachment A-1**.

A.1.3.1 Monitoring Well Gauging

Fluid levels were gauged in each of the monitoring wells after installation and prior to collection of groundwater samples. Static water levels and LNAPL thickness (if applicable) were measured in each monitoring well using an oil/water interface probe, capable of detecting LNAPL on the water to an accuracy of 0.01 feet. Results of the well gauging activities completed during the pilot test activities are presented in **Table A-1**.

A.1.3.2 Groundwater Sampling

Baseline groundwater sampling was completed following the installation and development of the new monitoring wells within the pilot test cell. Groundwater samples were collected from the DV-1 monitoring well cluster using Passive Diffusion Bags (PDBs) for laboratory analytical analysis of VOCs. One PDB was used for approximately every 5 feet of monitoring well screen with PDBs set in the DV-1S at approximately 12.5 feet, 17.5 feet, and 22.5 feet; in monitoring well DV-1I at 28 and 33 feet; and in monitoring well DV-1D at a depth of 37 feet.

Groundwater samples were also collected from mid screen interval from each of the DV monitoring wells for laboratory analytical analysis using a peristaltic pump.



Each of the monitoring wells were sampled for VOCs and TPH DRO/ORO. Monitoring wells were also sampled for natural attenuation parameters using low flow groundwater sampling methods as outlined in the 2015 Sampling and Analysis Plan. Parameters measured in the field included:

- oxidation-reduction potential (ORP),
- pH,
- temperature,
- conductivity,
- dissolved oxygen (DO), and
- ferrous iron.

Additional parameters analyzed by the laboratory included:

- alkalinity,
- nitrate,
- sulfate,
- methane,
- total organic carbon (TOC),
- biological oxygen demand (BOD),
- total and dissolved arsenic, manganese, and iron.

The dissolved arsenic, manganese and iron were field filtered prior to preservation.

Samples were shipped under chain of custody to ALS Environmental Houston Texas for analysis.

A.2 Pilot Test Injection

Data collected during the hydraulic injection testing were used to determine pilot test injection parameters and amount of reagent materials required for the test injections. Regenesis shipped 9,200 pounds of PetroFix in 23 drums along with 23 electron acceptor (nitrate + sulfate) pails (20 pound each) to the site prior to the injection activities. Regenesis Remediation Services (RRS) applied the Regenesis technologies by mixing the products in the RRS injection trailer and injecting through temporary injection points install by Below Ground Surface, Inc. (BGS). RRS used a bottom-up injection using 1.5-inch diameter Geoprobe rods with a retractable 3-foot length exposed screen injection tool. The injection trailer contained tanks used for mixing the Regenesis product, pumps, and delivery system equipped for direct connection to the injection wells through ¾-inch injection hosing.

The PetroFix pilot test barrier was completed in two injection rows set approximately 5 feet apart from each other. Injection points within each row were set on 5-foot centers for a total of seven injection locations within each row. The application interval was over 35 feet long, 10 feet wide, and a 30-foot vertical thickness (see **Figure A-2**).

A total solution of 4,914 gallons containing 6,200 pounds of PetroFix was injected into the west seven injection points from approximately 12 to 32 feet bgs (shallow zone). The shallow zone injection was



completed prior to the deeper injection into the sand and gravel unit to reduce the possibility of short circuiting into the more permeable deeper zone. The PetroFix solution was initially injected into the shallow zone at a rate of approximately 40 gallons per vertical foot. At this rate, the PetroFix had a larger radius of influence than expected. Regenesis reformulated the PetroFix batching to be more concentrated and reduced the application rate to 20 gallons per vertical foot. Flow rates were observed between 1.5 to 3.7 gallons per minute (gpm). Flow rates and injection pressures were monitored to limit surfacing potential and to keep injection pressures from exceeding 50 pounds per square inch (psi). Injection pressures remained steady at 5 to 50 psi in the shallow injection locations.

A total solution of 1,630 gallons containing 3,000 pounds of PetroFix was injected into the deeper sand and gravel unit (32 to 41 feet bgs) in the east seven injection points. The PetroFix solution was injected into the deeper zone at an application rate of 20 gallons per vertical foot. Flow rates were observed between 2.1 and 3.7 gpm. Injection pressures remained steady at 5 to 30 psi in the deeper locations.

A.3 Monitoring and Results

After the PetroFix application, post-pilot testing activities included groundwater sample collection for analysis as outlined in **Section A.1.3**, at approximately 2 weeks, 2 months, 3 months, and five months for performance monitoring. The following section summarizes pre- and post-pilot testing monitoring results.

A.3.1 Well Gauging Activities

Results of the well gauging activities completed during the pilot test activities are presented in **Table A-1**. **Figure A-3** presents the deep monitoring well potentiometric surface contour map for the pilot test cell on April 29, 2019, just before the PetroFix application activities, and **Figure A-4** presents the deep monitoring well potentiometric surface contour map for the pilot test cell on September 30, 2019, approximately 150 days after the PetroFix application. The groundwater flow direction for both gauging events is to the southeast across the pilot test cell towards the Walnut River. The hydraulic gradient calculated for the deep monitoring wells across the pilot test cell ranges from 0.1140 on April 29, 2019 to 0.0810 on September 30, 2019.

A.3.2 Light Non-Aqueous Phase Liquid Occurrence

LNAPL was measured at 0.01 feet in the shallow monitoring well DV-1S immediately after installation and development on October 23, 2018. LNAPL was again measured at 0.10 feet in monitoring well DV-1S on December 14, 2018, but after removal was never noted again during any of the other sample gauging events.

A.3.3 Pre-Pilot Test Soil and Groundwater Sampling Results

Summary of the soil and groundwater analysis are shown in **Tables A-2** and **A-3**, respectively. Measured field parameters are also included on **Table A-3**.

Soil samples were collected from a soil boring at the location of monitoring well cluster DV-1 to provide a vertical profile of hydrocarbon mass in the soil. The highest concentrations of hydrocarbons in soil were reported in the soil sample collected from a depth of 24 to 25 feet with a GRO concentration of 45 mg/kg and DRO of 170 mg/kg. Benzene, toluene, ethylbenzene, and xylenes were all non-detect in DV-1 with the exception of a detection of benzene at 12 ug/kg in the soil sample collected from a depth of 39 to 40 feet.

The baseline benzene concentrations in groundwater collected from the deep monitoring wells within the pilot test area in October 2018 are shown on **Figure A-5**. The highest benzene concentration in groundwater was reported in the deep downgradient monitoring well DV-4 at 340 µg/l.

Groundwater samples were also collected from DV-1S, DV-II, and DV-1D for vertical profiling in November 2018. Benzene, toluene, ethylbenzene, and xylenes (BTEX) were all below laboratory reporting limits at 12.5 feet, 17.5 feet, 22.5 feet, 28 feet, and 33 feet. However, in the deepest groundwater sample from 37 feet, benzene, toluene, and xylenes were reported at 310 µg/l, 7.6 µg/l, and 7.3 µg/l, respectively.

Baseline TPH groundwater samples were also collected in October 2018. All six monitoring wells contained TPH DRO ranging from 0.38 mg/L to 2.6 mg/L, and TPH ORO ranging from 0.23 mg/L to 0.32 mg/L. The highest detection was TPH DRO in DV-1S at 2.6 mg/L.

A.3.4 Post-Pilot Test Groundwater Monitoring Results

The post injection groundwater monitoring results show reduction in BTEX and TPH DRO/ORO concentrations in all of the DV monitoring wells within the pilot test area. Benzene concentrations in groundwater collected from the deep monitoring wells within the pilot test area on June 17, 2019 (45 days following injection) and September 30, 2019 (150 days following injection) are shown on **Figure A-6** and **Figure A-7**, respectively. Groundwater analytical results from the September 30, 2019 sampling event reported a trace of benzene in the deep downgradient monitoring well DV-4 at 0.048 µg/l; prior to injection in October 2018, benzene was 340 µg/l in DV-4. Benzene concentrations in all other DV monitoring wells were below laboratory detection limits during the same sampling event.

Pre injection in October 2018, TPH DRO ranged from 0.38 mg/L to 2.6 mg/L; post injection in September 2019, TPH DRO ranged from 0.025 mg/L to 0.19 mg/L. Pre injection, TPH ORO ranged from 0.23 mg/L to 0.32 mg/L; post injection TPH ORO ranged from 0.039 mg/L to 0.083 mg/L.

Both sulfate and nitrate concentrations showed an increase after the initial injection and then decrease over post injection time. The normal depletion of nitrate is within 1 or 2 months and for sulfate depletion is normally within 6 months after injection at most sites.

Concentrations of methane increased over background as expected as a result of syntrophic bioremediation. The end results of syntrophic bacteria surviving after nitrate and sulfate start to deplete is a fermentation of petroleum hydrocarbons and intermediates to acetate and hydrogen, which are then removed by methanogens, therefore the increase in methane concentrations.

The oxidation-reduction potentials (ORP) also showed a negative increase immediately after injection, reflecting an increase in reducing conditions within the treatment zone.



A.4 Pilot Test Conclusion

Reduction of BTEX and TPH DRO/ORO concentrations to near non-detectable concentrations have occurred across the pilot test cell. Other natural attenuation parameters (increase in methane and ORP reducing conditions) also indicate increase in biodegradation performance across the barrier.

Microbial growth and acclimation within a biological barrier typically takes 6 to 12 months for the system to achieve optimal performance. Monitoring will continue for at least two more quarterly events to confirm biodegradation performance.

Current results from the pilot testing indicate that a permeable sorption barrier has application as a site remedy as part of the Corrective Measures within this area at the FAR.

Table A-1

Groundwater Elevation Data
PetroFix Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

PetroFix Injection Completed 4/30/2019 through 5/3/2019

Well ID	Date	Top of Casing Elevation	Depth to Water (TOC)	Depth to Product (TOC)	Ground Water Elevation
DV-1S	10/23/2018	1218.67	10.73	10.72	1207.94
	10/25/2018	1218.67	11.1		1207.57
	12/14/2018	1218.67	13.22	13.12	1205.45
	4/29/2019	1218.67	11.07		1207.6
	5/16/2019	1218.67	8.42		1210.25
	6/17/2019	1218.67	7.33		1211.34
	7/25/2019	1218.67	10.08		1208.59
	9/30/2019	1218.67	11.63		1207.04
DV-1I	10/23/2018	1218.78	10.15		1208.63
	10/25/2018	1218.78	10.86		1207.92
	12/14/2018	1218.78	12.92		1205.86
	4/29/2019	1218.78	10.75		1208.03
	5/16/2019	1218.78	7.95		1210.83
	6/17/2019	1218.78	7.74		1211.04
	7/25/2019	1218.78	9.98		1208.8
	9/30/2019	1218.78	11.32		1207.46
DV-1D	10/23/2018	1218.87	14.85		1204.02
	10/25/2018	1218.87	13.28		1205.59
	12/14/2018	1218.87	15.93		1202.94
	4/29/2019	1218.87	14.59		1204.28
	5/16/2019	1218.87	10.94		1207.93
	6/17/2019	1218.87	11.5		1207.37
	7/25/2019	1218.87	14.5		1204.37
	9/30/2019	1218.87	15.08		1203.79
DV-2	10/23/2018	1222.10	14.85		1207.25
	10/26/2018	1222.10	15.01		1207.09
	12/14/2018	1222.10	17.42		1204.68
	4/29/2019	1222.10	15.86		1206.24
	5/16/2019	1222.10	13.08		1209.02
	6/17/2019	1222.10	14		1208.10
	7/25/2019	1222.10	16.8		1205.3
	9/30/2019	1222.10	17.4		1204.7
DV-3	10/23/2018	1220.87	11.53		1209.34
	10/26/2018	1220.87	13.62		1207.25
	12/14/2018	1220.87	15.85		1205.02
	4/29/2019	1220.87	14.18		1206.69
	5/16/2019	1220.87	11.43		1209.44
	6/17/2019	1220.87	12.53		1208.34
	7/25/2019	1220.87	15.29		1205.58
	9/30/2019	1220.87	15.92		1204.95
DV-4	10/23/2018	1217.88	15.88		1202.00
	10/26/2018	1217.88	15.33		1202.55
	12/14/2018	1217.88	16.9		1200.98
	4/29/2019	1217.88	16.03		1201.85
	5/16/2019	1217.88	11.68		1206.20
	6/17/2019	1217.88	13.91		1203.97
	7/25/2019	1217.88	15.98		1201.9
	9/30/2019	1217.88	16.35		1201.53

Table A-2

Soil Analytical Results

PetroFix Pilot Test

Former Augusta Refinery, Augusta, Kansas

Williams Petroleum Services, LLC

	Depth (feet)	Benzene (ug/kg)	Toluene (ug/kg)	Ethylbenzene (ug/kg)	Xylenes (ug/kg)	GRO (mg/kg)	ORO (mg/kg)	DRO (mg/kg)
DV-1	18 - 20	< 3.6	< 3.6	< 3.6	< 3.6	2.8	0.81J	37
	24 - 25	< 3.8	< 3.8	< 3.8	< 3.8	45	< 17	170
	29 - 30	< 3.8	< 3.8	< 3.8	< 3.8	0.39	0.74J	43
	34 - 35	< 4.7	< 4.7	< 4.7	< 4.7	< 0.049	13	16
	39 - 40	12	< 4.4	< 4.4	< 4.4	< 0.050	2.9J	< 1.7

J: Estimated concentration between MDL and Reporting Limit

GRO: Gasoline Range Organics

DRO: Diesel Range Organics

ORO: Oil Range Organics

Table A-3

Groundwater Analytical Results
PetroFix Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

PetroFix Injection Completed 4/30/2019 through 5/3/2019

Well ID	Date	Diffusion Bag Depth (feet)	Depth to Water (feet)	Benzene (µg/l)	Toluene (µg/l)	Ethylbenzene (µg/l)	Xylenes (mg/l)	Methane (mg/l)	TPH DRO (mg/l)	TPH ORO (mg/l)	Total Arsenic (mg/l)	Total Iron (mg/l)	Total Manganese (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	TOC (mg/l)	Total Alkalinity (mg/l)	BOD (mg/l)	Ferrous Fe (mg/l)	DO (mg/l)	ORP (mV)	Temperature (°C)	Conductivity (mS/cm)	pH
DV-1S	10/25/2018							0.0585	2.6	0.3	0.0372	6.13	2.67	<0.0300	1.46	2.27	157	<2.00	3	1.94	-50.9	19.01	0.311	8.02
	11/14/2018	12.5		<0.20	<0.20	<0.30	<0.30																	
	11/14/2018	17.5		<0.20	<0.20	<0.30	<0.30																	
	11/14/2018	22.5		<0.20	<0.20	<0.30	<0.30																	
	5/16/2019		8.42	<1.0	<1.0	<1.5	<1.5	0.0455	0.28	0.033J	0.00308	4.45	2.43	20.9	121	8.21	195	<1.86	3	3.93	-90.7	12.89	0.697	6.63
	6/17/2019		7.33	<0.20	<0.20	<0.30	<0.30	0.00324	0.039J	<0.021	0.000547J	0.147J	0.019	0.0384J	13.2	1.63	222	<2.00	0	0.23	-38.1	14.9	0.476	6.72
	7/25/2019		10.08	<1.0	<1.0	<1.5	<1.5	0.0155	1.1	<0.021	0.00926	2.87	1.13	0.0442J	14.3	9.26	154	<6.24	0.5	0.32	-54	15.2	0.348	6.61
	9/30/2019		11.63	<0.20	<0.20	<0.30	<0.30	0.107	0.093	0.083J	0.0164	2.47	1.65	<0.0300	2.21	7.38	150	<2.00	2	0.39	-91.5	21.7	0.328	6.92
DV-1I	10/25/2018							0.0759	0.45	0.32	0.0342	3.22	2.87	<0.0300	0.488J	1.85	137	<2.00	2.75	1.77	-95.7	19.98	0.276	8.5
	11/14/2018	28		<0.20	<0.20	<0.30	<0.30																	
	11/14/2018	33		<0.20	<0.20	<0.30	<0.30																	
	5/16/2019		7.95	<1.0	<1.0	<1.5	<1.5	0.0618	0.34	<0.021	0.00716	11.8	7.68	32.8	166	16.3	131	<1.86	2.5	0.28	-183	12.66	0.758	7.07
	6/17/2019		7.74	<1.0	<1.0	<1.5	<1.5	0.0283	0.6	<0.020	0.00615	3.8	2.95	0.0372J	55.1	18.8	145		0.5	0.33	-141.5	13.1	0.432	7.15
	7/25/2019		9.98	<1.0	<1.0	<1.5	<1.5	0.0643	1	<0.021	0.0174	4.69	2.64	0.0783J	21.5	7.98	155	<3.12	2.5	0.29	-158	13.6	0.368	7.17
	9/30/2019		11.32	<0.20	<0.20	<0.30	<0.30	0.153	0.065	0.057	0.0242	2.47	1.76	<0.0300	0.927	4.12	133	<2.00	1	0.3	-135.2	22.9	0.297	7.17
DV-1D	10/25/2018							1.18	0.72	0.25	0.341	12.5	0.324	0.079J	<2.00	7.95	493	<2.00	3.5	2.15	-122.3	16.94	0.374	9.16
	11/14/2018	37		310	7.6	0.75J	7.3																	
	5/16/2019		10.94	0.74J	<0.20	<0.30	<0.30	6.63	<0.021	<0.021	0.0543	12.7	0.962	3.65	19	2.39	511	<1.86	5	0.27	-176.9	14.63	0.886	6.96
	6/17/2019		11.5	<1.0	<1.0	<1.5	<1.5	1.4	<0.022	<0.022	0.13	5.6	1.41	0.554	19.1	5.55	346	<2.00	3.5	0.25	-120.4	14.3	0.739	7
	7/25/2019		14.5	<1.0	<1.0	<1.5	<1.5	1.39	<0.021	<0.021	0.128	5.5	2.59	0.347	16	4.89	278	<1.56	3	0.31	-130	14.2	0.578	7.02
	9/30/2019		15.08	<0.20	<0.20	<0.30	<0.30	0.143	0.19	0.079J	0.0334	2.71	1.67	0.0316J	3.64	8.42	146	<2.00	1	0.32	-127.2	21.3	0.319	7.29
DV-2	10/16/2018			6.9	<0.20	<0.30	<0.30	0.0211	0.4	0.32	0.0593	0.883	1.5	0.0780J	0.626	2	144	<2.00	1	1.48	-83.1	20.71	0.279	7.93
	5/16/2019		13.08	2.9	<0.20	<0.30	<0.30	2.11	<0.021	<0.021	0.0674	7.32	1.99	0.201	3.73	4.01	326	<1.86	2.75	0.34	-158	14.07	0.651	6.73
	6/17/2019		14	<0.20	<0.20	<0.30	<0.30	0.0853	<0.021	<0.021	0.0254	1.27	2.15	0.0364J	0.852	1.72	182	<2.00	1	0.27	-146	12.9	0.384	7.17
	7/25/2019		16.8	<0.20	<0.20	<0.30	<0.30	0.0999	0.095	<0.021	0.029	1.24	2	0.0423J	<0.200	1.48	127	<2.00	1.5	0.29	-143	16	0.267	7.12
	9/30/2019		17.4	<0.20	<0.20	<0.30	<0.30	0.252	0.17	0.064J	0.0355	0.987	1.62	<0.0300	<0.200	1.54	120	<2.00	1.5	0.31	-114.6	22.4	0.267	7.13
DV-3	10/26/2018			0.31J	<0.20	<0.30	<0.30	0.128	0.38	0.29	0.0361	1.15	0.79	0.0770J	<0.200	1.97	150	<2.00	1.5	1.81	-74.3	19.8	0.291	8.4
	5/16/2019		11.43	0.86J	<0.20	<0.30	<0.30	0.242	0.047	0.12	0.0605	2.33	1.16	1.95	12.7	4.02	172	<1.86	1.75	0.31	-176	13.11	0.32	7.05
	6/17/2019		12.53	3.2	<0.20	<0.30	<0.30	0.201	<0.020	<0.020	0.0927	2.73	0.927	0.0361J	4.1	2.04	177	<2.00	2	0.26	-162.1	13.4	0.382	7.34
	7/25/2019		15.29	0.58J	<0.20	<0.30	<0.30	0.125	<0.021	<0.021	0.0296	1.5	1.26	0.00417J	1.66	1.32	137	<2.00	1.5	0.29	-144	16.1	0.288	7.15
	9/30/2019		15.92	<0.20	<0.20	<0.30	<0.30	0.208	0.037J	0.061J	0.037	1.18	1.17	<0.0300	0.394J	1.59	127	<2.00	1.5	0.29	-120.4	21.2	0.287	7.14
DV-4	10/26/2018			340	7.2	<0.30	1.7	1.5	0.77	0.23	0.346	12.6	0.347	<0.0300	<0.200	8.36	501	<2.00	2.5	2.09	-109.8	17.63	0.831	9.41
	5/16/2019		11.68	<0.20	<0.20	<0.30	<0.30	8.75	<0.021	0.081J	0.0639	12.4	1.13	5.79	29.7	3.92	466	5.67	5	0.27	-180	15.1	0.87	6.82
	6/17/2019		13.91	1.9	<0.20	<0.30	<0.30	2.49	<0.021	<0.021	0.127	6.23	1.17	<0.0300	35.1	3.79	359	<2.00	3.5	0.21	-112.1	14.4	0.792	7.04
	7/25/2019		15.98	8.6	<0.20	<0.30	<0.30	2.28	<0.022	<0.022	0.183	8.93	1.69	0.0566J	15	2.28	320	3.43	4.5	0.29	-152	14.4	0.688	6.97
	9/30/2019		16.35	0.048	0.00034J	<0.30	<0.30	3.12	0.025J	0.039J	0.173	7.14	1.13	<0.0300	3.23	3.65	332	<2.00	5	0.35	-130.8	16.7	0.659	7.06

µg/l: micrograms per liter
mg/l: milligrams per liter
TPH: total petroleum hydrocarbons
DRO: diesel range organics

ORO: oil range organics
TOC: total organic carbon
BOD: biological oxygen demand
DO: dissolved oxygen

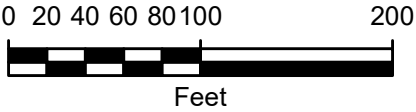
ORP: oxidation-reduction potential
mS/cm: millisiemens per centimeter
°C: degrees Celsius

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LEGEND

- DVT Clear Water Test Boring Location
- Shallow Monitoring Well
- Deep Monitoring Well
- Pilot Test Cell Location



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST
CELL LOCATION

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-1

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

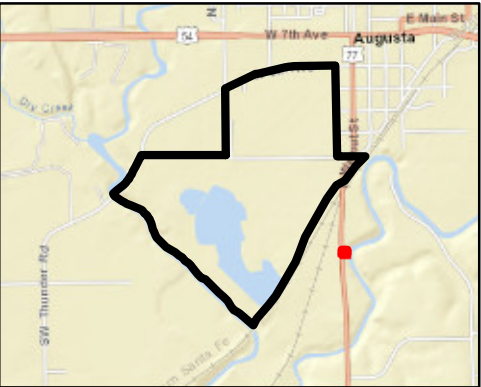
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LEGEND

- Design Verification Well
- Injection Location
- Pilot Test Cell Location

Note:
Imagery from DigitalGlobe (2019)



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST CELL

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-2

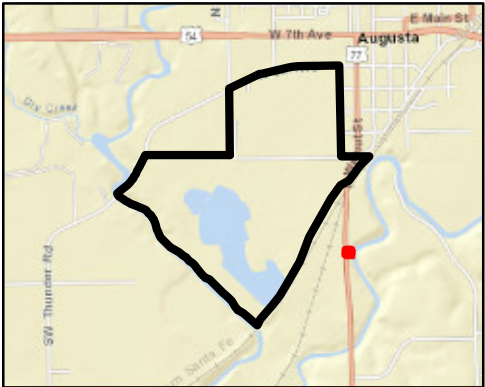
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LEGEND

- Design Verification Well
- Injection Location
- Pilot Test Cell Location
- 1 ft Groundwater Contours
- Groundwater Flow Direction

Notes:
1. Gradient = 0.1140
2. Imagery from DigitalGlobe (2019)



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST
POTENTIOMETRIC SURFACE CONTOURS
(APRIL 29, 2019)

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-3

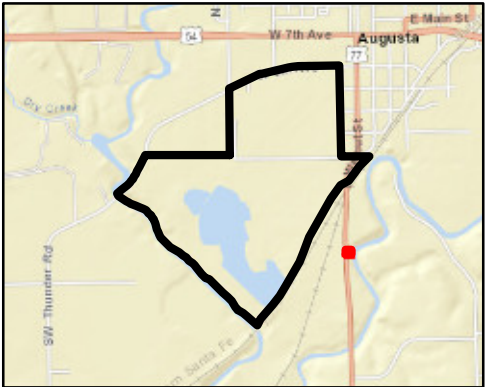
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LEGEND

- Design Verification Well
- Injection Location
- Pilot Test Cell Location
- 1 ft Groundwater Contours
- Groundwater Flow Direction

- Notes:
- Gradient = 0.0810
 - Imagery from DigitalGlobe (2019)



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST
POTENTIOMETRIC SURFACE CONTOURS
(SEPTEMBER 30, 2019)

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-4

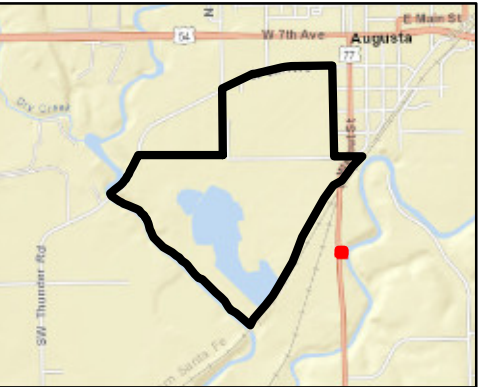
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LEGEND

- Design Verification Well
- Injection Location
- Pilot Test Cell Location

- Notes:
- PetroFix™ injection completed 4/30/19 through 5/3/19.
 - Imagery from DigitalGlobe (2019)





2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST
BASELINE ANALYSIS
(OCTOBER 26, 2018)

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-5

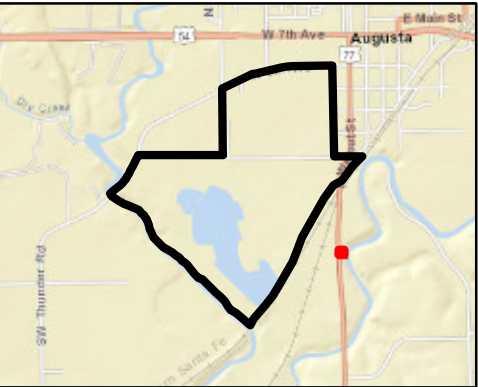
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LEGEND

- Design Verification Well
- Injection Location
- Pilot Test Cell Location

- Notes:
- PetroFix™ injection completed 4/30/19 through 5/3/19.
 - Imagery from DigitalGlobe (2019)



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST
45 DAYS FROM INJECTION
(JUNE 17, 2019)

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-6

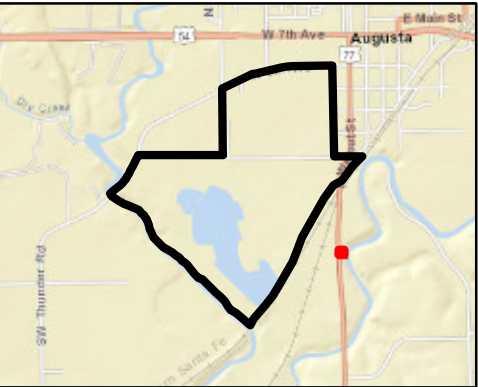
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LEGEND

- Design Verification Well
- Injection Location
- Pilot Test Cell Location

- Notes:
- PetroFix™ injection completed 4/30/19 through 5/3/19.
 - Imagery from DigitalGlobe (2019)



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

PETROFIX™ PILOT TEST
150 DAYS FROM INJECTION
(SEPTEMBER 30, 2019)

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
A-7



2872 N. Ridge Road, Suite 102
Wichita, Kansas 67205
(316) 220-8020

Site Id: DV-1D

Date Started: 10/21/18

Project Name: Williams FAR

Coordinate X: 1751996.89

Blank Casing:

Project Number: 149093

Coordinate Y: 1679937.60

type: PVC dia:2.00in
fm:0.00' to:34.00'

Location: Plumestop Pilot

Static Water Level: 15.93'

Screens:

Logged By: Austin Haller

Measuring Point: 1218.87'

type: Slotted size: 0.010in dia: 2.00in
fm: 35.00' to: 40.00'

Contractor: Plains

Total Depth: 41.50'

Drilling Method: HSA

Borehole Dia.: 8.25 in

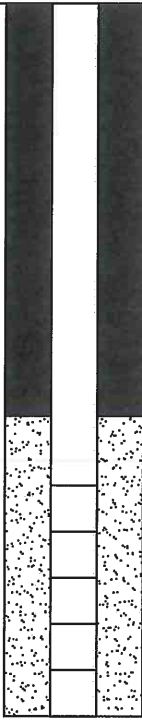




Annular Fill:

type: Bentonite fm: 0.00' to: 33.50'
type: Sand Pack fm: 33.50' to: 40.00'

Remarks: Ground elevation: 1219.18'

Completed Depth: 40.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
				3.9 ppm				0-5' Clay: silty, dark brown (10YR 4/3)
5			100	3.9 ppm		CH		5-10' Clay: silty, light brown (10YR 3/2), soft
			95	9.2 ppm		CH		10-15' Clay: light brown (10YR 3/2), hard
10			100	7.1 ppm		CH		15-17' Clay: light brown (10YR 3/2), staining
15			100	9.0 ppm		CH		17-20' Clay: (2.5YR 3/1)
				8.2 ppm				20-25' Clay: (2.5YR 3/1), staining, odor
			100	16.6 ppm		CH		
20				323.8 ppm		CH		
			100	399.1 ppm		CH		
25								

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25			100	40.7 ppm		CL		25-30' Clay: (2.5YR 3/1), silty
				11.5 ppm				
30			100	10.4 ppm		CL		30-34.75' Clay: silty (2.5YR 3/1)
				12.2 ppm				
35			90	5.3 ppm		SW/GW		34.75-35' Sand and Gravel
						SW		35-38' Gravelly Sand: medium to coarse grained clay layers
				5.7 ppm		SW		38-41.5' Sand
40								
								41.5' Limestone
								Total Boring Depth 41.5'



2872 N. Ridge Road, Suite 102
Wichita, Kansas 67205
(316) 220-8020

Site Id: DV-1I

Date Started: 10/20/18

Project Name: Williams FAR

Coordinate X: 1751996.94

Blank Casing:

type: PVC dia: 2.00in
fm: 0.00' to: 25.00'

Project Number: 149093

Coordinate Y: 1679940.44

Location: Plumestop Pilot

Static Water Level: 12.92'

Screens:

type: Slotted size: 0.010in dia: 2.00in
fm: 25.00' to: 35.00'

Logged By: Austin Haller

Measuring Point: 1218.78'

Contractor: Plains

Total Depth: 35.00'

Drilling Method: HSA

Borehole Dia.: 8.25 in

Annular Fill:

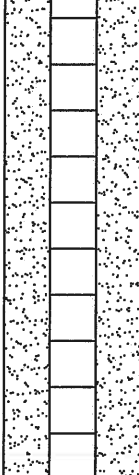
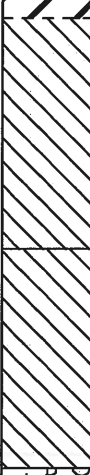
type: Bentonite fm: 0.00' to: 24.00'
type: Sand Pack fm: 24.00' to: 35.00'

Remarks: Ground elevation: 1219.19'

Lithology description taken from DV-1D. Soil boring not sampled.

Completed Depth: 35.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
0								0-5' Clay: silty, dark brown (10YR 4/3)
5						CH		
5-10								5-10' Clay: silty, light brown (10YR 3/2), soft
10						CH		
10-15								10-15' Clay: light brown (10YR 3/2), hard
15						CH		
15-17								15-17' Clay: light brown (10YR 3/2), staining
17-20						CH		17-20' Clay: (2.5YR 3/1)
20								
20-25								20-25' Clay: (2.5YR 3/1), staining, odor
25						CH		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25						CL		25-30' Clay: (2.5YR 3/1), silty
30								30-34.75' Clay: silty (2.5YR 3/1)
35						SW/GW		34.75-35' Sand and Gravel Total Boring Depth 35'
40								
45								
50								
55								



2872 N. Ridge Road, Suite 102
Wichita, Kansas 67205
(316) 220-8020

Site Id: DV-1S

Date Started: 10/20/18

Project Name: Williams FAR

Coordinate X: 1751996.44

Project Number: 149093

Coordinate Y: 1679935.32

Location: Plumbstop Pilot

Static Water Level: 13.22'

Logged By: Austin Haller

Measuring Point: 1218.67'

Contractor: Plains

Total Depth: 26.00'

Drilling Method: HSA

Borehole Dia.: 8.25 in

Blank Casing:

type: PVC dia: 2.00in
fm: 0.00' to: 10.00'

Screens:

type: Slotted size: 0.010in dia: 2.00in
fm: 10.00' to: 25.00'

Annular Fill:



type: Bentonite fm: 0.00' to: 9.00'
type: Sand Pack fm: 9.00' to: 25.00'

Remarks: Surface elevation: 1219.20'

Lithology description taken from DV-1D. Soil boring not sampled.

Completed Depth: 25.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
						CH		0-5' Clay: silty, dark brown (10YR 4/3)
5						CH		5-10' Clay: silty, light brown (10YR 3/2), soft
10						CH		10-15' Clay: light brown (10YR 3/2), hard
15						CH		15-17' Clay: light brown (10YR 3/2), staining
						CH		17-20' Clay: (2.5YR 3/1)
20						CH		20-25' Clay: (2.5YR 3/1), staining, odor
25						CH		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25								Total Boring Depth 26'
30								
35								
40								
45								
50								
55								



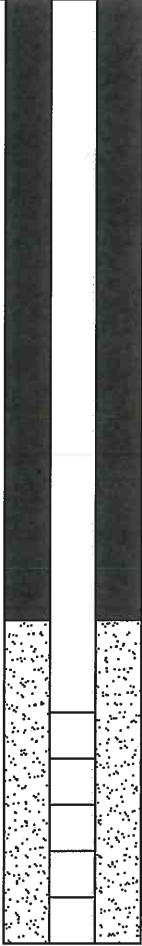





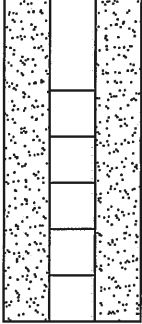




2872 N. Ridge Road, Suite 102
Wichita, Kansas 67205
(316) 220-8020

Site Id: DV-2

Date Started: 10/21/18

Project Name: Williams FAR	Coordinate X: 1751972.63	Blank Casing: type: PVC dia:2.00in fm:0.00' to:40.00'
Project Number: 149093	Coordinate Y: 1679943.54	
Location: Plumestop Pilot	Static Water Level: 17.42'	Screens: type: Slotted size:0.010in dia: 2.00in fm:40.00' to:45.00'
Logged By: Austin Haller	Measuring Point: 1222.10'	
Contractor: Plains	Total Depth: 45.00'	
Drilling Method: HSA/CS/HA	Borehole Dia.: 8.25 in	Annular Fill: type: Bentonite fm:0.00' to:38.00' type: Sand Pack fm:38.00' to:45.00'
Remarks: Surface elevation: 1222.60'		Completed Depth: 45.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
				20.8 ppm		CH		0-5' Clay: very dark brown (10YR 2/2), firm
5				59.3 ppm		CH		5-8' Clay: very dark brown (10YR 2/2), soft
			80			CH		8-10' Clay: dark brown (10YR 3/3), firm
10				98.8 ppm		CH		10-12.5' Clay: very dark brown (10YR 2/2), soft
			100			CH		12.5-15' Clay: dark brown (10YR 3/3), firm
15				108.3 ppm		CH		15-17' Clay: dark brown (10YR 3/3), soft
		▽	100			CH		17-20' Clay: very dark gray (2.5YR 3/1), firm, streaking, odor
20				312.8 ppm		CH		20-25' Clay: very dark gray (2.5YR 3/1), firm, streaking, odor
			100			CH		
25								

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25				426 ppm				25-30' Clay: very dark gray (2.5YR 3/1), odor, firm
			100			CL		
30				378 ppm				30-35' Clay: same as above
			100			CH		
35								35-40' Clay: very dark gray (2.5YR 3/1), soft, moist
			100			CH		
40				300.1 ppm				40-44' Clay: sandy, very dark gray (2.5YR 3/1), soft, moist
			100			CL		
45								44-45' Sand: clayey, medium to coarse grained, weathered limestone gravel
								45' Limestone
								Total Boring Depth 45'
50								
55								



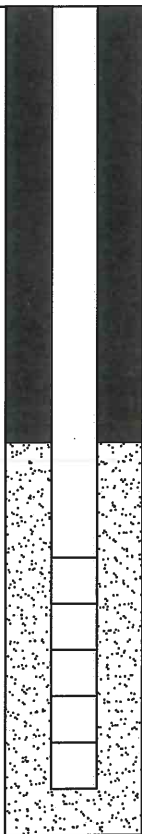




2872 N. Ridge Road, Suite 102
Wichita, Kansas 67205
(316) 220-8020

Site Id: DV-3

Date Started: 10/21/18

Project Name: Williams FAR	Coordinate X: 1751979.54	Blank Casing: type: PVC dia:2.00in fm:0.00' to: 35.00'
Project Number: 149093	Coordinate Y: 1679962.40	
Location: Plumestop Pilot	Static Water Level: 15.85'	Screens: type: Slotted size: 0.010in dia: 2.00in fm: 36.50' to: 41.50'
Logged By: Austin Haller	Measuring Point: 1220.87'	
Contractor: Plains	Total Depth: 42.50'	
Drilling Method: HSA	Borehole Dia.: 8.25 in	Annular Fill: type: Bentonite fm: 0.00' to: 34.00' type: Sand Pack fm: 34.00' to: 42.50'
Remarks: Ground elevation: 1221.37' Lithology description taken from DV-2. Soil boring not sampled.		Completed Depth: 41.50'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
0								0-5' Clay: very dark brown (10YR 2/2), firm
5						CH		
								5-8' Clay: very dark brown (10YR 2/2), soft
						CH		
								8-10' Clay: dark brown (10YR 3/3), firm
10						CH		
								10-12.5' Clay: very dark brown (10YR 2/2), soft
						CH		
								12.5-15' Clay: dark brown (10YR 3/3), firm
15								
								15-17' Clay: dark brown (10YR 3/3), soft
						CH		
								17-20' Clay: very dark gray (2.5YR 3/1), firm, streaking, odor
20								
								20-25' Clay: very dark gray (2.5YR 3/1), firm, streaking, odor
						CH		
25								

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25						CL		25-30' Clay: very dark gray (2.5YR 3/1), odor, firm
30						CH		30-35' Clay: same as above
35						CH		35-40' Clay: very dark gray (2.5YR 3/1), soft, moist
40						CH		
45								Total Boring Depth 42.5'
50								
55								



2872 N. Ridge Road, Suite 102
Wichita, Kansas 67205
(316) 220-8020

Site Id: DV-4

Date Started: 10/22/18

Project Name: Williams FAR

Coordinate X: 1752015.75

Blank Casing:

type: PVC dia: 2.00in
fm: 0.00' to: 34.50'

Project Number: 149093

Coordinate Y: 1679936.96

Location: Plumestop Pilot

Static Water Level: 16.90'

Screens:

type: Slotted size: 0.010in dia: 2.00in
fm: 34.50' to: 39.50'

Logged By: Austin Haller

Measuring Point: 1217.88'

Contractor: Plains

Total Depth: 39.50'

Drilling Method: HSA/CS

Borehole Dia.: 8.25 in

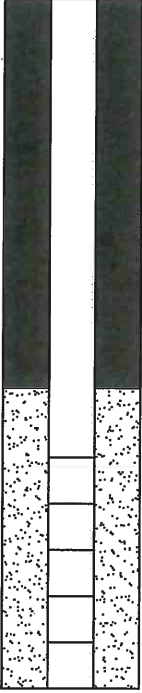



Annular Fill:

type: Bentonite fm: 0.00' to: 33.00'
type: Sand Pack fm: 33.00' to: 39.50'

Remarks: Ground elevation: 1218.28'

Completed Depth: 39.50'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
						FL		0-0.5' Topsoil
			95	121.3 ppm		CH		0.5-5' Clay: dark brown (10YR 3/3)
5						CH		5-8' Clay: silty, dark brown (10YR 3/3), soft
			100			CH		8-10' Clay: very dark brown (10YR 2/2), firm
10				328.7 ppm		CH		10-15' Clay: dark brown (10YR 3/3), hard, staining throughout, odor
			100			CH		15-17.5' Clay: dark brown (10YR 3/3), firm, odor
15				379.2 ppm		CH		17.5-20' Clay: very dark gray (10YR 3/1), soft, odor
			100	1228 ppm		CH		20-25' Clay: very dark gray brown (10YR 3/2), firm to soft, odor
20						CH		
			100			CH		
25						CH		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25			100	811.5 ppm		CH		25-30' Clay: very dark gray (10YR 3/1), very soft, smear, odor
30				340.3 ppm				30-34.5' Clay: very dark gray (10YR 3/1), soft to firm
35			100	24.5 ppm		SW		34.5-35' Clayey Sand: weathered limestone gravel, medium to coarse grained
						SW		35-38.5' Sand: coarse with clay
40						CH		38.5-39.5' Clay: very dark gray (10YR 3/1), sandy 39.5' Limestone Total Boring Depth 39.5'



Appendix B



BIO-SPARGE PILOT TEST

The purpose of the pilot test is to evaluate the effectiveness of bio-sparge technology to stimulate naturally occurring microbes into degrading the residual dissolved petroleum hydrocarbons. Attenuation monitoring performed at the site over a period of many years has demonstrated the subsurface system's natural ability to attenuate hydrocarbons over distance, but enhancements may be appropriate to address hydrocarbons in key locations.

Bio-sparge is a cost effective technology for remediation of dissolved hydrocarbons through biodegradation. Biodegradation does not volatilize dissolved contaminants. The low air injection flow of bio-sparging minimizes the risk of enhancing the horizontal migration of petroleum contamination. Bio-sparging does not require vacuum extraction, provided the injection pressure/flow does not promote contaminant volatilization.

During the pilot test, operating parameters were collected to evaluate efficacy and provide data for potential design and construction of a bio-sparge treatment system. Key objectives for the testing included:

- Determine the ability of bio-sparge to promote biodegradation of dissolved hydrocarbons in the subsurface.
- Determine the ability and degree of altering redox potential through bio-sparge and promote precipitation of dissolved arsenic.
- Determine the effective radius of influence for sparge air injection.

B.1 Pilot Test Scope of Work and Methodology

B.1.1 Pilot Test Layout

The bio-sparge pilot test location is located onsite in the vicinity FAR08-12D at the southeast side of the FAR (see **Figure B-1**). The average depth to water in the area of FAR08-12D during pilot testing activities ranged from approximately 1 foot below ground surface (bgs) in the shallow monitoring wells to 3 feet bgs in the deep monitoring wells. This test location was selected based upon the dissolved benzene concentrations in the deep sand and gravel unit and historically depleted dissolved oxygen in the area.

The pilot test layout consisted of three air sparge (AS) injection wells, three monitoring well clusters (MP-1S/1D, MP-2S/2D, MP-3S/3D), and an up gradient monitoring well (MP-4D). The AS injection wells were placed on 15 foot centers from each other, with the monitoring points set at distances of 10, 20, and 40 feet hydraulically down gradient of the center AS injection well. The layout for the pilot test is presented on **Figure B-2**

B.1.2 Sparge and Monitoring Point Installation

A GeoProbe® was used for installation of the AS injection wells and MPs. The AS injection wells were installed to a total depth of approximately 39 feet bgs at the top of the weathered bedrock to allow injection within the deeper sand and gravel unit. Each AS injection well was constructed using 1-inch diameter poly-vinyl chloride (PVC) riser threaded to a two-foot long 1-inch diameter porous polyethylene 40-micron sparge point well screen. A silica sand filter pack was placed two to three feet above the screen. To provide an adequate seal of the borehole, a minimum of one-foot bentonite seal was placed above the sand filter pack and grout seal to surface. The injection interval in each AS was approximately 34 to 39 feet bgs. The AS injection wells were surface finished in 8-inch manholes with bolt-down, water-rated lids.

The MPs were constructed of 2-inch diameter schedule 40 PVC riser with a 5-foot section of 0.010-inch slotted 2-inch diameter PVC screen for the deep monitoring wells and 10-foot section of 0.010-inch slotted 2-inch diameter PVC screen for the shallow monitoring wells. The shallow monitoring wells MP-1S and 2S were screened from five to 10 feet bgs, and MP-3S was screened from seven to 17 feet bgs. The four deep MPs were screened from 34 to 39 feet bgs, setting on the top of the weathered bedrock. A silica sand filter pack was placed one to two feet above the screen with a bentonite seal placed above the sand filter pack to within one foot of surface. Each monitoring well was completed at surface in a two-foot diameter concrete pad, with an 8-inch diameter flush mount manhole with bolt-down water-rated lid.

An APTIM field geologist was present to oversee the soil sampling and monitoring well installation activities. Specific boring logs and monitoring well completion diagrams are included in the **Appendix Attachment B-1**.

B.1.3 Pilot Test Groundwater Sampling

B.1.3.1 Monitoring Well Gauging

Fluid levels were gauged in each of the monitoring points after installation and prior to collection of groundwater samples. Static water levels and LNAPL thickness (if applicable) were measured in each well using an oil/water interface probe, capable of detecting LNAPL on the water to an accuracy of 0.01 feet. Results of the well gauging activities are presented in **Table B-1**.

B.1.3.2 Groundwater Sampling

Baseline groundwater sampling was completed following the installation and development of the new monitoring points and from existing monitoring well FAR08-12D within the pilot test cell. A post pilot test groundwater sampling event was completed from the same wells at the completion of the pilot test activities.

Groundwater samples were collected using a peristaltic pump from mid screen interval from each of the wells for laboratory analytical analysis.



Each of the monitoring wells were sampled for VOCs and TPH DRO/ORO analysis. Monitoring wells were also sampled for natural attenuation parameters using low flow groundwater sampling methods as outlined in the 2015 Sampling and Analysis Plan. Parameters measured in the field included:

- oxidation-reduction potential (ORP),
- pH,
- temperature,
- conductivity,
- dissolved oxygen (DO), and
- ferrous iron.

Additional parameters analyzed by the laboratory included:

- alkalinity,
- nitrate,
- sulfate,
- methane,
- total and dissolved arsenic and iron, and total manganese.

The dissolved arsenic and iron were field filtered prior to preservation. The total and dissolved iron analysis were not included during the baseline groundwater sampling event.

Samples were shipped under chain of custody to ALS Environmental, Houston, Texas for analysis.

B.1.4 Bio-Sparge Pilot Test

B.1.4.1 Test Equipment

A Gast oil-less piston pump model 8LDF supplied the sparge air. Air injection flow/pressure control to each injection point was performed using a pressure regulator and a 0.5 to 5 standard cubic feet per minute (scfm) variable area mechanical flowmeter at each of the AS injection wells. The compressor is capable of delivering up to 10 scfm at 50 pounds per square inch (psi) and can be operated at 100% duty cycle on standard, single-phase, 115-volt power. The compressor was housed in a small vented outdoor storage enclosure.

Each monitoring point was equipped with a slip cap and threaded pressure Pete's Plug to allow the collection of well head pressures and other well head air readings as needed.

Wellhead pressures were collected with a 0 to 60 psi gauge fitted with a Pete's Plug needle or a Dwyer differential pressure digital manometer for low range (0 to 10 psi) pressure readings.

Soil gas analysis in the well head space was completed with a MiniRAE 3000 10.6 electron volt (eV) photoionization detector (PID) for VOC monitoring and Landtec GEM 2000 to monitor for oxygen, carbon dioxide, and methane.

Down well water readings were collected using a YSI Water Surveyor. Down well water readings included temperature, conductivity, dissolved oxygen (DO), pH, and oxidation-reduction potential (ORP).



B.1.4.1 Test Monitoring

Data collected during the bio-sparge pilot testing included:

- depth to water;
- well head pressure;
- soil gas field screening in the well head space for VOCs, oxygen, carbon dioxide, and methane;
- temperature, conductivity, DO, pH, and ORP field analysis of the groundwater;
- AS injection well injection pressure and injection flow.
- Observations of groundwater mounding, air bubble formation, or odors

B.2 Monitoring and Results

B.2.1 Well Gauging Activities

Results of the well gauging activities before and after pilot test activities are presented in **Table B-1**. **Figure B-3** presents the deep potentiometric surface contour map for the pilot test cell on December 10, 2018, just before bio-sparge pilot test activities. The groundwater flow direction for the gauging event is to the southeast across the pilot test cell. The hydraulic gradient calculated for the deep monitoring wells across the pilot test cell is 0.0068.

From October 30, 2018 to January 16, 2019, the groundwater elevation dropped approximately 3.5' across the test cell between the start of pilot test activities to the end of pilot test activities.

B.2.2 Light Non-Aqueous Phase Liquid Occurrence

LNAPL was noted in soil during installation of the monitoring points and has been observed in monitoring wells downgradient to the south and upgradient to the northwest of the bio-sparge test area. In the bio-sparge test cell, well gauging data collected before and after pilot test activities noted measurable LNAPL in deep wells MP-2D and MP-3D (**Table B-1**, **Table B-4**, **Table B-5**). Initial LNAPL thickness noted in MP-2D was 4.59 feet and in MP-3D was 0.07 feet. LNAPL was removed by use of a peristaltic pump from both the wells and was noted to return during pilot test activities, with a greatest noted thickness of 0.26 feet in MP-2D and 4.43 feet in MP-3D. LNAPL was removed from the wells each time after being measured and noted.

B.2.3 Pre and Post Pilot Test Groundwater Sampling Results

Summary of the pre and post pilot test groundwater analysis are shown in **Table B-2**. Measured field parameters are also included on **Table B-2**.

The baseline groundwater sampling was completed October 31, 2018. The post groundwater sampling event was completed on January 16, 2019, approximately two days after the bio-sparge pilot testing had ended. The benzene and TPH DRO/ORO concentrations in groundwater collected from the wells within the pilot test area are shown on **Figure B-4**.

Generally, there was a minimal increase in benzene concentrations in wells between the pre and post test sampling events. However, except for monitoring point MP-3S, benzene concentrations for pre and post

test sampling events did not show significant variance. Pre test benzene concentrations ranged from 0.13 mg/L to 0.73 mg/L and post test benzene ranged from 0.14 mg/L to 0.81 mg/L. For MP-3S, there was an increase in benzene from a pre test concentration of 0.0082 mg/L to a post test concentration of 0.1 mg/L. The highest benzene concentration in groundwater was reported in the deep up gradient monitoring point MP-4D at 2 mg/L during both pre and post test sampling events.

TPH concentrations for pre and post test sampling events did not show significant variance. TPH DRO ranged from 1.4 mg/L to 13 mg/L, and TPH ORO ranged from <0.11 mg/L to 0.57 mg/L. The highest detection was TPH DRO in the shallow monitoring point MP-1S at 13 mg/L, collected during the post groundwater sampling event.

B.2.4 Pilot Test Monitoring Results

Short duration (3 to 5 hours), 24-hour, and extended duration (1 week) pilot testing was completed in phases from December 11, 2018 through January 14, 2019. The wellhead pressure response versus time noted at each of the monitoring points during each of the bio-sparge tests is included in **Table B-3**. The field soil gas and down well groundwater readings collected from each of the monitoring points during the short duration and the 24-hour tests are included in **Table B-4**. The field soil gas and down well groundwater readings collected from each of the monitoring points during the extended test are included in **Table B-5**.

The first phase of the pilot test was to determine the individual break-through pressure for each of the injection wells. Break-through pressures required for injection flow to the formation at each AS injection well are calculated as one psig for every 2.3 feet of hydraulic head. The initial saturated thickness to the top of each of the sparge points was measured at approximately 30.1 feet with a calculated break-through pressure of 13 psi for each of the AS injection wells. Actual wellhead sparge pressures ranged from 12 to 13.5 psi in each of the AS injection wells during the pilot test activities.

Short duration (3 to 5 hours) bio-sparge pilot tests were initially completed on each of the AS injection wells at a sparge flow rate of approximately 0.5 scfm. A bio-sparge test was then completed at injection well AS-1 at a sparge flow rate of approximately 0.5 scfm for a duration of approximately 24-hours. During each of the short duration bio-sparge pilot tests, pressures as high as 11 to 12.5 psi were noted in the deep monitoring points at distances up to 25 feet from the AS injection well.

The extended duration pilot test was completed at injection wells AS-1 and AS-3, each with a flow rate of approximately 0.5 scfm, for a duration of approximately 1-week. Approximately five days into the test, condensation froze in the AS-1 and AS-3 flow meters, limiting the accuracy of the sparge air flow readings and the extended test was completed by switching the sparge flow to AS-2 at a sparge flow rate of 0.5 scfm. Results for the extended duration pilot test were as follows:

- Pressure responses were noted in both deep and shallow monitoring points. Pressure responses as high as 12 to 13 psi were noted in monitoring points FAR08-12D, MP-1D, and MP-2D at approx-



imate distances of 16 feet, 19 feet, and 26 feet, respectively. Pressure responses were also noted in shallow monitoring points at 1.9 psi in MP-1S (17 feet), 1.6 psi in MP-2S (24 feet), and 1.1 psi in MP-3S (42 feet).

- The high pressure response in some of the close deep monitoring points prevented the collection of some of the in-well monitoring during the pilot test. Air bubbling within water was noted in some of the closer monitoring points when the well cap was removed.
- DO readings increased in groundwater from most of the monitoring points during the extended bio-sparge pilot test, but decreased back to near baseline readings during post pilot test sampling.
- The ORP readings also showed a positive increase in most of the monitoring points during the extended bio-sparge pilot test, reflecting a decrease in reducing conditions, but also decreased back to more negative readings during the post pilot test sampling event.
- At the end of the extended bio-sparge test, a short-term (less than 1-minute) flow test was completed on AS-2 to observe flow rate versus pressure at the sparge point. A maximum flow rate of greater than 5 scfm was applied with a noted sparge pressure of 16 psi, 3 psi greater than break-through pressure of 13 psi.

B.3 Pilot Test Conclusion

Bio-sparge can be completed in the sand and gravel unit at the calculated break-through pressures of 12 to 13 psi.

Confined aquifer responses were noted during the bio-sparge pilot testing with near break-through pressure responses in the deep monitoring points with pressures of 12 to 13 psi at radiuses of 25 feet. Pressure responses were also noted in the shallow monitoring points. Pressures were noted to decrease towards the end of the extended bio-sparge testing because of flow meter freezing and possible short circuiting of air flow to surface near some of the wells. Air bubbles were noted at surface in some areas in standing surface water and around some of the well annuluses.

Increases in DO and positive increase in ORP were noted during the bio-sparge testing, which returned to static after ending the test. With the amount of hydrocarbon mass in the area of the pilot testing, any dissolved oxygen concentrations were quickly consumed.

No significant variations were observed in groundwater VOC concentrations from baseline to post bio-sparge sampling events. Generally, there was a minimal increase in benzene concentrations. There was also an average 3.5' drop in water elevation during this same time period. Minimal variations could be associated with pilot testing activities and/or a result of groundwater fluctuations. Reductions associated with biological activity would not be expected at this time given the bio-sparge pilot testing was conducted over a short time period. With time, bio-sparging would stimulate naturally occurring microbes into degrading the residual dissolved petroleum hydrocarbons.

LNAPL has been noted in wells downgradient to the south and upgradient to the northwest of the test cell, and was observed in soil during installation of the pilot test monitoring points. During the testing, an in-



crease in LNAPL was most notable in monitoring points MP-2D and MP-3D. An increase in pore pressures during bio-sparge pilot testing activities liberated LNAPL trapped in fine grained soils within the area into the monitoring points.

Current results from the pilot testing indicate that bio-sparge may have application as a site remedy as part of the Corrective Measures within select areas at the FAR. Bio-sparging would be best implemented in short cycles for better control of radial pressure responses and to prevent short circuiting of air to surface.

Table B-1

Groundwater Elevation Data
 Biosparge Pilot Test
 Former Augusta Refinery, Augusta, Kansas
 Williams Petroleum Services, LLC

Well ID	Date	Top of Casing Elevation	Depth to Water (feet)	Depth to Product (feet)	Product Thickness (feet)	Corrected Depth to Water (feet)	Ground Water Elevation
MP-1S	10/30/2018	1217.64	1.17			1.17	1216.47
	12/10/2018	1217.64	4.01			4.01	1213.63
	12/14/2018	1217.64	3.22			3.22	1214.42
	1/16/2019	1217.64	3.74			3.74	1213.9
MP-1D	10/30/2018	1217.72	3.50			3.50	1214.22
	12/10/2018	1217.72	6.59			6.59	1211.13
	12/14/2018	1217.72	7.00			7.00	1210.72
	1/16/2019	1217.72	7.77			7.77	1209.95
MP-2S	10/30/2018	1217.77	1.33			1.33	1216.44
	12/10/2018	1217.77	4.09			4.09	1213.68
	12/14/2018	1217.77	3.78			3.78	1213.99
	1/16/2019	1217.77	4.93			4.93	1212.84
MP-2D	10/31/2018	1217.59	3.87			3.87	1213.72
	12/10/2018	1217.59	10.30	5.71	4.59	6.63	1210.96
	12/14/2018	1217.59	7.03			7.03	1210.56
	1/16/2019	1217.59	7.84	7.83	0.01	7.83	1209.76
MP-3S	10/30/2018	1218.08	1.65			1.65	1216.43
	12/10/2018	1218.08	4.82			4.82	1213.26
	12/14/2018	1218.08	4.90			4.90	1213.18
	1/16/2019	1218.08	5.71			5.71	1212.37
MP-3D	10/31/2018	1217.91	4.23			4.23	1213.68
	12/10/2018	1217.91	7.10	7.03	0.07	7.04	1210.87
	12/14/2018	1217.91	7.43	7.42	0.01	7.42	1210.49
	1/16/2019	1217.91	7.92			7.92	1209.99
MP-4D	10/30/2018	1217.47	3.11			3.11	1214.36
	12/10/2018	1217.47	6.21			6.21	1211.26
	12/14/2018	1217.47	6.61			6.61	1210.86
	1/16/2019	1217.47	7.35			7.35	1210.12
AS-1	12/10/2018	1217.53	6.45			6.45	1211.08
	12/14/2018	1217.53	6.88			6.88	1210.65
AS-2	12/10/2018	1217.44	6.40			6.40	1211.04
	12/14/2018	1217.44	6.83			6.83	1210.61
AS-3	12/10/2018	1217.43	6.35			6.35	1211.08
	12/14/2018	1217.43	6.80			6.80	1210.63
FAR08-12D	10/30/2018	1220.29	6.11			6.11	1214.18
	12/10/2018	1220.29	9.18			9.18	1211.11
	1/16/2019	1220.29	8.50			8.50	1211.79

Table B-2

Groundwater Analytical Results
Biosparge Pilot Test
Pre and Post Test Monitoring
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

Well ID	Sample Date	Benzene (mg/l)	Toluene (mg/l)	Ethylbenzene (mg/l)	Xylenes (mg/l)	Methane (mg/l)	TPH DRO (mg/l)	TPH ORO (mg/l)	Total Arsenic (mg/l)	Total Manganese (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Total Alkalinity (mg/l)	Total Iron (mg/l)	Ferrous Fe (mg/l)	DO (mg/l)	ORP (mV)	Temperature (° C)	Conductivity (mS/cm)	pH
MP-1S	10/30/18	0.73	0.15	0.35	0.33	0.799	11	0.43	0.0517	8.24	<0.200	1130	308		6.0	1.93	-117	16.1	2.272	7.61
	1/16/19	0.81	0.029	0.065	0.058	0.0276	13	<0.45	0.00924	9.92	<0.100	1510	69.8	47.0		5.56	54.9	9.7	2.645	5.74
MP-1D	10/30/18	0.66	0.012	<0.0050	<0.0050	8.42	3.9	0.022J	0.0455	1.26	<0.100	0.740	1180		5.0	1.40	-93.2	14.9	2.025	7.77
	1/16/19	0.70	0.0084	0.012	0.0033J	2.43	4.9	<0.11	0.0562	1.04	<0.100	0.884	1130	10.2		0.43	-74.6	13.7	2.209	6.68
MP-2S	10/31/18	0.14	0.0030J	0.027	<0.0050	0.233	6.8	0.56	0.0120	9.24	<0.200	908	572		3.5	2.28	-49.0	15.6	2.211	7.34
	1/16/19	0.13	<0.0050	<0.0050	<0.0050	0.0557	8.1	<0.45	0.00647	9.56	0.113	1070	353	3.17		0.39	-29.8	11.5	2.444	6.63
MP-2D	10/31/18	0.62	0.012	0.0087	0.0032J	2.36	4.3	0.22	0.0414	0.653	<0.100	1.21	1140		6.5	2.07	-94.8	14.8	2.015	8.24
	1/16/19	0.73	0.0086	0.0098	0.0057	1.61	5.6	<0.11	0.0598	0.704	<0.100	0.572	1130	16.5		0.38	-94.9	13.2	2.217	6.65
MP-3S	10/30/18	0.0082	<0.0050	<0.0050	<0.0050	0.511	1.4	0.22	0.0336	2.07	<0.100	47.1	639		4.0	1.76	-68.2	16.0	1.013	7.40
	1/16/19	0.10	<0.0050	<0.0050	<0.0050	0.194	3.6	0.12	0.0189	1.40	0.230	96.3	436	7.35		0.39	-66.1	12.2	0.888	6.73
MP-3D	10/31/18	0.69	0.011	0.0084	<0.0050	2.91	4.5	0.19	0.0389	0.733	<0.100	0.722	1120		6.0	1.49	-89.9	14.8	2.002	8.18
	1/16/19	0.81	0.0096	0.0084	0.0051	1.81	4.9	<0.11	0.0414	0.712	<0.100	0.692	1110	16.0		0.45	-110	14.7	2.211	6.74
MP-4D	10/30/18	2.00	0.028	0.059	<0.010	26.7	6.1	0.57	0.156	4.30	<0.100	1.17	1520		6.0	2.09	-114	15.1	2.354	8.16
	1/16/19	2.00	0.025	0.067	0.0074	1.13	9.0	<0.45	0.206	4.28	<0.100	1.18	1450	27.1		0.41	-101	13.4	2.422	6.72
FAR08-12D	10/30/18	0.51	0.0074	<0.0050	<0.0050	7.68	4.2	0.25	0.0456	0.806	<0.100	0.624	1110		6.5	1.46	-21.7	14.8	2.012	7.80
	1/16/19	0.80	0.0098	0.01	0.0039J	2.00	4.7	0.16	0.0534	0.968	<0.100	2.03	1130	5.53		0.38	-42.6	12.1	2.178	6.70

mg/l: milligrams per liter
TPH: total petroleum hydrocarbons
DRO: diesel range organics

TOC: total organic carbon
BOD: biological oxygen demand
DO: dissolved oxygen

ORP: oxidation-reduction potential
mS/cm: millisiemens per centimeter
°C: degrees Celsius

Well Head Pressures Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

				Well ID	AS-2	FAR08-12D	MP-1D	MP-1S	AS-1	AS-3	MP-2D	MP-2S	MP-4D	MP-3D	MP-3S
Date	Time	Δ T (min)	Flow Rate	Dist (ft)	0.0	5.0	10.2	10.0	15.2	15.5	19.8	19.0	24.5	39.2	39.7
12/12/2018	12:03	0	0.5		13.0		NR	NR	NR	NR	NR	NR	NR	NR	NR
	12:15	12	0.5		NR	10.0	NR	NR	NR	NR	NR	NR	NR	NR	NR
	12:30	27	0.5		NR	11.5	NR	NR	NR	NR	NR	NR	NR	NR	NR
	12:45	42	0.5		12.5	12.0	0.000	1.350	0.000	0.000	5.0	NR	0.000	NR	NR
	13:00	57	0.5		12.5	12.0	0.000	1.280	0.000	0.000	11.8	0.620	-0.007	NR	0.068
	13:30	87	0.5		12.5	12.0	2.020	1.290	0.000	0.000	12.0	1.500	-0.004	0.013	0.078
	14:00	117	0.5		12.5	12.0	4.960	1.330	0.000	0.000	12.0	1.370	-0.007	0.004	0.097
	14:30	147	0.5		12.5	12.0	7.100	1.350	0.000	0.000	11.5	1.334	-0.012	0.021	0.072
	15:00	177	0.5		12.5	12.0	8.200	1.345	-0.003	0.000	11.5	1.317	-0.013	0.099	0.051
	15:55	232	0.5		12.5	12.0	8.330	1.353	-0.001	0.000	11.5	1.303	NR	NR	NR
	16:30	267	0.5		12.5	12.0	6.300	NR (open)	0.000	0.000	12.0	NR (open)	NR	NR	NR
	16:55	Stopped	0.0		12.5	12.0					12.0				
	17:07	12	0.0		10.5	11.0					11.5				
	17:30	35	0.0		7.0	10.5					11.0				

[illegible]

Table B-4

Well Monitoring Vapor and Groundwater Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

Individual Short Duration BioSparge Tests and AS-1 24-hour Bio-Sparge Test
Flow Rate: 0.5 scfm breakout approximately 13 psi

					Well Head Space						Groundwater measurements									Comments
Spurge Test	Date	Time	Well ID	Dist (ft)	Pressure (psi)	PID (ppmv)	CH ₄ %	CO ₂ %	O ₂ %	Balance	DTP	DTW	LNAPL Thick	Temp °C	Cond mS/cm	DO%	DO mg/l	pH	ORP	
FAR08-12D																				
	12/10/2018	1500		5.0								9.18								
Baseline AS 2	12/11/2018	1300										8.90		16.12	2.334	10.6	1.03	6.69	-95.8	
end sparge AS 2	12/12/2018	1500			12.0															
day after sparge	12/13/2018	1000			-0.013							9.29		16.14	2.260	26.1	2.56	6.87	19.6	
Baseline AS 1	12/17/2018	1130		16		678	3.6	1.5	20.6	74.3		9.82		16.12	2.278	10.8	1.06	6.80	1.5	
end AS 1 sparge	12/17/2018	1730			12.0															
Baseline AS 3	12/18/2018	1200		16		785	19.4	3.2	17.7	62.3		9.73		16.10	1.839	24.2	2.36	6.85	-9.1	
end AS 3 sparge	12/18/2018	1730																		
Baseline AS 1 24 hr	12/19/2018	900		16		468	15.5	2.9	19.8	61.6		9.56		16.11	1.846	9.2	0.90	6.80	-17.1	
		1330																		
		1700																		
End AS 1 24 hr	12/20/2018	1100																		
MP-1D																				
	12/10/2018	1500		10								9.10								
Baseline AS 2	12/11/2018	1300				545	25.1	3.8	18.2			8.84		16.13	2.332	10.3	1.03	6.70	-89.3	
end sparge AS 2	12/12/2018	1500			8.33	700	26.5	1.7	20.3	51.0										
day after sparge	12/13/2018	1000			-0.034	661	19.6	2.5	20.2	58.3		9.21		16.14	2.272	25.5	2.49	6.76	-3.3	
Baseline AS 1	12/17/2018	1130		19		936	7.2	0.9	20.2	72.1		9.73		16.11	2.247	13.1	1.28	6.67	-56.5	
end AS 1 sparge	12/17/2018	1730			11.5															
Baseline AS 3	12/18/2018	1200		17		1194	30.9	3.3	18.8	47.3		9.85		16.12	1.874	17.0	1.67	6.80	-61.2	
end AS 3 sparge	12/18/2018	1730																		
Baseline AS 1 24 hr	12/19/2018	900		19		725	20.9	3.1	20.2	55.7		9.48		16.10	1.883	8.7	0.86	6.73	-44.9	
		1330																		
		1700																		
End AS 1 24 hr	12/20/2018	1100																		

Table B-4

Well Monitoring Vapor and Groundwater Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

Individual Short Duration BioSparge Tests and AS-1 24-hour Bio-Sparge Test
Flow Rate: 0.5 scfm breakout approximately 13 psi

[illegible]

Table B-4

Well Monitoring Vapor and Groundwater Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

Flow Rate: 0.5 scfm breakout approximately 13 psi

MP-2S																			
	12/10/2018	1500		19							6.59								
Baseline AS 2	12/11/2018	1300				17	0.4	3.8	20.2	75.7	6.50		16.09	2.632	8.2	0.80	6.72	-91.6	
end sparge AS 2	12/12/2018	1500			1.303	278	25.6	9.6	15.2	48.8	5.30		15.14	2.603	84.0	8.37	6.57	-1.1	
day after sparge	12/13/2018	1000			0.012	229	72.6	12.7	12.5	2.3	6.05		15.66	2.532	18.5	1.82	6.53	-32.6	
Baseline AS 1	12/17/2018	1130		24		249	2.8	4.0	20.2	72.9	6.51		15.04	2.532	16.0	1.60	6.38	-60.2	
end AS 1 sparge	12/17/2018	1730			0.973	174	20	7.7	16.1	55.6	5.88		14.83	2.513	60.5	6.09	6.50	-1.2	hear air bubble in well
Baseline AS 3	12/18/2018	1200		25		652	67	10.4	13.6	9.4	6.37		14.97	1.980	6.9	0.69	6.55	9.8	
end AS 3 sparge	12/18/2018	1730				242	34	7.3	14.8	39.5	5.72		14.63	1.967	50.1	5.04	6.65	-0.2	hear air bubble in well
Baseline AS 1 24 hr	12/19/2018	900		24		368	58	9.3	14.8	17.0	6.48		14.83	1.963	20.1	2.02	6.56	12.4	
		1330									5.98		14.74	1.912	79.5	7.99	6.67	-6.6	hear air bubble in well
		1700				818	46	5.5	18.0	30.5	6.18		14.81	1.890	86.2	8.66	6.65	39.7	hear air bubble in well
End AS 1 24 hr	12/20/2018	1100				631	30.3	3.4	18.7	47.0	6.71		14.90	1.807	93.6	9.39	6.67	63.8	hear air bubble in well
MP-4D																			
	12/10/2018	1500		25							8.72								
Baseline AS 2	12/11/2018	1300				92					8.48		16.07	2.555	14.0	1.37	6.72	-84.6	
end sparge AS 2	12/12/2018	1500			-0.015	270	0.8	1.5	20.6	77.1	8.22		16.04	2.578	14.2	1.39	6.70	-102.0	
day after sparge	12/13/2018	1000			-0.004	167	1.1	0.8	21.1	76.0	8.80		16.00	2.549	14.7	1.43	6.72	-103.2	
Baseline AS 1	12/17/2018	1130		29		225	0.6	2.4	20.2	76.9	9.34		16.11	2.640	19.6	1.90	6.65	-55.0	
end AS 1 sparge	12/17/2018	1730				109	0.2	0.5	21.3	78.0	8.73		15.98	2.594	23.2	2.26	6.70	-76.2	
Baseline AS 3	12/18/2018	1200		29		302	0.5	1.1	20.8	77.7	9.20		16.09	2.113	3.9	0.38	6.75	-137.6	
end AS 3 sparge	12/18/2018	1730				137	0.4	0.6	20.7	78.3	8.83		15.86	2.150	4.1	0.40	6.75	-96.8	
Baseline AS 1 24 hr	12/19/2018	900		29		281	0.7	1.0	21.0	77.4	9.06		15.94	2.091	3.2	0.30	6.68	-126.6	
		1330									8.70		15.82	2.144	4.6	0.45	6.69	-101.2	
		1700				167	0.5	0.5	20.7	78.3	8.77		15.82	1.995	4.0	0.39	6.71	-89.7	
End AS 1 24 hr	12/20/2018	1100				378	1.1	1.2	20.5	77.8	9.29		16.08	2.121	3.6	0.35	6.72	-117.2	

Table B-4

Well Monitoring Vapor and Groundwater Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

Individual Short Duration BioSparge Tests and AS-1 24-hour Bio-Sparge Test
Flow Rate: 0.5 scfm breakout approximately 13 psi

MP-3D																				
	12/10/2018	1500		39							9.5	9.57	0.07							Removed 4-oz LNAPL
Baseline	12/11/2018	1300				411	75.8	1.8	20.2	1.8		9.26		16.29	2.314	9.7	0.94	6.69	-94.4	
end sparge	12/12/2018	1500			0.099	365	3.4	0.3	21.0	75.1	8.26	11.44	3.18							
day after sparge	12/13/2018	1000			-0.008	229	>>>	2.7	18.4	>>>	8.82	13.25	4.43	16.27	2.285	8.1	0.79	6.69	-89.5	Removed 112 oz LNAPL
Baseline AS 1	12/17/2018	1130		42		380	72.6	1.7	20.4	4.9	10.1	10.11	0.01	16.29	2.271	8.0	0.78	6.63	-87.4	
end AS 1 sparge	12/17/2018	1730			0.075	460	9.6	0.1	21.4	68.2		9.33		16.22	2.145	26.4	2.57	6.68	-49.8	
Baseline AS 3	12/18/2018	1200		42		549	71	3.1	18.2	10.1	9.93	10.09	0.16	16.24	1.895	1.9	0.18	6.72	-101.9	pumped off 4 oz LNAPL
end AS 3 sparge	12/18/2018	1730				197	17.4	1.4	19.8	61.9	trace	9.41		16.24	1.803	4.4	0.43	6.77	-71.2	
Baseline AS 1 24 hr	12/19/2018	900		42		331	>>>	6.5	15.9	>>>	9.82	10.07	0.25	16.24	1.893	3.0	0.29	6.69	-92.6	pumped off 4 oz LNAPL
		1330									trace	9.38		16.22	1.784	5.4	0.53	6.65	-43.1	Pumped trace LNAPL off
		1700				358	45.5	3.1	18.4	33.2		9.37		16.36	1.766	28.1	2.74	6.71	-17.7	0.87 ft LNAPL @1720 pumped 20 oz
End AS 1 24 hr	12/20/2018	1100				376	>>>	7.8	15.0	>>>	9.99	10.00	0.01	16.26	1.906	3.7	0.36	6.67	-88.2	pumped 8 oz LNAPL before readings
MP-3S																				
	12/10/2018	1500		40								7.26								
Baseline AS 2	12/11/2018	1300				890	2.6	4.0	18.8			7.09		16.33	1.293	7.8	0.76	6.75	-83.7	
end sparge AS 2	12/12/2018	1500			0.051	770	3.5	2.9	19.4	74.2		6.92		16.40	1.300	5.1	0.49	6.79	-108.3	
day after sparge	12/13/2018	1000			-0.01	486	1.5	1.2	20.5	76.8		7.18		16.26	1.276	5.4	0.52	6.74	-94.1	
Baseline AS 1	12/17/2018	1130		42		1171	2.8	1.3	20.9	75.4		7.54		16.07	1.271	7.3	0.72	6.72	-88.6	
end AS 1 sparge	12/17/2018	1730			0.024	510	1.1	0.5	21.6	76.9		7.37		15.59	1.266	11.1	1.11	6.72	-66.3	
Baseline AS 3	12/18/2018	1200		43		880	2.9	0.5	20.2	76.3		7.47		15.46	1.034	4.9	0.49	6.84	-95.1	
end AS 3 sparge	12/18/2018	1730				473	0.8	0.3	20.8	78.0		7.36		15.51	1.032	2.3	0.26	6.84	-82.9	
Baseline AS 1 24 hr	12/19/2018	900		42		518	3.5	0.9	21.8	73.6		7.43		15.45	1.023	2.4	0.24	6.78	-97.4	
		1330										7.38		15.75	1.025	2.9	0.29	6.77	-92.5	
		1700				419	1.6	0.4	20.8	77.1		7.37		15.51	1.004	3.7	0.36	6.70	-69.8	
End AS 1 24 hr	12/20/2018	1100				501	201	1.0	20.6	76.4		7.46		15.40	0.948	3.7	0.37	6.66	-68.4	

Notes:
Dist (ft): distance in feet
psi: pounds per square inch
PID: photoionization detector
ppmv: parts per million by volume
>>>>: out of range

CH4 %: methane percent
CO₂ %: carbon dioxide percent
O2 %: oxygen percent
DTP: depth to product feet
DTW: depth to water feet

LNAPL: light non-aqueous phase liquid
ORP: oxidation-reduction potential
mS/cm: millisiemens per centimeter
°C: degrees Celsius
DO mg/l: dissolved oxygen in milligrams per liter

Table B-5

Well Monitoring Vapor and Groundwater Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

BioSparge Test AS 1 and AS 3
Flow Rates: 0.5 scfm breakout approximately 13 psi

MP-2S																				
Baseline	1/7/2019	1500			25		335	12.2	6.2	15.4	66.5		5.19		13.57	2.052	2.6	0.27	6.50	-89.2
Start Sparge	1/8/2019	9:25	0:00										5.40							
		16:00	395				732	36.6	6.5	17.2	40.2		5.15		13.57	1.940	80.2	8.21	6.58	-18.5
	1/9/2019	16:00	1835				837	17.2	2.7	19.5	60.3		5.55		13.79	1.829	95.0	9.76	6.67	49.4
	1/10/2019	15:30	3245				1298	20.2	2.3	19.7	57.4		5.56		13.95	1.796	96.2	9.85	6.61	56.6
	1/11/2019	11:00	4415				787	19.1	2.3	19.4	58.2		5.52		13.73	1.790	87.3	9.00	6.68	49.9
	1/14/2019	15:00	8975				453	53.0	5.4	14.6	26.5		5.00		13.70	1.740	64.1	6.60	6.55	47.1
End Sparge	1/14/2019	16:50	9085																	hear sparge air
Post Sampling	1/16/2019	12:00					490	47.7	4.9	14.9	35.1		4.93		11.45	2.444		0.39	6.63	
MP-4D																				
Baseline	1/7/2019	1500			29		163	2.6	4.0	19.6	74.2		7.70		16.23	1.912	4.1	0.40	6.75	-118.8
Start Sparge	1/8/2019	9:25	0:00										8.03							
		16:00	395				260	1.3	1.3	21.0	76.8		7.56		16.05	2.028	4.7	0.46	6.78	-129.2
	1/9/2019	16:00	1835				270	1.5	1.5	20.5	77.0		8.15		16.07	2.046	4.5	0.44	6.73	-136.6
	1/10/2019	15:30	3245				175	1.4	1.8	21.0	75.8		7.87		15.84	1.878	5.0	0.49	6.66	-127.5
	1/11/2019	11:00	4415				330	0.5	0.3	21.4	78.1		7.86		16.08	2.093	4.6	0.45	6.66	-137.1
	1/14/2019	15:00	8975				360	2.3	3.6	20.4	73.8		7.47		16.05	1.999	4.5	0.44	6.75	-135.6
End Sparge	1/14/2019	16:50	9085																	See sparge air around well
Post Sampling	1/16/2019	15:10					353	2.4	2.6	20.9	74.2		7.35		13.42	2.422		0.41	6.72	-100.9
MP-3D																				
Baseline	1/7/2019	1500			42		596	75.0	1.5	20.2	5.4	8.39	8.56	0.17	16.28	1.891	2.1	0.21	6.73	-104.5
Start Sparge	1/8/2019	9:25	0:00									Trace	8.79							
		16:00	395				522	23.9	0.8	21.1	54.0		8.22		16.27	1.730	21.7	2.12	6.80	-31.1
	1/9/2019	16:00	1835				414	>>>	6.5	15.6	>>>	8.87	9.00	0.13	16.30	1.785	18.8	1.83	6.77	-23.3
	1/10/2019	15:30	3245				307	71.2	3.7	18.6	6.4	Trace	8.70		16.28	1.877	3.5	0.34	6.64	-75.4
	1/11/2019	11:00	4415				524	49.6	3.0	19.4	30.0		8.57		16.29	1.869	4.3	0.42	6.64	-66.3
	1/14/2019	15:00	8975				680	46.0	3.0	19.7	31.3	Trace	8.17		16.29	1.865	3.7	0.36	6.69	-91.0
End Sparge	1/14/2019	16:50	9085																	
Post Sampling	1/16/2019	10:15					664	28.8	2.3	20.1	48.6		7.92		14.70	2.211		0.45	6.79	-110.2

Table B-5

Well Monitoring Vapor and Groundwater Readings
Biosparge Pilot Test
Former Augusta Refinery, Augusta, Kansas
Williams Petroleum Services, LLC

BioSparge Test AS 1 and AS 3
Flow Rates: 0.5 scfm breakout approximately 13 psi

MP-3S																					
Baseline	1/7/2019	1500			42		561	1.8	4.7	19.7	74.7		6.37		14.51	0.992	2.2	0.23	69.83	-107.3	
Start Sparg	1/8/2019	9:25	0:00										6.67								
		16:00	395				399	3.4	2.7	20.0	74.0		6.49		13.99	0.860	30.5	3.12	6.77	-41.5	
	1/9/2019	16:00	1835				395	49.7	5.9	14.6	31.3	Trace	6.56		14.48	0.778	35.1	3.58	6.75	58.6	Pump trace LNAPL
	1/10/2019	15:30	3245				364	23.0	2.6	18.9	63.6		6.34		14.27	0.710	7.4	0.75	6.64	15.3	
	1/11/2019	11:00	4415				276	33.0	4.5	15.5	47.0		6.37		14.26	0.695	15.2	1.55	6.63	32.0	
	1/14/2019	15:00	8975				967	62.9	5.7	12.7	21.6	Trace	5.73		14.02	0.679	3.7	0.38	6.75	-52.0	Pump trace LNAPL
End Sparge	1/14/2019	16:50	9085																		
Post Sampling	1/16/2019	10:50					653	0.8	0.2	21.2	77.9		5.71		12.17	0.888		0.39	6.73	-66.1	

Notes:

Dist (ft): distance in feet

psi: pounds per square inch

PID: photoionization detector

ppmv: parts per million by volume

>>>>: out of range

CH4 %: methane percent

CO₂ %: carbon dioxide percent

O2 %: oxygen percent

DTP: depth to product feet

DTW: depth to water feet

LNAPL: light non-aqueous phase liquid

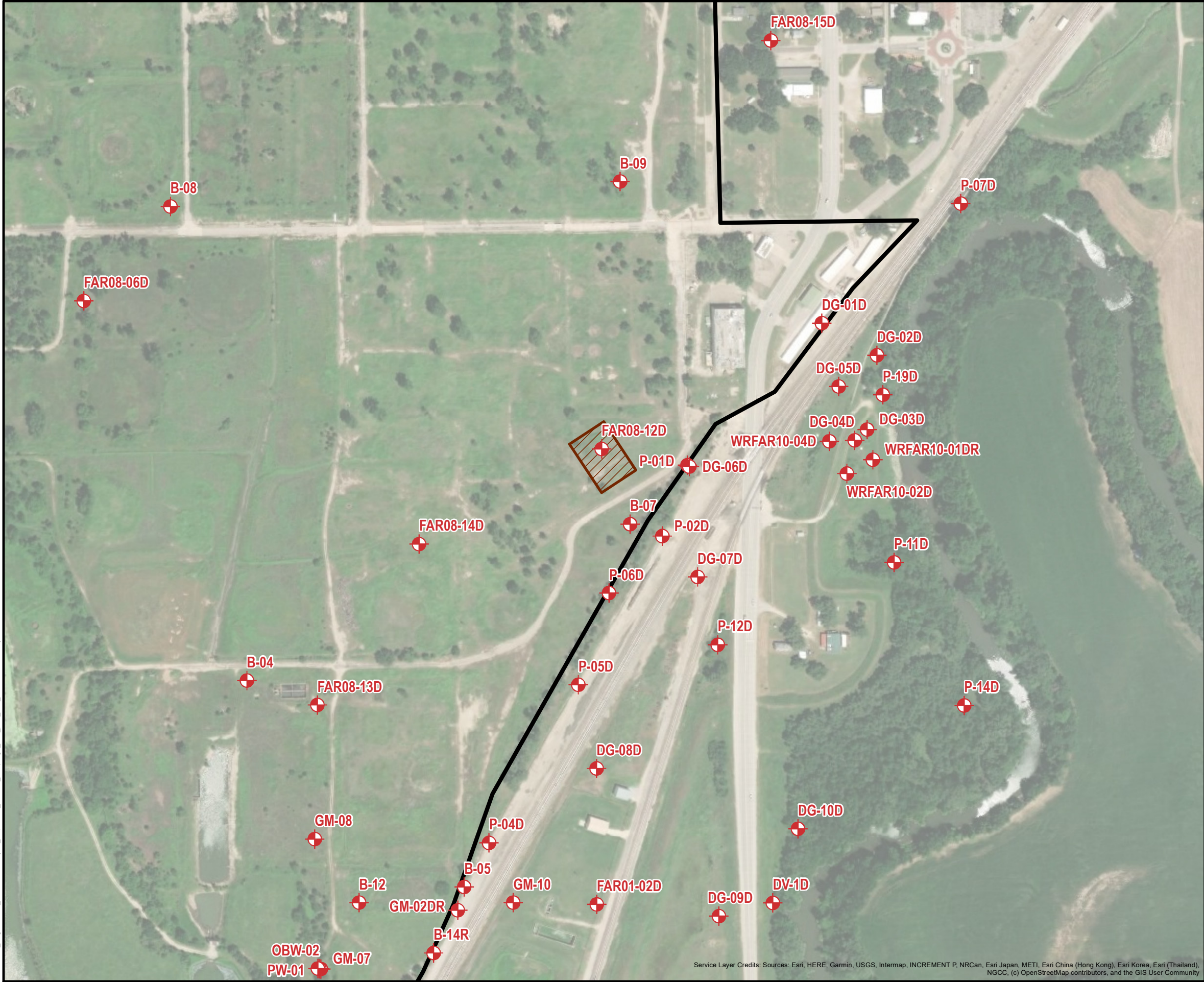
ORP: oxidation-reduction potential

mS/cm: millisiemens per centimeter

°C: degrees Celsius




DO mg/l: dissolved oxygen in milligrams per liter

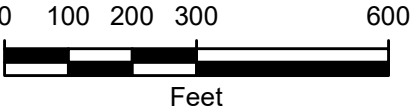
ΔT: Elapsed time in minutes



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LEGEND

-  Deep Monitoring Well
-  Facility Boundary
-  Bio-Sparge Pilot Test Location



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

BIO-SPARGE PILOT TEST LOCATION

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
B-1

G:\Williams_Augusta\GIS_Documents\Project_Map\wfar_149093_biosparge_001_well_locations.mxd; Analyst: Ben Holt; Date: 1/9/2020 9:30:28 AM

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LEGEND

- Air Sparge Injection Well
- Monitoring Point
- Deep Monitoring Well
- Bio-Sparge Pilot Test Boundary



2872 NORTH RIDGE ROAD, SUITE 102B
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(316) 220-8020

BIO-SPARGE PILOT TEST LAYOUT

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
B-2

G:\Williams_Augusta\GIS_Documents\Project_Map\wfar_149093_biosparge_002_potentiometric_contours_20191210.mxd; Analyst: Ben Holt; Date: 1/17/2020 8:04:19 AM

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

- Air Sparge Injection Well
- Monitoring Point
- Deep Monitoring Well
- 0.1 ft Groundwater Contour
- Groundwater Flow Direction
- Bio-Sparge Pilot Test Boundary

Notes:
Gradient = 0.0068
* = MP-1D elevation not used in contouring



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POTENTIOMETRIC SURFACE
CONTOURS
(DECEMBER 10, 2018)

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES





LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

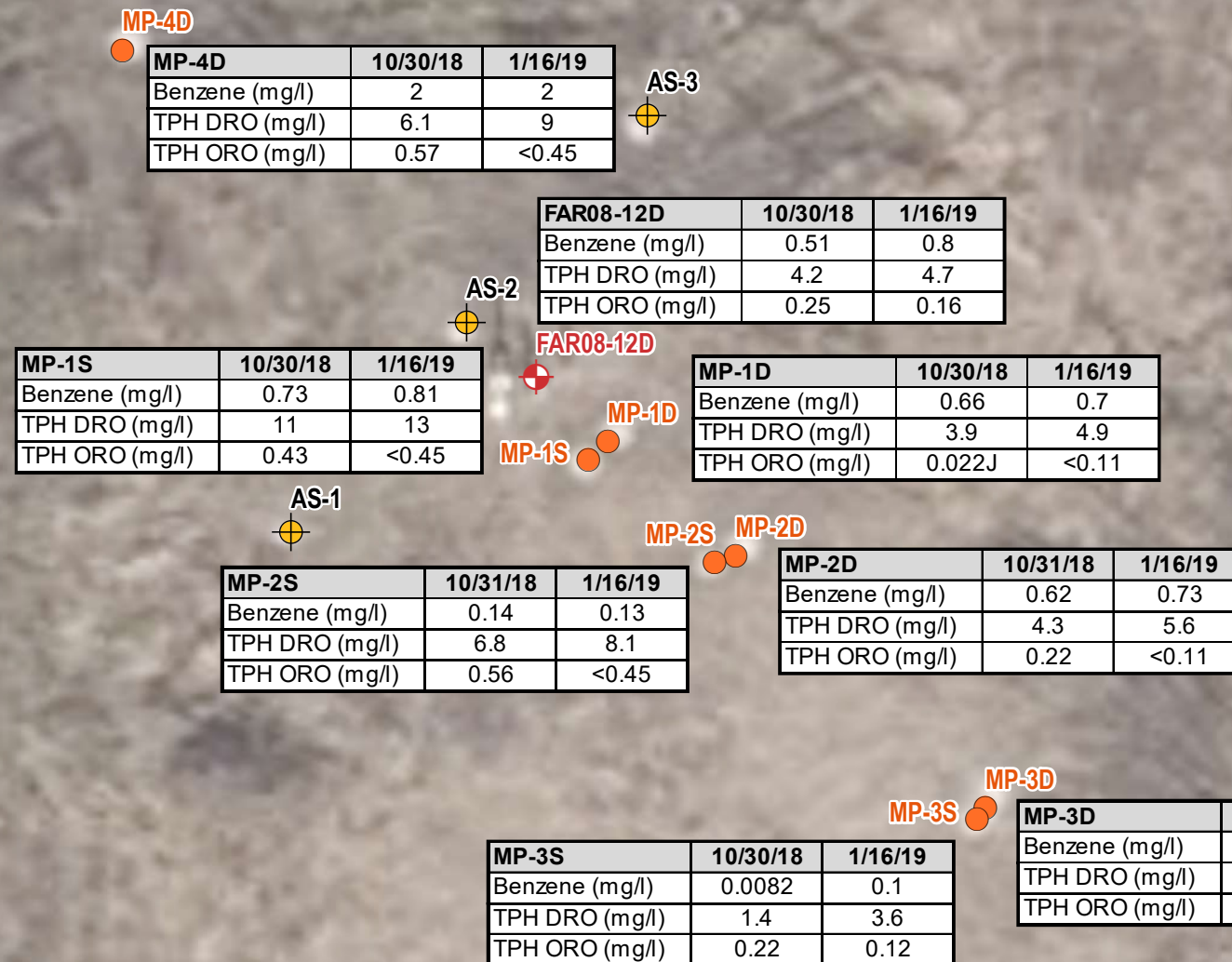
FIGURE:
B-3

G:\Williams_Augusta\GIS_Documents\Project_Mapalwar_149093_biosparge_003_analytical_results.mxd; Analyst: Ben Holt; Date: 1/10/2020 10:23:21 AM

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

-  Air Sparge Injection Well
-  Monitoring Point
-  Deep Monitoring Well
-  Bio-Sparge Pilot Test Boundary



2872 NORTH RIDGE ROAD, SUITE 102B
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(316) 220-8020

BIO-SPARGE PILOT TEST PRE AND POST TEST GROUNDWATER ANALYTICAL RESULTS

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
B-4

G:\Williams_Augusta\GIS_Documents\Project_Mapalwar_149083_biosparge_004_pressure_response.mxd; Analyst: Ben Holt; Date: 1/10/2020 9:31:52 AM

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

- Air Sparge Injection Well
- Monitoring Point
- Deep Monitoring Well
- Bio-Sparge Pilot Test Boundary

Notes:
Δt = time in minutes
psi = pounds per square inch
AS-1 Sparge Flow Rate = 0.5 scfm
AS-3 Sparge Flow Rate = 0.5 scfm
scfm = standard cubic feet per minute



2872 NORTH RIDGE ROAD, SUITE 102B
WICHITA, KANSAS 67205
(316) 220-8020

AS-1 AND AS-3
EXTENDED BIO-SPARGE
PILOT TEST PRESSURE RESPONSE

CLIENT: FORMER AUGUSTA REFINERY
WILLIAMS PETROLEUM SERVICES

LOCATION: 215 N OAK STREET
AUGUSTA, KANSAS 67010

FIGURE:
B-5

MP-4D (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.25	-0.01	0	-0.06	-0.03	0

MP-4D

AS-3 (Sparge Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	13.5	13	13.5	12	13	10

AS-3

AS-2 (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.52	-0.04	0	-0.09	-0.07	0

AS-2

FAR08-12D (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	6	13	12.5	11.5	12.5	0.37

FAR08-12D

MP-1S (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.12	1.91	1.69	1.39	0.58	0.05

MP-1S

MP-1D (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.51	13	12	1.63	-0.01	-0.14

MP-1D

AS-1 (Sparge Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	13.5	13	13	12.5	13.5	12

AS-1

MP-2S (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.01	1.61	1.07	1	1.09	0.88

MP-2S

MP-2D (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.42	12.5	12.5	12	-0.05	0

MP-2D

MP-3S (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0	0.1	1.09	0.66	0.72	0.76

MP-3S

MP-3D (Response Pressure)						
Δt	15	155	1375	4415	5750	7150
psi	0.3	0.17	-0.14	-0.09	-0.02	-0.14

MP-3D



2872 N. Ridge Road, Suite 102
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(316) 220-8020

Site Id: AS-1

Date Started: 10/15/18

Project Name: Williams FAR

Coordinate X: 1751459.78

Blank Casing:

Project Number: 149093

Coordinate Y: 1681317.66

type: PVC dia:1.00in
fm:0.00' to:37.00'

Location: Biosparge Pilot

Static Water Level: 6.88'

Screens:

Logged By: Austin Haller

Measuring Point: 1217.53'

type:Slotted size:0.010in dia:1.00in
fm:37.00' to:39.00'

Contractor: Plains

Total Depth: 39.50'

Drilling Method: CS/DP

Borehole Dia.: 3.00 in

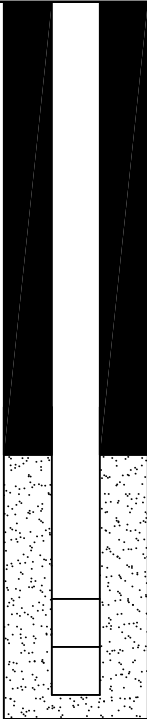

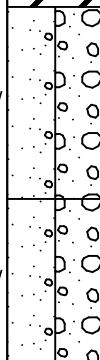
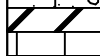
Annular Fill:

type: Bentonite fm:0.00' to:34.00'
type: Sand Pack fm:34.00' to:39.50'

Remarks:

Completed Depth: 39.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
				90.2 ppm		FL		0-0.5' Topsoil: dark brown
			50			CH		0.5-5' Clay: dark brown (7.5YR 3/1), staining @ 4', firm, odor
5				1000.2 ppm		CH		5-10' Clay: dark gray (10YR 3/1), staining until 8', firm, odor
			100			CH		10-15' Clay: dark gray (10YR 3/1)
10				407.8 ppm		CH		15-20' Clay: dark gray (10YR 3/1), firm, odor
			100			CH		20-25' Clay: dark brown (10YR 3/3), firm, odor
15				242.5 ppm		CH		
			100			CH		
20				181.8 ppm		CH		
			100			CH		
25						CH		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25			20	626.8 ppm		CH		25-30' Clay: dark brown (10YR 3/3), sand lense @ 29', medium to coarse grained
30				328.0 ppm				30-31' Clay: dark brown (10YR 3/3), firm, odor
				100		SW/GW		31-35' Sand/Gravel: coarse to medium, wet
35				50.3 ppm		SW/GW		35-38.5' Sand/Gravel: same as above
40				100		CH LS		38.5-39' Clay: dark brown (10YR 3/3) 39-39.5' Limestone
								Total Boring Depth 39.5'
45								
50								
55								



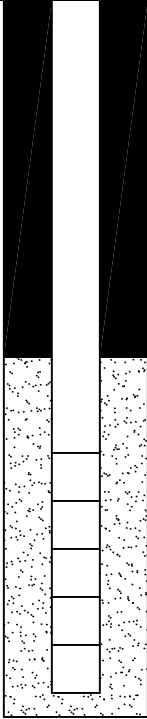
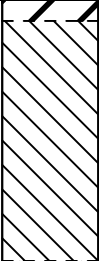

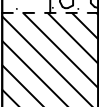
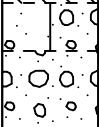
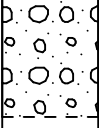
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Site Id: AS-2

Date Started: 10/15/18

Project Name: Williams FAR	Coordinate X: 1751469.60	Blank Casing: type: PVC dia:1.00in fm:0.00' to:37.00'
Project Number: 149093	Coordinate Y: 1681329.37	Screens: type:Slotted size:0.010in dia: 1.00in fm:37.00' to:39.00'
Location: Biosparge Pilot	Static Water Level: 6.83'	Annular Fill: type: Bentonite fm:0.00' to:32.00' type: Sand Pack fm:32.00' to:39.50'
Logged By: Austin Haller	Measuring Point: 1217.44'	
Contractor: Plains	Total Depth: 39.50'	
Drilling Method: CS/DP	Borehole Dia.: 3.00 in	Completed Depth: 39.00'
Remarks: Lithology description taken from FAR08-12D. Soil boring not sampled.		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
5						CH		0-5' Fat Clay: dark brown (10YR 3/3), stiff, black petroleum staining below 3', strong petroleum odor
						CH		5-10' Fat Clay: black (10YR 2/1), petroleum staining
10						CH		10-15' Fat Clay: very dark gray/brown (10YR 3/2), moist, stiff, decrease in petroleum staining/smearing
15						CH		15-20' Fat Clay: very dark gray/brown (10YR 3/2), very strong petroleum odor, speckled smearing of black petroleum staining
20						CH		20-25' Clay: dark gray (10YR 4/1), saturated with oil sheen, trace silt with depth
25								

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25						CL		25-30' Silty Lean Clay: dark gray (10YR 4/1), saturated, soft, strong petroleum odor and staining
30						GW/SW		30-32' Sand and Gravel: dark gray, sand is medium grained, gravel is coarse
						CL		32-34' Silty Clay: dark gray
35						GW/SW		34-39' Sand and Gravel: dark gray, petroleum stained, petroleum odor
40						GW		Limestone bedrock, fossiliferous, cherty at 39' Total Boring Depth 39.5'
45								
50								
55								



2872 N. Ridge Road, Suite 102
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Site Id: AS-3

Date Started: 10/16/18

Project Name: Williams FAR

Coordinate X: 1751479.72

Blank Casing:

Project Number: 149093

Coordinate Y: 1681340.94

type: PVC dia:1.00in
fm:0.00' to:37.00'

Location: Biosparge Pilot

Static Water Level: 6.80'

Screens:

Logged By: Austin Haller

Measuring Point: 1217.43'

type:Slotted size:0.010in dia:1.00in
fm:37.00' to:39.00'

Contractor: Plains

Total Depth: 39.50'

Drilling Method: CS/DP

Borehole Dia.: 3.00 in

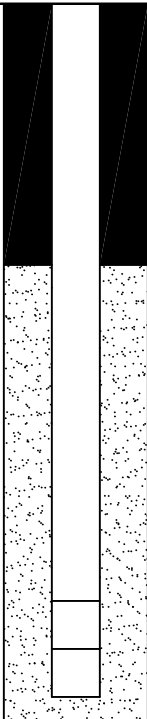




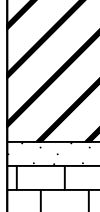
Annular Fill:

type: Bentonite fm:0.00' to:30.00'
type: Sand Pack fm:30.00' to:39.50'

Remarks:

Completed Depth: 39.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
				66.6 ppm		FL		0-0.5' Topsoil: dark brown (7.5YR 3/1)
						CH		0.5-5' Clay: dark brown, some staining, firm
5				366.4 ppm		CH		5-10' Clay: black, firm, odor
10				185.8 ppm		CH		10-15' Clay: dark gray (10YR 3/1), staining from 10' to 10.5', firm, odor
15				319.9 ppm		CH		15-20' Clay: dark gray (10YR 3/1), firm, odor
20				61.5 ppm		CH		20-25' Clay: dark brown (10YR 3/3), firm
25				90		CH		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25				299.8 ppm		CH		25-30' Clay: dark brown (10YR 3/3), gravel lense @ 29.5', firm, odor
30				20.2 ppm		CH		30-31' Clay with gravel: dark brown (10YR 3/3)
						CH		31-35' Clay: dark brown (10YR 3/3), firm, odor
35				8.6 ppm		CH		35-38' Clay: dark brown (10YR 3/3), firm
40						SW LS		38-38.5' Sand: medium to coarse grained, wet 38.5-39.5' Limestone: weathered
								Total Boring Depth 39.5'
45								
50								
55								



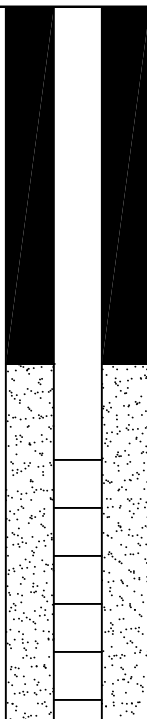
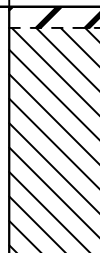
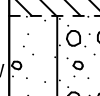

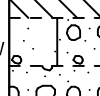
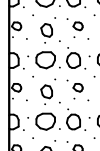
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(316) 220-8020


Site Id: MP-1D

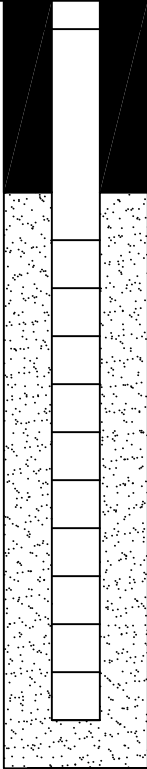

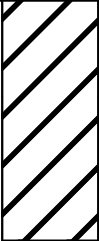
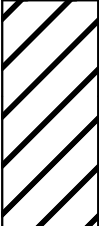
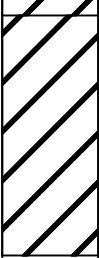
Date Started: 10/19/18

Project Name: Williams FAR	Coordinate X: 1751477.50	Blank Casing: type: PVC dia:2.00in fm:0.00' to:34.00'
Project Number: 149093	Coordinate Y: 1681322.69	Screens: type:Slotted size:0.010in dia:2.00in fm:34.00' to:39.00'
Location: Biosparge Pilot	Static Water Level: 7.00'	Annular Fill: type: Bentonite fm:0.00' to:32.50' type: Sand Pack fm:32.50' to:39.00'
Logged By: Austin Haller	Measuring Point: 1217.72'	
Contractor: Plains	Total Depth: 39.50'	
Drilling Method: HSA	Borehole Dia.: 8.25 in	Completed Depth: 39.00'
Remarks: Lithology description taken from FAR08-12D. Soil boring not sampled.		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
0			100	1977 ppm		CH		0-5' Fat Clay: dark brown (10YR 3/3), stiff, black petroleum staining below 3', strong petroleum odor
5			100	1613 ppm		CH		5-10' Fat Clay: black (10YR 2/1), petroleum staining
10			100	1092 ppm		CH		10-15' Fat Clay: very dark gray/brown (10YR 3/2), moist, stiff, decrease in petroleum staining/smearing
15			100	1701 ppm		CH		15-20' Fat Clay: very dark gray/brown (10YR 3/2), very strong petroleum odor, speckled smearing of black petroleum staining
20			100	1977 ppm		CH		20-25' Clay: dark gray (10YR 4/1), saturated with oil sheen, trace silt with depth
25								

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description	
25			80	759 ppm		CL		25-30' Silty Lean Clay: dark gray (10YR 4/1), saturated, soft, strong petroleum odor and staining	
30			100	97 ppm		GW/SW		30-32' Sand and Gravel: dark gray, sand is medium grained, gravel is coarse	
						CL		32-34' Silty Clay: dark gray	
35						GW/SW		34-39' Sand and Gravel: dark gray, petroleum stained, petroleum odor	
						GW		Limestone bedrock, fossiliferous, cherty at 39'	
40								Total Boring Depth 39.5'	
45									
50									
55									

 <div> 2872 N. Ridge Road, Suite 102 Wichita, Kansas 67205 (316) 220-8020 </div>		Site Id: MP-1S
		Date Started: 10/19/18
Project Name: Williams FAR	Coordinate X: 1751476.40	Blank Casing: type: PVC dia:2.00in fm:0.00' to:5.00'
Project Number: 149093	Coordinate Y: 1681321.69	
Location: Biosparge Pilot	Static Water Level: 3.22'	Screens: type:Slotted size:0.010in dia:2.00in fm:5.00' to:15.00'
Logged By: Austin Haller	Measuring Point: 1217.64'	
Contractor: Plains	Total Depth: 16.00'	
Drilling Method: HSA	Borehole Dia.: 8.25 in	Annular Fill: type: Bentonite fm:0.00' to:4.00' type: Sand Pack fm:4.00' to:16.00'
Remarks: Lithology description taken from FAR08-12D. Soil boring not sampled.		
		Completed Depth: 15.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
<div> <div>5</div> <div>10</div> <div>15</div> <div>20</div> <div>25</div> </div>						CH		0-5' Fat Clay: dark brown (10YR 3/3), stiff, petroleum staining below 3', strong petroleum odor
						CH		5-10' Fat Clay: black (10YR 2/1), petroleum staining
						CH		10-15' Fat Clay: very dark gray/brown (10YR 3/2), moist, stiff, decrease in petroleum staining/smearing, stiff, decrease in petroleum staining/smearing
								Total Boring Depth 16'



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Site Id: MP-2D

Date Started: 10/18/18

Project Name: Williams FAR

Coordinate X: 1751484.65

Blank Casing:

Project Number: 149093

Coordinate Y: 1681316.30

type: PVC dia:2.00in
fm:0.00' to:34.00'

Location: Biosparge Pilot

Static Water Level: 7.03'

Screens:

Logged By: Austin Haller

Measuring Point: 1217.59'

type:Slotted size:0.010in dia:2.00in
fm:34.00' to:39.00'

Contractor: Plains

Total Depth: 39.00'

Drilling Method: HSA

Borehole Dia.: 8.25 in

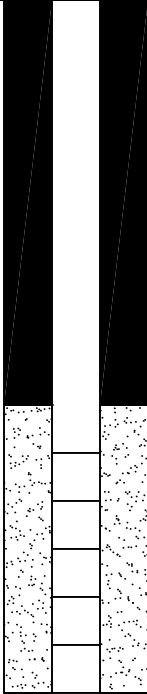


Annular Fill:

type: Bentonite fm:0.00' to:33.00'
type: Sand Pack fm:33.00' to:39.00'

Remarks:

Completed Depth: 39.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
5				205 ppm		CH		0-5' Clay: dark brown (7.5YR 3/1), staining, odor
10						CH		5-10' Clay: black, staining, strong odor
15				711.5 ppm		CH		10-13' Clay: black, staining, odor
20						CH		13-15' Clay: dark gray (10YR 3/1), odor
25						CH		15-20' Clay: dark gray (10YR 3/1), staining, odor
						CH		20-25' Clay: dark gray (10YR 3/1), odor, moist

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25				585 ppm		CH		25-30' Clay: same as above
30								30-35' Clay: same as above
35								35-38' Clay: same as above
40						SP		38-39' Sand
45								39' Limestone Total Boring Depth 39'
50								
55								

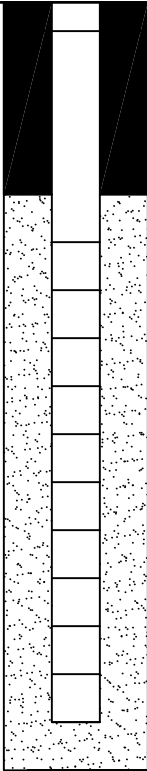

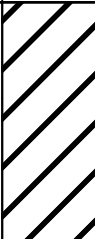





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Site Id: MP-2S

Date Started: 10/20/18

Project Name: Williams FAR	Coordinate X: 1751483.48	Blank Casing: type: PVC dia:2.00in fm:0.00' to:5.00'
Project Number: 149093	Coordinate Y: 1681315.94	Screens: type:Slotted size:0.010in dia:2.00in fm:5.00' to:15.00'
Location: Biosparge Pilot	Static Water Level: 3.78'	Annular Fill: type: Bentonite fm:0.00' to:4.00' type: Sand Pack fm:4.00' to:16.00'
Logged By: Austin Haller	Measuring Point: 1217.77'	
Contractor: Plains	Total Depth: 16.00'	
Drilling Method: HSA	Borehole Dia.: 8.25 in	Completed Depth: 15.00'
Remarks:		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
0						CH		0-5' Clay: dark brown (7.5YR 3/1), staining, odor
5						CH		5-10' Clay: black, staining, strong odor
10						CH		10-13' Clay: black, staining, odor
15						CH		13-15' Clay: dark gray (10YR 3/1), odor
16								Total Boring Depth 16'
20								
25								



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Site Id: MP-3D

Date Started: 10/16/18

Project Name: Williams FAR

Coordinate X: 1751498.65

Blank Casing:

Project Number: 149093

Coordinate Y: 1681302.22

type: PVC dia:2.00in
fm:0.00' to:34.00'

Location: Biosparge Pilot

Static Water Level: 7.43'

Screens:

Logged By: Austin Haller

Measuring Point: 1217.91'

type:Slotted size:0.010in dia:2.00in
fm:34.00' to:39.00'

Contractor: Plains

Total Depth: 40.00'

Drilling Method: HSA/CS

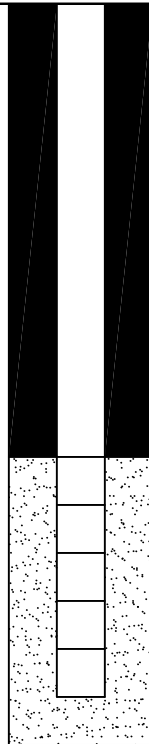



Borehole Dia.: 8.25 in

Annular Fill:
type: Bentonite fm:0.00' to:34.00'
type: Sand Pack fm:34.00' to:39.00'

Remarks:

Completed Depth: 39.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
				222.8 ppm		FL		0-1' Topsoil: dark brown (7.5YR 3/1) staining, odor
			60			CH		1-5' Clay: black, staining @ 4'
5				254.3 ppm				5-10' Clay: black, staining to 7.5', strong odor
			80			CH		
10				375 ppm				10-15' Clay: dark gray (10YR 3/1), odor, firm
			100			CH		
15				67.1 ppm				15-20' Clay: same as above
			100			CH		
20				68.8 ppm				20-25' Clay: dark brown (10YR 3/3), firm moist
			100			CH		
25								

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description	
25			100	230.2 ppm		CH		25-30' Clay: dark brown to gray, medium firm	
30				374.3 ppm				30-31.5' Clay: gray, medium firm	
			100			CL		31.5-34' Sandy Clay: clay with sand and gravel, medium grained	
35				42.7 ppm		SW/GW		34-35' Sand with Gravel	
			80			SW/GW		35-39.5' Sand with Gravel: clean, medium to coarse grained, some clay at 39.5'	
40						LS		39.5-40' Limestone Total Boring Depth 40'	
45									
50									
55									

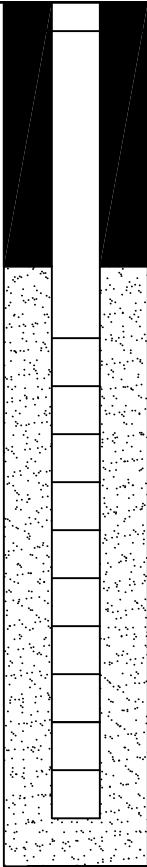




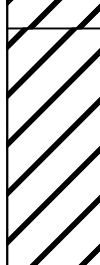
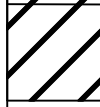


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Site Id: MP-3S

Date Started: 10/18/18

Project Name: Williams FAR	Coordinate X: 1751498.19	Blank Casing: type: PVC dia:2.00in fm:0.00' to:7.00'
Project Number: 149093	Coordinate Y: 1681301.57	Screens: type:Slotted size:0.010in dia:2.00in fm:7.00' to:17.00'
Location: Biosparge Pilot	Static Water Level: 4.90'	Annular Fill: type: Bentonite fm:0.00' to:5.50' type: Sand Pack fm:5.50' to:18.00'
Logged By: Austin Haller	Measuring Point: 1218.08'	
Contractor: Plains	Total Depth: 18.00'	
Drilling Method: HSA	Borehole Dia.: 8.25 in	Completed Depth: 17.00'
Remarks:		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
0						TS		0-1' Topsoil: dark brown (7.5 YR 3/1)
1						CH		1-5' Clay: black, staining @ 4'
5						CH		5-10' Clay: black, staining to 7.5', strong odor
10						CH		10-15' Clay: dark gray (10YR 3/1), odor, firm
15						CH		15-17' Clay, same as above
18								Total Boring Depth 18'
20								
25								



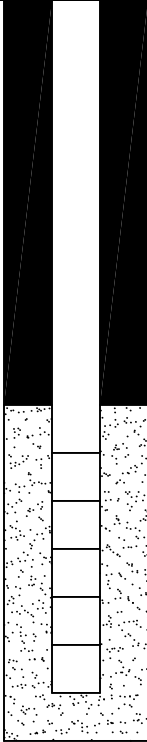
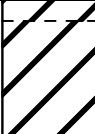

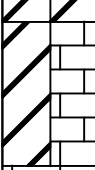

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Site Id: MP-4D

Date Started: 10/16/18

Project Name: Williams FAR	Coordinate X: 1751450.33	Blank Casing: type: PVC dia:2.00in fm:0.00' to:34.00'
Project Number: 149093	Coordinate Y: 1681344.58	Screens: type:Slotted size:0.010in dia:2.00in fm:34.00' to:39.00'
Location: Biosparge Pilot	Static Water Level: 6.61'	
Logged By: Austin Haller	Measuring Point: 1217.47'	
Contractor: Plains	Total Depth: 40.00'	Annular Fill: type: Bentonite fm:0.00' to:33.00' type: Sand Pack fm:33.00' to:40.00'
Drilling Method: HSA/CS	Borehole Dia.: 8.25 in	
Remarks:		Completed Depth: 39.00'

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
0				33.1 ppm		FL		0-0.5' Topsoil: dark brown (7.5YR 3/1), sandy
5			80			CH		0.5-5' Clay: black to brown (10YR 3/3)
				38.25 ppm				5-10' Clay: brown (10YR 3/3), medium firm, staining at 7-8', odor
10			90			CH		10-15' Clay: gray (10YR 3/1), firm, odor
				182.5 ppm		CH		15-20' Clay: same as above
15			100			CH		20-25' Clay: dark brown (10YR 3/3), firm odor
20				210.2 ppm				
25			100			CH		

Depth	Well Construction	Water Level	% Recovery	PID	Sample No.	USCS Code	Graphic Log	Material Description
25			100	37.1 ppm		CH		25-30' Clay: dark brown (10YR 3/3), firm, sand lense from 29.5-30'
30				26.5 ppm				30-34' Clay: dark brown (10YR 3/3), firm
35				22.7 ppm		SW		34-36' Sand: medium to coarse grained
40						CH/LS		36-36.5' Clay: dark brown (10YR 3/3), firm, wet 36.5-39.5' Clay: with weathered limestone gravel
45						LS		39.5-40' Limestone Total Boring Depth 40'
50								
55								