AOC-16

PILOT STUDY EVALUATION REPORT

CALUMET MONTANA REFINING, LLC
GREAT FALLS, MONTANA

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LIST OF ACRONYMS

1,2-DCA	1,2-Dichlorethane
%RE	% reference emitter
AOC-16	Area of Concern 16
API	American Petroleum Institute
AS	air sparge
bgs	below ground surface
cm	centimeter
cm/sec	centimeters per second
CMR	Calumet Montana Refining
Consent Order	Corrective Action Administrative Order of Consent
DEQ-7 HHS	Montana DEQ-7 Human Health Standards - Groundwater
DPE	dual phase extraction
EPA	Environmental Protection Agency
EPH	Extractable Petroleum Hydrocarbon
ft/day	feet per day
ft-msl	feet above mean sea level
ft^2/day	square feet per day
IM	interim measure
ISCO	in-situ chemical oxidation
ISCR	in-situ chemical reduction
ITRC	Interstate Technology Regulatory Council
LIF	laser-induced fluorescence
LNAPL	Light Non-Aqueous Phase Liquid
MDEQ	Montana Department of Environmental Quality
MPE	multi-phase extraction
NAPL	Non-aqueous Phase Liquid
NSZD	Natural Source Zone Depletion
OM&M	operation, maintenance and monitoring
OWS	oil-water separator
PID	Photoionization Detector
PLSS	Public Land Survey System
POTW	Publicly Owned Treatment Works
PPE	personal protective equipment
PRB	permeable reactive barrier
Ramboll	Ramboll US Corporation
RBCA	risk-based corrective action
RBSL	risk-based screening level
RFI	RCRA Facility Inspection
ROW	Right-of-Way
RTO	regenerative thermal oxidizer
scfm	standard cubic feet per minute
Site	CMR property east of 10^{th} Street NE
SVE	soil vapor extraction

SVOC	Semi-Volatile Organic Compound
µg/L	micrograms per liter
UVOST®	ultra-violet optical screening tool
VGAC	vapor phase granular activated carbon
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbon
WWTP	waste water treatment plant

EXECUTIVE SUMMARY

In June 2019, an *Area of Concern 16 Interim Measure Evaluation (IM) Report* (CMR, 2019) was submitted to the Montana Department of Environmental Quality (MDEQ) where the selected IM remedy was biosparging and Air Sparging/Soil Vapor Extraction (AS/SVE) technologies. In order to verify remediation technology applicability and to collect additional site characterization data necessary to prepare the IM remedial system designs, pilot tests were completed in three areas downgradient of the historic releases of the truck loading rack in October 2019.

The biosparging and AS/SVE pilot tests completed in the MW-64, MW-22, and MW-41 areas indicate that biosparging, AS, and SVE within the native soils was not effective and application of these technologies as an IM to address the identified impacts at AOC-16 will likely be unsuccessful without modification to the native soil conditions. In the MW-64 area, hydrocarbon-degrading bacteria are present in groundwater indicating that subsurface conditions are favorable to support biodegradation of residual petroleum VOCs; however, an insufficient volume of water (or saturated aquifer thickness) is present to effectively oxygenate and distribute air within the saturated soils to effectively implement the biosparging technology. Furthermore, the presence of Light Non-Aqueous Phase Liquids (LNAPL) discovered at both the MW-64 and MW-22 test locations at the Truck Rack area will result in long operational times to address the LNAPL mass.

In the MW-41 Native Material Pilot Test Area, AS/SVE pilot tests were not successful due to the presence of very dense fine-grained soils (fine-grain sands, silts, and clays). The presence of the fine-grained silts and clays resulted in the inability to extract air through the soil formation resulting in little or no influence from the SVE and AS tests. The low permeability soils coupled with a highly variable or perched groundwater table and minimal evidence of subsurface air flow from the pilot testing indicates that the AS/SVE technology in the native soil materials will not be effective in achieving the goal of the IM in the MW-41 area.

AS and SVE testing performed within the backfill materials (e.g., trenched or fill material) within the Primary Recovery Trench (PRT) located in the MW-22 area determined that SVE is amenable for the extraction of vapor and LNAPL. This is likely due to the increased permeability from the disturbed soils within the PRT. The higher permeability soils allowed for air flow to be effectively distributed throughout the trench resulting in collection and capture of VOC, free phase and residual Non-Aqueous Phase Liquid (NAPL) present within the PRT. This was evident when approximately 15 gallons of LNAPL was collected during the SVE step-rate test at SVE-2B during one-hour of operation. AS within the trench was not successful due to insufficient volume of water to effectively sparge within the saturated soils or water column. Due to the presence of LNAPL within the PRT and increased permeability of the PRT materials as compared to corresponding native materials, the SVE VOC removal rate in the Truck Rack area achieved in PRT materials was approximately 37 times greater than that achieved in corresponding native materials.

The recommended alternative IM remedial approach for the AOC-16 is Dual Phase Extraction (DPE) in the existing Truck Dock PRT with product recovery wells and passive treatment trench along River Road. A DPE system within the existing PRT is the recommended remedial option for the Truck Dock area to effectively address the NAPL and petroleum related constituents present within the vadose zone, variable saturated conditions of the perched materials, and presence of a more extensive LNAPL area than previously understood. The SVE pilot test of the MW-22 PRT demonstrated the effectiveness of the DPE approach in this portion of the site. A triplet of contingency product recovery wells immediately upgradient of a passive treatment trench is recommended remedial option to address petroleum impacted dissolved phase perched groundwater downgradient of the AOC-16 Truck Rack and upgradient of River Road and the Missouri River. Monitoring wells adjacent and downgradient will also be required to monitor the effectiveness of the passive recovery trench.

SIGNATORY PAGE

I certify under penalty of law that this document and all attachments were prepared under my direct supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, 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.

Signature:	
Name:	Wayne Leiker
Title:	Vice President – Calumet Montana Refining, LLC
Date:	1-9-20

1. INTRODUCTION

Ramboll US Corporation (Ramboll) has prepared this Biosparging and Air Sparing/Soil Vapor Extraction Pilot Test Evaluation Report (the "Pilot Test Report") for the Calumet Great Falls Montana Refining (CMR) facility located at 1900 10th Street Northeast in Great Falls, Montana. This Report describes the completed field activities and results of the field-scale pilot tests (biosparging, air sparging [AS], and soil vapor extraction [SVE]) conducted from October 21 through 25, 2019 south of the Truck Loading Rack identified as Area of Concern 16 (AOC-16).

1.1 SOURCE AND PILOT TEST AREA DESCRIPTION

The CMR refinery, located at 1900 10th Street in Great Falls, Montana, is comprised of 82.7 acres of industrial/refinery operations and office buildings. The refinery produces gasoline, middle distillates, and asphalt for distribution in Washington, Montana, Idaho, and Alberta, Canada. AOC-16, referred to as the "Gasoline and Light Oil Loading Rack" or "truck loading rack," is located within an approximate 7.6-acre parcel (the "Site") to the east of the active refinery and is owned by CMR. The Public Land Survey System (PLSS) description of the area is the NW1/4 of the NE1/4, of Section 01, Township 20 North, Range 03 East, of Cascade County, Montana. AOC-16 encompasses approximately 1.3 acres and is within the truck loading rack in the northern portion of the Site, a CMR three-floored office building (CMR Office Building) is in the east portion and an access road, set down area and vegetation area in the southern portion of the Site. The truck loading rack (1020 Smelter Avenue NE in Black Eagle, Montana), accessed from Smelter Avenue NE, is secured by a 6-foot chain-link fence. The property extends north to Mountain View Co-Op Cenex or Smelter Avenue NE, east to 11 Street NE, which is bounded by residential properties on the east side. To the south, the property is bounded by a railroad bed/loading area owned by a third-party, then by a Right-of-Way (ROW) and area owned by a separate third-party, and then the Missouri River. To the west, 10th Street NE bounds the property along with a third-party parcel, which operates a natural gas line transfer station.

Historic releases have been documented at or near AOC-16 since operation of the truck loading rack commenced. To capture released material in the subsurface, a Primary Recovery Trench (PRT) was installed in the 1990s and utilized into the early 2000s for light non-aqueous phase liquid (LNAPL) recovery from historical releases. The PRT is "L" shaped and extends approximately 100 feet in the north-south direction east of the third-property parcel operated by a natural gas company and 300 feet east-west along the southern CMR property boundary. According to PRT construction drawings dated May 3, 1995, a 4-inch diameter perforated pipe is installed the entire length of the trench.

In June 2019, an *Area of Concern 16 Interim Measure Evaluation (IM) Report* (CMR, 2019) was submitted to the Montana Department of Environmental Quality (MDEQ) where the selected IM remedy was biosparging and AS/SVE technologies. The MDEQ approved the selected technology shortly after document submission. As part of the selected remediation technology applicability, this pilot test was run to collect additional site characterization data necessary to prepare the IM remedial system designs. Pilot tests were completed in three

areas downgradient of the historic releases of the truck loading rack in October 2019 (Figure 1). A biosparging and AS/SVE pilot test was conducted just south of the truck loading rack, in native materials[1] adjacent to MW-64, an AS/SVE pilot test was conducted just south of the truck rack, in the PRT near MW-22, and an AS/SVE pilot test was conducted just north of River Road in native materials adjacent to MW-41.

1.2 REMEDIATION TECHNOLOGY DESCRIPTION

AS/SVE systems involve the injection of air (AS) below the water table to drive the mass transfer of dissolved- and sorbed-phase contaminant mass into the flowing air stream. The injected air travels upward through channels created in the saturated soil matrix; carrying the petroleum volatile organic compounds (PVOCs) removed from the groundwater into the vadose zone soil. In the unsaturated zone, a SVE system extracts the impacted air and discharges vapor or treated vapor to the atmosphere. Biosparging involves low-pressure air sparging for the primary purpose of adding oxygen to stimulate biodegradation of PVOCs in groundwater. A biproduct of the biosparging technology is in-situ aerobic biodegradation, and therefore, the biosparging technologies are typically paired with in-situ aerobic biodegradation. Soil vapors generated during biosparging are vented to the atmosphere via shallow wells installed above the water table.

1.3 PILOT TEST OVERVIEW AND OBJECTIVES

The objectives of the pilot tests were to verify that biosparging, AS, and/or SVE are feasible remedial technologies to stabilize and reduce hydrocarbon-related groundwater concentrations to below applicable standards and prevent migration of the dissolved-phase groundwater impacts in the areas immediately south of Truck Rack and immediately north of North River Road in the right-of-way (ROW) and to collect additional site characterization data necessary to prepare the IM remedial system designs. Presuming the pilot tests demonstrated effectiveness, pilot test results would be used to design a full-scale interim measure remedy. Additionally, the pilot tests were completed to quantify the extractable vapor-phase PVOCs and subsequent treatment requirements in each pilot test area.

This Pilot Test Report describes the test methods and procedures implemented during the biosparging and AS/SVE pilot tests, documents the test results, provides interpretations on the data, and evaluates the efficacy of biosparging and AS/SVE in the AOC-16 area. Due to geologic and hydraulic conditions observed during pre-pilot testing field activities, specific design data evaluated in this report are focused on the SVE portion of the pilot test and include:

- Horizontal and vertical pneumatic conductivity of the subsurface soil;
- Optimal subsurface air extraction flow rate;
- Subsurface vacuum and air-flow radius of influence (ROI);
- Subsurface air flow velocity versus distance from the extraction well;
- Estimated mass removal rate;
- Total VOC concentration in extracted soil vapor and air discharge/emission rates, and

[1] Non-engineered unconsolidated matrix consisting of either fill and/or native geologically deposited sediments.

- Potential variability in pneumatic performance throughout the vertical unsaturated soil profile in the MW-64 area.

2. PRE-PILOT TEST FIELD ACTIVITIES

Pre-pilot test field activities were completed at the Site from September 1 to October 20, 2019, to define the property boundaries, complete a utility locate, and install four sparging wells, four SVE wells, and three observation/monitoring wells. This work is discussed in this section.

2.1 BOUNDARY SURVEY ALONG NORTH RIVER ROAD

Prior to well installation and pilot testing activities along the North River Road ROW, a boundary survey was completed by a TD&H Engineering of Great Falls, a Montana licensed surveyor on September 3, 2019. The work was completed to ensure all work activities were completed on CMR property or private property with access granted via email.

2.2 WELL INSTALLATION AND SAMPLING

To complete the pilot tests, four sparging wells, four SVE wells, and three monitoring wells were installed. The following subsections describe the installation methods and materials of construction. Soil cuttings from well installation activities were containerized in properly labeled United States Department of Transportation (US DOT) -compliant 55-gallon drums and incorporated into CMR waste stream. Additionally, four existing monitoring wells were used as performance monitoring wells during pilot test activities. Well construction details for the existing and new wells are presented in Table 1. Boring logs and well construction diagrams are presented in Appendix A.

2.2.1 BIOSPARGING AND AS WELL INSTALLATION

Four biosparging/AS wells were installed to facilitate injection of air for the pilot test at the approximate locations shown on Figure 2 and Figure 3. The borings were completed using sonic drilling methods utilizing a 6-inch diameter core barrel with 7-inch diameter override casing. Soils were geologically logged and screened with a photoionization detector (PID). Originally, one sparging well was to be installed into the MW-22 PRT Pilot Test Area; however, initial sparging well AS-2A encountered less than 1.5 feet of saturated materials above the dusky red silt confining layer. A second sparging well, AS-2B, was installed approximately 2 feet south of AS-2A to the dusky red silt confining layer. Water and LNAPL were immediately observed in AS-2B and water and LNAPL were observed in AS-2A the following day.

The biosparging/AS wells were constructed with 2-inch diameter Schedule 40 polyvinyl chloride (PVC) well screens and riser pipe terminated just below the ground surface and protected with a flush-mount steel well vault concreted in-place (see Appendix A for well construction diagrams). The biosparging and AS well risers at the surface are threaded with a National Pipe Thread (NPT) tapered to facilitate the placement of an airtight locking cap and connection to the air sparge piping connections and equipment. The annular space surrounding the biosparging/AS wells screens were backfilled with silica sand pack to one foot above the top of the well screen. A minimum one-foot hydrated bentonite chip seal was placed within the annular space above the top of the sand pack. The remaining annular

space surrounding the well riser was backfilled with a cement seal to approximately one-foot below the surface. The grout was installed from the top of the bentonite seal upwards using a tremie pipe. The upper one foot was backfilled with cement and the well vault. Each AS/biosparging well was developed until water was relatively clear of sediment by using a peristaltic pump. Development fluids were containerized and disposed in the CMR facility wastewater treatment plant (WWTP) as directed by CMR personnel.

2.2.2 SVE WELL INSTALLATION

Four SVE wells were installed to facilitate soil vapor extraction for the pilot test at the approximate locations shown on Figure 2 and Figure 3. The borings were completed using sonic drilling methods utilizing a 6-inch diameter core barrel with 7-inch diameter override casing. Soils were geologically logged and screened with a PID. Originally, one SVE well was to be installed into the MW-22 PRT Pilot Area; however, initial SVE well SVE-2A appeared dry during installation and LNAPL was observed approximately 30-minutes after installation. A second SVE well, SVE-2B was installed approximately 2 feet south of SVE-2A to a shallower depth to avoid fluid collection.

The SVE wells were constructed with 3-inch diameter Schedule 40 polyvinyl chloride (PVC) well screens and riser pipe terminated just below the ground surface and protected with a flush-mount steel well vault concreted in-place (see Appendix A for well construction diagrams). The annular space surrounding the SVE wells screens were backfilled with silica sand pack to one-half foot above the top of the well screen. A minimum one-half foot hydrated bentonite chip seal was placed within the annular space above the top of the sand pack. The remaining annular space surrounding the well riser was backfilled with a cement seal to approximately one-foot below the surface. The grout was installed from the top of the bentonite seal upwards using a tremie pipe. The upper one foot was backfilled with cement and the well vault.

2.2.3 MONITORING WELL INSTALLATION

Three shallow groundwater monitoring wells (MW-102, MW-103, and MW-104) were installed at the approximate locations shown on Figure 2. Each monitoring well was geologically logged and constructed of 2-inch diameter schedule 40 PVC with 0.020-inch slot PVC screens. A protective flush-mount well compartment was concreted in place at each location. Monitoring wells were installed at various distances (between 5 and 10 feet) radially from each AS/SVE well cluster in the both MW-64 Native Material and the MW-22 PRT Pilot Test Areas. Monitoring wells were constructed of a 10-foot screen installed across the water table.

The monitoring wells were developed until water was relatively clear of sediment by using a peristaltic pump. Development fluids were containerized and disposed in the CMR facility WWTP as directed by CMR personnel.

2.2.4 GEOTECHNICAL ANALYSES

Three soil samples were collected using a Shelby tube from each pilot test area (MW-22 PRT Pilot Test Area, MW-64 Native Material Pilot Test Area, and MW-41 Native Material Pilot Test Area) and analyzed by a geotechnical laboratory for porosity, soil bulk density, grain size, water content/percent saturation, and hydraulic conductivity. Samples were collected from just below the water table and within the saturated unconsolidated materials. Samples were submitted to Core Laboratories LP of Bakersfield, California. Geotechnical samples are discussed in Section 3.2.

2.2.5 SOIL SAMPLING

Two soil samples were collected from monitoring well MW-102 and MW-103 installed north of MW-64 (MW-64 Pilot Test Area: Native Material). Each sample was collected from just above the water table and was analyzed for microbial population (colony forming units [CFUs]) and nutrients (nitrogen and phosphorus). Nutrient soil samples were submitted for laboratory analysis to Shealy Environmental Services, Inc. of West Columbus, South Carolina. Microbial population soil samples were submitted to Microbial Insights of Knoxville, Tennessee. Soil biodegradation chemistry and microbial analytical results are discussed in Section 3.3.

2.2.6 GROUNDWATER SAMPLING

Groundwater samples were collected from the monitoring well MW-103 and submitted for laboratory analysis for nutrients (nitrogen and phosphorous) and microbial population (CFUs). Nutrient groundwater samples were submitted for laboratory analysis to Shealy Environmental Services, Inc. of West Columbus, South Carolina. Microbial population groundwater samples were submitted to Microbial Insights of Knoxville, Tennessee. Biodegradation groundwater analytical results are discussed in Section 3.3.

2.2.7 SOIL GAS SAMPLING

Baseline soil gas sampling was initially planned to be completed to establish vadose zone soil gas conditions prior to conducting pilot test activities. Well locations screened across or above the water table were originally planned to be screened with a soil gas meter (RKI Eagle 2) for oxygen, carbon dioxide, and methane concentrations, and a PID for total volatile organic compound (VOC) concentrations. Soil gas sampling was not completed in both MW-64 Native Material and the MW-22 PRT Pilot Test Areas due to LNAPL observations. Soil gas sampling was not completed in the MW-41 Native Material Pilot Test Area due to ineffectiveness of the AS/SVE technologies (e.g., inability to extract or inject air).

3. PHYSICAL CHARACTERSTICS OF PILOT TEST AREA

3.1 SURFACE CONDITIONS

The AOC-16 area is located north of the Missouri River and grades from Smelter Avenue Northeast to the River. Surface elevation ranges from 3,350 feet above mean sea level (ft-amsl) at MW-64 to 3,340 ft-amsl at MW-41 along the northern North River Road ROW, to 3,311 ft-amsl at sand point well MW-43, located on the bank of the Missouri River. Surface cover primarily consists gravel with intermittent paved asphalt areas and roadways in the Truck Rack MW-64 Native Material and MW-22 PRT Pilot Test Areas to undulating vegetated and bare soil towards the MW-41 Native Material Pilot Test Area.

3.2 SUBSURFACE SOIL CHARACTERISTICS

The following subsection describes the geology and hydrogeology of the AOC-16 area.

3.2.1 GEOLOGY

The geologic characteristics in the AOC-16 area reflect the revised understanding of the subsurface Conceptual Site Model derived from the recent investigative activities in the Rail Area of the site. From the surface to a depth of 8 to 15 feet below ground surface (ft-bgs), unconsolidated Pleistocene deposits and fill materials described as sand or silty sand or gravel fill have been logged. Intermittent layers of clay up to 2 feet thick were observed in borings but are not consistent throughout the area and were not confirmed during pre-pilot test drilling activities. Occasional sandstone interbeds, either residually or perhaps re-cemented, were observed within this shallow horizon. These intermittent clay and cemented sand units influence the permeability of fluids through the geologic matrix. Observations of the tight geologic lithology were confirmed during pilot test activities and discussed in Section 5.

Only three borings were advanced to depths greater than 13 ft-bgs, two in the MW-64 Area and one in the MW-41 Area near River Road. The shallow horizon is directly underlain by a dry dusky red unit composed primarily of silts and clays. This unit was encountered at 15 ft-bgs in the boings advanced in the MW-64 Area and at approximately 11 ft-bgs in the boring near River Road. The PRT is installed from the surface to the top of the dusky red silt confining layer.

Observations of the tight geologic lithology were confirmed during pilot test activities and discussed in Section 5.

3.2.2 HYDROGEOLOGY

Groundwater flow in the perched unconsolidated materials above the dusky red silt confining layer is south towards the Missouri River. Average 2018 and 2019 fluid levels across the groundwater monitoring network for AOC-16 generally fluctuate between an average high, at up-gradient well RFI-8, of 3,351 ft-amsl to 3,327 ft-amsl, at downgradient

well MW-62, located on North River Road. The average high horizontal hydraulic gradient across AOC-16 is 0.07 feet per feet.

Previously calculated hydraulic conductivity testing was completed in the AOC-16 area in the early 2000's at monitoring well MW-25 (previously located southwest of AOC-16). The calculated hydraulic conductivity value was 0.15 feet per day (ft/day) (5×10^{-5} centimeters per second [cm/sec]) and a groundwater flow velocity was 0.06 ft/day (0.02 cm/day) at MW-25.

3.2.3 GEOTECHNICAL ANALYTICAL RESULTS

Geotechnical samples (CMR-AS2B-5.0-7.5-191018-ST [MW-22 PRT Pilot Test Area], CMR-AS3-6.0-7.0-191018-ST [MW-41 Native Material Pilot Test Area], and CMR-SB102-9.0-10-191018-ST [MW-64 Native Material Pilot Test Area]) were collected on October 19, 2019 at the approximate water table elevation. Samples were analyzed for moisture content, dry bulk density, total porosity, total organic carbon, fractional organic carbon, effective permeability to water, and hydraulic conductivity. Sample results are provided in Table 2 and the geotechnical laboratory report is provided in Appendix B.

Based on the data presented in Table 2, the grain size descriptions of each sample are:

- MW-22 PRT Pilot Test Area: Fine-Grained Sand
- MW-64 Native Material Pilot Test Area: Very Fine-Grained Sand
- MW-41 Native Material Pilot Test Area: Silt

These geotechnical results are verified through boring log diagrams in Appendix A at the appropriate depth.

3.3 BIOGEGRADATION CHEMISTRY

Petroleum-related compounds and LNAPL in soil and groundwater in AOC-16 and downgradient of AOC-16 have been documented in historic release records, previous Site investigations, and ongoing quarterly monitoring events. Pilot testing soil boring, sampling point installation, and pilot testing activities collectively documented a more wide-spread presence of LANPL across portions of the Truck Dock area including the PRT than was previously understood. While the LNAPL layer present is less than 1 foot thick, its presence presented an obstacle to some of the planned pilot testing activities and poses a challenge to the planned biosparging remedial approach for the main Truck Dock area (see Figure 4).

Benzene is the primary chemical of concern and benzene-impacted groundwater is present in AOC-16 at concentrations greater than the MDEQ 7 Human Health Standards – Groundwater Risk-Based Screening Levels of 5 micrograms per liter (µg/L) or parts per billion (ppb).

Pilot test microbial and nutrient soil and groundwater samples were collected from monitoring wells MW-102 and MW-103 in the MW-64 Native Material Pilot Test Area: Native Material to evaluate biosparging effectiveness. However, due to the presence of LNAPL in

MW-102, planned pilot test groundwater sampling activities were not conducted at MW-102. Groundwater was sampled in MW-103. The pilot test sample results are presented in Table 3 and discussed below. Soil and groundwater analytical laboratory reports are provided in Appendix C.

On October 19, 2019, hydrocarbon-degrading bacteria (HDB) populations (microbial samples) were analyzed in soil at the groundwater interface approximately 9 to 10 ft-bgs from both MW-102 and MW-103 at concentrations of 505 CFUs per gram (CFU/g) and 305 CFU/g, respectively. Used as a qualitative indicator of in-situ microbial growth, HDB populations should exceed on the order of 1,000 CFU/g in soil samples within the treatment zone as biological treatment progresses (USEPA, 2017). If the HDB plate counts are low, additional oxygen, other electron acceptors, nutrients, and possibly active cultures can be applied to a treatment area. As groundwater remediation approaches completion, the HDB plate counts will ultimately decrease. Soil concentrations indicate that the application of a biologic remedy for soil immediately above the water table would require the addition of active cultures, nutrients, or oxygen to increase HDB populations.

On October 22, 2019, one HDB population sample (microbial sample) was collected in groundwater from MW-103 at a concentration of 255,000 CFUs per milliliter (CFU/mL). Like soil, HDB populations should exceed on the order of 1,000 CFU/mL in groundwater samples within the treatment zone as biological treatment progresses (USEPA, 2017). If the HDB plate counts are low, additional oxygen, other electron acceptors, nutrients, and possibly active cultures can be applied to a treatment area. As groundwater remediation approaches completion, the HDB plate counts will ultimately decrease. The HDB concentrations in MW-103 groundwater sample indicate that the application of a biosparging remedy for groundwater within this portion of the site likely would not warrant addition of active cultures and could be a potential remedy after elimination or reduction of LNAPL at the site below the water table.

Nutrients (soluble nitrate/nitrate in soil, nitrate/nitrite in water, and phosphorous) in soil and groundwater simulate biologic growth. Soil samples were collected on October 19, 2019 at the groundwater interface approximately 9 to 10 ft-bgs from both MW-102 and MW-103 for nutrients. Soluble nitrate/nitrate concentrations in soil were 1.3 milligrams per kilogram (mg/kg) in MW-102 and 2.4 mg/kg in MW-103. Phosphorous concentrations in soil were 450 mg/kg in MW-102 and 410 mg/kg in MW-103. Nutrient concentrations in groundwater were collected from MW-103. Nitrate/nitrate was not detected in MW-103. Phosphorous was detected at a concentration of 0.15 milligrams per liter.

Ideal nutrient concentrations are based on stoichiometry ratios of 100:10:1 to 100:1:0.5 of carbon, nitrate/nitrite, phosphorus (USEPA, 2017). Based on the nutrient results the ratios are 6923:1:346 in soil at MW-102 and 3750:1:171 in soil at MW-103 nitrogen would need to be added to the soil. Nutrient concentrations within the AOC-16 MW-64 Pilot Test Area: Native Material indicate that conditions are not conducive for biosparging given the quantities of microbial and nutrient concentrations in soil. Groundwater microbial results; however, indicate that conditions are favorable for biosparging in the native material outside of LNAPL impacted areas. Due to the presence of LNAPL and unfavorable soil conditions for

microbial and nutrient concentrations, biosparging effectiveness within the AOC-16 MW-64 Native Material and MW-22 PRT Pilot Test Areas may be limited.

4. PILOT TEST SETUP AND PROCEDURES

The following sections describe the equipment used and testing procedures for the pilot.

4.1 EQUIPMENT

The following sections describe the piping network for both the sparging and vapor extraction, sparging compressor, SVE blower, and associated equipment during pilot test activities.

4.1.1 PIPING

Primary piping for the both sparging and vapor extraction were composed of vacuum-rated fluorinated ethylene propylene (FEP)-lined flex hose with Cam-Lock™ fittings at 1-inch and 2-inch diameters, respectively. Air sparging and biosparging piping connected at the wellhead and ran to a Cam-Lock™ fitting at the trailer. SVE piping connected to a 2-inch diameter Schedule 40 galvanized steel pipe, approximately 6-feet in length, mounted to a board directly to the wellhead equipped with a Cam-Lock™ fitting and connected to the FEP flex hose and to the trailer. The galvanized pipe (also referred to as the "instrumentation apparatus") was fitted with ports for measuring the air temperature from the SVE well, a flow valve to regulate the air flow at the SVE well, and sampling ports to measure vacuum and potentially collect vapor concentration measurement (e.g., PID or Summa canister).

4.1.2 PILOT TEST TRAILER AND EQUIPMENT

The biosparging and AS/SVE equipment (portable pilot test unit) was staged in the vicinity of each pilot test location. The trailer-mounted equipment was supplied by a remediation equipment vendor, Fliteway Technologies, Inc. (Fliteway). The pilot test equipment, process air piping systems, and electrical power supply to operate the pilot test equipment is described in this section. A process and instrumentation diagram (P&ID) for the portable pilot test unit is included as Appendix D.

Electricity for the pilot test equipment was provided by a portable 63-kilowatt (kW) diesel powered generator located adjacent to the mobile pilot test trailer. The portable electric generator for the SVE blower equipment was rated for 208/480 VAC 50 amps, 3-phase power with ground.

The pilot test equipment was trailer-mounted, and the necessary controls and instrumentation were designed for Class I Division II locations. The major system components include the following:

- Equipment Supplier: Fliteway Technologies, Inc.
- Equipment Type: Mobile AS/SVE Pilot Test Unit.
- Enclosed Trailer: Interstate I712TA2 7'6" wide by 12'5" Long by 6'4" Tall with 3,500-pound Dual Axle.

- SVE blower type and model: Rietschle C-VLR 301 Rotary Claw Vacuum Blower, or equivalent.
- Maximum SVE Air Flow Capacity: 180 ACFM (66 SCFM) at 20" HG (Blower rated for up to 24 in-HG).
- Motor Horsepower (HP): 7.5 HP with VFD controller.
- Inlet Connections: 3 inches with Camlock fitting.
- Outlet Connection: 4-inch diameter line with Camlock fitting.
- Vapor Liquid Separator Storage Capacity: 117 gallons.
- Condensate Removal Capacity: Up to 15 GPM.
- AS compressor type and model: Mattei ERC511L Air-Cooled Rotary Vane Air Compressor.
- Maximum AS Air Flow Capacity: 67 CFM at 125 pounds per square-inch gauge (PSIG).
- AS Compressor Motor Horsepower: 15 HP.
- AS Compressor Pressure Tank capacity: 60 Gallons.
- Full Load Electrical Amps @ 480-240/3/60: 12-24A.
- Main Electrical Panel Circuit Breaker Requirement: 60 amp.
- Main Control Panel: NEMA 4 Control Panel (230/460 VAC Three Phase) mounted inside trailer.
- Electrical Rating: Class 1, Division 2.
- Low Pressure Drop ½ HP Heat Exchanger to reduce the SVE discharge to within 20 degrees of ambient.

4.1.3 OFF-GAS TREATMENT

Off-gas treatment was not necessary based on discussions and approval from Montana Department of Environmental Quality. The approval letter is included as Appendix E.

4.2 PILOT TEST METHODS, PROCEDURES, AND MEASUREMENTS

The pilot test methods, procedures, and measurements discussed below were completed in the MW-64, MW-22, and MW-41 pilot test locations. An AS/SVE pilot test was conducted at each pilot test location. A biosparging pilot test was attempted at the MW-64 Native Material Pilot Test Area; however, due to the poor performance of AS testing and the presence of LNAPL, biosparging testing was not completed.

4.2.1 AIR APARGING – STEP RATE TEST

The AS step-rate test was developed to provide the data necessary to assess the feasibility of air sparging in the formation and to determine the design parameters for a full-scale system. Each AS step-rate test was completed by applying incremental pressure levels (or steps) to an injection point (AS or biosparging well). The stabilized injection flow rate and

surrounding dissolved oxygen concentrations were measured at each injection pressure level. The results of the AS stepped-rate test were used to select the optimum injection pressure and flow rate for the constant-rate test. The stepped-rate test was conducted at the pilot test areas in a minimum of three steps over approximately one-hour per test. Due to geologic constraints and limited water column available, all air sparging/biosparging step-rate tests completed in the pilot test areas were not successful. Discussion of the AS and biosparging step-rate results is discussed in Section 5.

4.2.2 AIR SPARGING – CONSTANT RATE TEST

The AS step rate testing procedures used in the pilot testing areas indicated that sparging (both air sparging and biosparging), including constant-rate or long-term sparging tests would not be successful. Constant-rate air sparging and biosparging test were not performed in the pilot test areas.

4.2.3 SVE – STEP-RATE TEST

A SVE step-rate test determines the achievable range of soil vapor extraction rates by applying incremental vacuum levels to an extraction point. The stabilized vapor flow rate and surrounding subsurface vacuum levels are measured at each corresponding applied vacuum level (or steps). The results of the step-rate test are used to select the optimum vacuum level and flow rate for the SVE constant-rate test. SVE step-rate tests were attempted at all pilot test areas. Each test consisted of approximately 5 steps over approximately 1 hour per test.

4.2.4 SVE – CONSTANT RATE TEST

Achievable vapor extraction ROI is determined with a constant-rate test, where the optimum vacuum levels (as determined during the SVE step-rate test) is applied to the extraction point for an extended period. The effective ROI is defined as the area surrounding a vapor extraction point in which vapor flow is effectively achieved. For this test, Ramboll defined the effective ROI as the subsurface area where vacuum was measured at greater than one percent of the applied test vacuum. Constant-rate tests were not completed in the MW-22 PRT Pilot Test Area or the MW-41 Native Material Pilot Test Area due poor subsurface conditions (unexpected quantities of LNAPL or no observable flow during step-rate testing). Data collected from and derived from the constant-rate test can be used for selection of extraction equipment, selection of vapor discharge treatment equipment, and determination of effective ROI. The constant-rate test in the MW-64 Native Material Pilot Test Area was conducted for approximately 2.5 hours.

4.2.5 AIR DISCHARGE MONITORING

Total VOCs from the SVE-constant rate test in the MW-64 Native Material Pilot Test Area were monitored to evaluate air discharge concentrations and emission rates. The air discharge from the off-gas treatment unit was monitored during the constant-rate test and analyzed for total VOCs in the field using a PID equipped with a 10.6 electron-volt (eV) lamp. PID measurements were documented in the bound field notebook.

Air analytical samples were collected at the SVE blower discharge (effluent) during the constant rate pilot test while operating at the maximum air flow extraction rate. To determine the VOC emission rate, two air samples were collected using 1-liter Summa canisters with 10-minute regulators and submitted for laboratory analysis of VOC using United States Environmental Protection Agency (USEPA) Test Method TO-15. Sample SVE-1 20191024 was collected at the conclusion of the SVE constant-rate test within the native material in the MW-64 area. Sample SVE-2B 20191023 was collected at the conclusion of the SVE step-rate test within the PRT in the MW-22 area. Soil vapor laboratory analytical report from the pilot test is included in Appendix F.

4.3 QUALITY ASSURANCE/QUALITY CONTROL METHODS

The following quality assurance/quality control (QA/QC) methods were implemented during the pilot testing activities:

- Sampling procedures to minimize potential from cross-contamination of vapor samples were followed.
- All site activities were recorded in a bound field notebook or on field data sheets specific to the pilot testing.
- Stringent chain of custody procedures was followed in accordance with Ramboll's standard operating procedures.
- All monitoring equipment was calibrated at the beginning of each work day. Daily calibrations were performed in accordance with the manufacturer's recommendations and recorded in the field notebook.

Air Samples Submitted for Laboratory Analysis

The following requirements and laboratory analysis methods for air samples collected during the pilot test were as follows:

- Summa canisters used were evacuated, laboratory-cleaned 1-liter stainless steel canisters equipped with the designated air flow controller/regulator.
- Air samples were submitted to Pace Analytical Services (Minneapolis, Minnesota) for laboratory analysis of VOCs using USEPA Method TO-15.
- Field and equipment blanks were not required because disposable sampling equipment was used for each sample.

Field Documentation

All site activities were documented in a bound field notebook, and the following activities are included in daily documentation:

- Chronological log of site activities.
- Personnel working on the site.
- Procedures for sampling and other routine activities associated with the pilot testing activities.

5. AS/SVE PILOT TEST DATA ANALYSIS AND RESULTS

The evaluation of the AS/SVE test data, including detailed equipment operation data and vacuum extraction performance monitoring data collected during the test, is summarized in this section and presented in Figures 5 through 8 and Tables 4 through 12. The evaluation includes graphical analysis of vacuum-flow response, graphical estimates of effective ROI, and an estimation of VOC vapor mass removal rates. Table 11 summarizes the laboratory analytical results of vapor samples collected during the SVE step-rate test in the MW-22 PRT Pilot Test Area and SVE constant-rate test in the MW-64 Native Material Pilot Test Area.

Both biosparging/AS and SVE test equipment and instrumentation operated normally and within anticipated operating conditions during the tests. The biosparging/AS and SVE test equipment could not be operated simultaneously due to an intermittent electrical fault which would shut down the SVE portion of the equipment. This issue did not prohibit testing activities because the biosparging/AS was not achievable due to an insufficient water column. Therefore, simultaneous operation was not required.

For organizational and readability, each pilot test in each area has been separated into subsections based on the location of the pilot test. The subsections are as follows:

- MW-64 Native Material Pilot Test Area
- MW-22 PRT Pilot Test Area
- MW-41 Native Material Pilot Test Area

5.1 TRUCK RACK PILOT TEST AREA

The Truck Rack pilot test area is shown in Figure 1 and located immediately south of AOC-16 on CMR property. The Truck Rack pilot test area was further separated into two sub-areas: the MW-64 Native Material area and MW-22 PRT area. Biosparging testing was the primary focus in the native material within the Truck Rack pilot test area; however, AS/SVE pilot test was also completed to evaluate if geologic conditions were favorable. Additionally, AS/SVE was completed in the PRT to evaluate how the trench materials responded to sparing and vapor excavation.

5.1.1 MW-64 NATIVE MATERIAL PILOT TEST AREA

The native material pilot test area is in the immediate vicinity of MW-64 (Figure 2). Two monitoring wells (MW-102 and MW-103), one SVE well (SVE-1), and one sparging well (AS-1) were installed to facilitate the pilot test. Each portion of the pilot test is discussed in the following sections.

Biosparging and AS Testing – MW-64 Native Material Pilot Test Area

Due to the similarities between biosparging and AS testing, both were evaluated in the MW-64 Pilot Test Area within the native materials. The biosparging and AS test data is presented Table 4 and summarizes the equipment operational measurements (applied pressures and flow) collected during the biosparging/AS step-rate test. Perimeter

monitoring measurements were collected during each step using a digital manometer or Magnehelic® gauge.

Applied flow rates were stepped at a rate of 5 standard cubic feet per minute (SCFM) starting at 5 SCFM and concluding at 15 SCFM (Table 4). Applied pressures at the AS wells in all three steps were reasonably consistent at 4, 5, and 4 pounds per square inch (PSI). Perimeter monitoring observations at nearby monitoring wells (Table 4) indicated increasing pressure values as applied pressure was increased. During typical biosparging/AS step-rate testing applied pressure will increase until water is pushed out from the well; however, this was not observed. It is hypothesized that due to unfavorable subsurface conditions applied pressure to AS-1 was moving through the shallow, more permeable geologic material when the water was purged from the well. This indicates an insufficient volume of water for biosparging and air sparging technologies to be effective.

SVE Testing – MW-64 Native Material Pilot Test Area

SVE testing in the MW-64 pilot test area within the native material was completed through a step-rate test and constant-rate test. The test data are presented in Tables 5 and 6. Table 5 summarizes the equipment operational measurements (mechanical operation and flow) collected during the step-rate test. Table 6 summarizes the performance data (applied vacuum, perimeter vacuum monitoring) collected during the constant-rate test. Perimeter vacuum monitoring measurements were collected using a digital manometer or Magnehelic® gauge. During the constant-rate test perimeter vacuum monitoring in MW-102 and MW-103 was collected using a pressure transducer equipped with a data logger. The results of the tests are discussed below.

SVE Step-Rate Test – Mw-64 Native Material Pilot Test Area

The area-specific response of vapor flow rate to applied vacuum at SVE-1 is shown on Figure 5 using the data generated from the step-rate test (Table 5). The step-rate test was completed in seven steps ranging from 2.5 to 17.5 inches of mercury (in-Hg) at SVE-1. The final three steps produced the largest observed vapor flow rate of approximately 6.9 SCFM. To eliminate activation of the vacuum-relief valve, the applied vacuum of 15 in-Hg was selected for the constant-rate test.

SVE Constant-Rate Test – Mw-64 Native Material Pilot Test Area

Figure 6 depicts the vacuum influence measured in the observation points during the constant-rate test and provides an estimate of effective ROI in the unsaturated soils surrounding SVE-1 in the native material. These measurements are summarized in Table 6. The initial chart in Figure 6 plots perimeter vacuum measurements versus distance from SVE-1 on a normal scale. The bottom chart in Figure 6 plots perimeter vacuum measurements versus distance from SVE-1 on a logarithmic scale to provide a straight-line analysis of the data. Using the linear trend line of the logarithmic chart and setting the horizontal intersection to zero, the estimated effective vacuum ROI is approximately 24 feet. Based on the geology present at SVE-1, this ROI is consistent with dense, fine sands.

5.1.2 MW-22 PRT PILOT TEST AREA

The MW-22 PRT pilot test area is located approximately 100 feet southwest of MW-64 (Figure 2). Two functional monitoring wells (SVE-2A and MW-104), one SVE well (SVE-2B), and two sparging wells (AS-2A and AS-2B) were installed to facilitate pilot testing within the engineered backfill of the PRT. Each portion of the pilot test is discussed in the following sections.

AS Testing – MW-22 PRT Pilot Test Area

AS was evaluated in the MW-22 Pilot Test Area within the PRT to evaluate the effectiveness of sparging within the PRT materials. The AS test data is presented Table 7 and summarizes the equipment operational measurements (applied pressures and flow) collected during the AS step-rate test within the PRT. Perimeter monitoring measurements were collected during each step using a digital manometer or Magnehelic® gauge.

Applied flow rates were stepped at a rate of 5 SCFM starting at 5 SCFM and concluding at 20 SCFM (Table 7). Applied pressures at all steps were reasonably consistent at between 5 and 9 PSI. Perimeter monitoring observations at nearby monitoring wells (Table 7) indicated increasing pressure values as applied pressures were increased. During typical biosparging/AS step-rate testing applied pressure will increase until water is pushed out of the well; however, this was not observed. Like the AS step-rate test completed at AS-1 in the native material near MW-64, the applied pressure to AS-2B was moving through the shallow, more permeable geologic material in the trench when the water was purged from the well. This indicates an insufficient water column for air sparging technologies within the PRT.

SVE Step-Rate Testing – MW-22 PRT Pilot Test Area

SVE testing in the MW-22 pilot test area within the PRT was completed through a step-rate test. The test data are presented in Table 8 and summarizes the equipment operational measurements (mechanical operation and flow) collected during the step-rate test.

The area-specific response of vapor flow rate to applied vacuum at SVE-2B is shown on Figure 7 using the data generated from the step-rate test (Table 8). The step-rate test was completed in five steps ranging from 2.5 to 15 inches of mercury (in-Hg) at SVE-2B. The final two steps produced the largest observed vapor flow rate of approximately 24 SCFM; however, this flow induced a vacuum capable of capturing and generating fluid (e.g., groundwater and LNAPL) within the PRT. Approximately 20 gallons of fluid was collected during the SVE step-rate test at SVE-2B during one-hour of operation. Approximately 15 gallons of the 20 gallons was LNAPL. All fluids were containerized and disposed in the CMR WWTP.

Due to fluid generation and unforeseen presence of LNAPL, a constant-rate test was not completed in the MW-22 PRT Pilot Test Area.

5.2 RIVER ROAD PILOT TEST AREA

The MW-41 Native Material Pilot Test Area is located immediately north of North River Road (Figure 3). Three existing monitoring wells (MW-41, MW-51, and MW-58) were used as perimeter monitoring wells. One SVE well (SVE-3), and one AS well (AS-3) were installed to facilitate the pilot test. Two of the perimeter monitoring wells (MW-41 and MW-58) were used as wells because they met the conditions of an air sparge well (e.g., submerged well screen) and because AS-3 had an inadequate water column (e.g., exposed well screen). It is important to note that AS-3 was installed 5 feet from MW-41 and MW-58 to a depth of 10 ft-bgs and groundwater was not observed. While MW-41 and 58 each had groundwater present to approximately 3 ft-bgs and 7 ft-bgs, respectively. The difference in groundwater elevations in the MW-41 Native Material Pilot Test Area indicates that perched water conditions likely exist due to surface infiltration within the more permeable soils in the upper few feet of soil. Each portion of the pilot test in the MW-41 area is discussed in the following sections.

5.2.1 AS TESTING – MW-41 NATIVE MATERIAL PILOT TEST AREA

AS was evaluated in the MW-41 Native Material Pilot Test Area to evaluate the effectiveness of sparging along North River Road. The AS test data is presented in Table 9 and summarizes the equipment operational measurements (applied pressures and flow) collected during the AS step-rate tests completed at AS-3, MW-41, and MW-58. Perimeter monitoring measurements were collected during each step using a digital manometer or Magnehelic® gauge.

Unlike the AS step-rate tests in the Truck Rack MW-64 and MW-22 areas, the applied steps for tests at AS-3 and MW-58 were administered based on pressure. Even though AS-3 did not accumulate groundwater, AS technology was attempted to evaluate if injection of air was possible. The steps at three locations were completed at varying pressures (Table 9). During pressure application, no flow was observed during the AS step-rate tests at AS-3 or MW-58 and the pressures did not fluctuate. It was confirmed through geotechnical analysis that geologic materials at this location are not conducive to accepting the injection of air (Table 2).

Applied flow rates at MW-41 during the AS step-rate test were stepped at a rate of 5 standard cubic feet per minute (SCFM) starting at 10 SCFM and concluding at 20 SCFM (Table 9). Pressures at the initial step was 3 PSI at 10 SCFM. The final two steps were reasonably consistent at 8 and 9 PSI. During typical biosparging/AS step-rate testing applied pressure will increase until water is purged from the well; however, this was not observed. Like the AS step-rate test completed at AS-1 and AS-2B, the applied pressure to MW-41 was moving through the shallow, more permeable geologic material in the trench when the water was purged from the well and exposed the shallow screen. This indicates MW-41 is not constructed appropriately for air sparge application.

Based on the AS step-rate tests completed at the three locations in the MW-41 area, air sparging in the MW-41 Native Material Pilot Test Area was not effective.

5.2.2 SVE STEP-RATE TESTING – MW-41 NATIVE MATERIAL PILOT TEST AREA

SVE testing in the MW-41 Native Material Pilot Test Area was completed through a step-rate test. The test data are presented in Table 10 and summarizes the equipment operational measurements (vacuum vs. flow) collected during the step-rate test. Perimeter vacuum monitoring measurements were collected during every step using a digital manometer or Magnehelic® gauge. The results of the tests are discussed below.

The area-specific response of vapor flow rate to applied vacuum at SVE-3 is shown on Figure 8 using the data generated from the step-rate test (Table 10). The step-rate test was completed in five steps ranging from 2.5 to 20 inches of mercury (in-Hg) at SVE-3. No observable flow was observed until the final two steps (17.5 and 20 in-Hg). Based on the step-rate tests observations it was concluded that similarly to air injection, native materials in the MW-41 pilot test area are not conducive vapor extraction technologies.

5.3 RIVER ROAD PILOT TEST AREA

5.3.1 MW-64 NATIVE MATERIAL PILOT TEST AREA

During the SVE-1 constant-rate test (MW-64 Native Material Pilot Test Area), a vapor sample was collected at the conclusion of the test for laboratory analysis. A summary of the vapor sample analytical data is included in Table 11. Estimation of VOC vapor removal rate was completed using the vapor concentration in micrograms per cubic meter ($\mu g/m^3$), the flow rate collected at the approximate time of sample collection, and the length of operation during the constant-rate test.

The SVE-1 constant-rate test removed 0.04 pounds of VOCs over the 2.5-hour period. Assuming consistent VOC recovery, the start-up removal rate would be expected to be approximately 0.46 pounds per day in one SVE extraction point in the native materials. Table 12 identifies the baseline removal rates for all analyzed VOC compounds.

5.3.2 MW-64 PRT PILOT TEST AREA

During the SVE-2B step-rate test (MW-22 PRT Pilot Test Area), a vapor sample was collected at the conclusion of the test for laboratory analysis. A summary of the vapor sample analytical data is included in Table 11. Estimation of VOC vapor removal rate in the PRT was completed using the vapor concentration in micrograms per cubic meter ($\mu g/m^3$), the flow rate collected at the approximate time of sample collection, and the length of operation during the step-rate test.

The SVE-2B step-rate test removed an estimated 0.76 pounds of VOCs over the 1-hour period. Assuming consistent VOC recovery, the start-up removal rate would be expected to be approximately 16.9 pounds per day per SVE extraction point within the PRT. Table 12 identifies the baseline removal rates for all analyzed VOC compounds.

6. PILOT TEST CONCULSIONS

The biosparging and AS/SVE pilot tests completed in the MW-64, MW-22, and MW-41 areas indicate that biosparging, AS, and SVE within the native soils was not effective and application of these technologies as an interim measure to address the identified impacts at AOC-16 will likely be unsuccessful without modification to the native soil conditions. In the MW-64 area, hydrocarbon-degrading bacteria are present in groundwater indicating that subsurface conditions are favorable to support biodegradation of residual petroleum VOCs; however, an insufficient volume of water (or saturated aquifer thickness) is present to effectively oxygenate and distribute air within the saturated soils to effectively implement the biosparging technology. Furthermore, the presence of LNAPL discovered at both the MW-64 and MW-22 test locations at the Truck Rack area will result in long operational times to address the LNAPL mass.

In the MW-41 Native Material Pilot Test Area, AS/SVE pilot tests were not successful due to the presence of very dense fine-grained soils (fine-grain sands, silts, and clays). The presence of the fine-grained silts and clays resulted in the inability to extract air through the soil formation resulting in little or no influence from the SVE and AS tests. The low permeability soils coupled with a highly variable or perched groundwater table and minimal evidence of subsurface air flow from the pilot testing indicates that the AS/SVE technology in the native soil materials will not be effective in achieving the goal of the interim measure in the MW-41 area.

AS and SVE testing performed within the backfill materials (e.g., trenched or fill material) within the PRT located in the MW-22 area determined that SVE is amenable for the extraction of vapor and LNAPL. This is likely due to the increased permeability from the disturbed soils within the PRT. The higher permeability soils allowed for air flow to be effectively distributed throughout the trench resulting in collection and capture of VOC, free phase and residual NAPL present within the PRT. This was evident when approximately 15 gallons of LNAPL was collected during the SVE step-rate test at SVE-2B during one-hour of operation. Air sparging within the trench was not successful due to insufficient volume of water to effectively sparge within the saturated soils or water column.

Due to the presence of LNAPL within the PRT and increased permeability of the PRT materials as compared to corresponding native materials, the SVE VOC removal rate in the Truck Rack area achieved in PRT materials was approximately 37 times greater than that achieved in corresponding native materials.

The ability to effectively recover NAPL and VOC mass from the PRT using SVE indicates that this technology is applicable for the collection and recovery of LNAPL and residual free-phase product with modified subsurface conditions (i.e., trench backfilled with a permeable material). Due to the limited amount of saturated thickness available for air sparging in both pilot test areas, including the PRT and the presence of low permeability soil at deeper depths with the subsurface, air sparging and biosparging will not be effective as an interim measure remedy for the AOC-16 area. Recommendations for implementing alternatives to

the previously selected interim measure technologies (SVE/AS and biosparging) for the AOC-16 area are discussed in Section 7.

7. ALTERNATIVE IM REMEDIAL OPTIONS AND RECOMMENDATIONS

Information gathered from the pilot testing activities indicate that biosparging, AS, and SVE technologies as presented in the *AOC-16 Interim Measures Evaluation Report* (CMR, 2019) will not be effective for the AOC-16 area. Based on the AOC-16 subsurface conditions documented during the pilot testing, this section presents one new remedial option for the Truck Rack area[2] and two new remedial options for the River Road area; two new remedial alternatives; and the recommended alternative IM remedial approach.

7.1 TRUCK RACK AREA: DUAL PHASE EXTRACTION SYSTEM WITHIN EXISTING PRODUCT RECOVERY TRENCH REMEDIAL OPTION

SVE technology proved more effective than sparging technologies in the Truck Rack MW-22 and MW-64 Pilot Test Areas (PRT and Native Material). Subsurface vadose air flow rates within the PRT was greater than that of native materials and LNAPL was readily recovered during the MW-22 PRT SVE pilot testing. A viable remedial option for the Truck Rack area would be to utilize the existing PRT for dual-phase extraction (DPE) by removing the existing 20-year old belt-skimmers with fluid extraction wells and DPE wells within the existing PRT.

DPE fluid extraction piping would remove groundwater, LNAPL, and soil vapor creating a fluid gradient toward each extraction location while simultaneously collecting LNAPL, dissolved phase impacts, and impacted soil vapor. Eleven recovery locations along the PRT would be added to capture a larger area of PVOC impacted groundwater and LNAPL. Maximum fluid recovery rates at each of the extraction locations is estimated to be approximately 2 to 3 gallons per minute (totaling 33 gallons per minute maximum). Fluid transfer piping and trenching would be required for the additional recovery locations. Examination of the current electrical connections at the two existing recovery locations would be required. Recovered groundwater and LNAPL would be directed to the CMR WWTP via existing WWTP transfer piping installed for previous PRT operation (if present and in sound condition). If previously installed transfer piping is not present or incapable of handling 33 gpm, transfer piping would be installed from each fluid extraction location to a centralized WWTP transfer piping header utilized for the truck loading rack.

Due to high vapor concentrations observed during MW-64 and MW-22 pilot tests, the DPE system will require treatment prior to discharging to the atmosphere. As evaluated in the *AOC-16 Interim Measure Evaluation Report*, the air treatment technologies considered are

[2] Although the extent and thickness of LNAPL was greater than previously appreciated, renewed operation of the mid-90's Truck Rack LNAPL recovery system is not deemed a viable remedial option because:

- The amount of readily recoverable LNAPL by the belt skimmer system had reportedly reached diminishing levels when the system was shut down more than 15 years ago,
- It is anticipated that most if not all the belt skimmer recovery system equipment would require replacement before it could become operational again,
- Such a system may require replacement by a total fluids treatment system soon.

vapor-phase granular activated carbon (VGAC), thermal treatment using a regenerative thermal oxidizer (RTO) or catalytic oxidation (CatOx). Vapor concentrations observed during pilot testing activities indicate that an RTO or CatOx would be best suited for the Site. VGAC technology is best used for low concentrations.

Capital costs associated with a DPE system include design, Site preparation, well installation, system installation, and start-up. Costs associated with DPE within the existing PRT is discussed in Sections 7.4 and 7.5.

7.2 RIVER ROAD MW-41 AREA: AS/SVE SYSTEM WITHIN AN ENGINEERED TRENCH REMEDIAL OPTION

Based on observations during the MW-41 pilot test the application of AS/SVE would only be possible in a trench backfilled with permeable materials (e.g., loose gravel or coarse sand). The trench would be installed parallel to North River Road. The dimensions of the engineered AS/SVE trench would be 100 feet in length (MW-58 to MW-50), 10 feet in thickness (one ft-bgs to 11 ft-bgs based on the boring log of AS-3), and 5 feet in width. To eliminate surficial influences, one foot of clay will be placed from the ground surface to one ft-bgs. The AS/SVE design would be simplified due to the trench application. AS/SVE technology requires operation, monitoring, and maintenance (OM&M) and the frequency of OM&M would be contingent on system specifications and seasonal fluid levels. Depending on the available saturated thickness of the AS portion of the system, a combination of horizontal and/or vertical injection well placement may be required.

Capital costs associated with an AS/SVE engineered trench with AS/SVE system include design, Site preparation, trench installation, system installation, and start-up. Costs associated AS/SVE technology within an engineered trench are discussed in Section 7.4.

7.3 RIVER ROAD MW-41 AREA: PRODUCT RECOVERY AND PASSIVE TREATMENT TRENCH TECHNOLOGY WITH GRANULAR ACTIVATED CARBON AND OXYGEN AMENDMENTS REMEDIAL OPTION

An alternative to the AS/SVE trench in the MW-41 area would be the installation of a passive sorption technology (e.g., granular activated carbon [GAC] with an amendment to create favorable subsurface conditions for PVOC capture and degradation) within a trench application. Due to infrequent observable LNAPL in MW-41, three product recovery wells utilizing solar-powered pneumatic pumps are also proposed to prevent LNAPL from entering the trench which could greatly diminish the passive sorption technology. These two technologies would eliminate the need for infrastructure installation and OM&M requirements (e.g., electricity, vapor treatment), which are necessary for AS/SVE systems. The passive treatment technology trench would be like the AS/SVE trench described in Section 0 (100-feet in length, by 5-feet in width, by 11-feet in depth).

Capital costs associated with a passive treatment trench system include design, bench testing of amendments, Site preparation, and trench installation. Costs associated with passive treatment trench technology is discussed in Section 7.5.

7.4 REMEDIAL ALTERNATIVE 1 – DPE IN THE PRT WITH AS/SVE WITHIN AN ENGINEERED TRENCH

Remedial Alternative 1 includes the recovery and removal of mobile and residual LNAPL, impacted groundwater, and impacted soil vapor utilizing DPE technology installed in along the entire Truck Rack PRT and removal and recovery of hydrocarbon constituents from groundwater and saturated soils utilizing AS/SVE technology within an engineered trench immediately north of North River Road (MW-41 Area). Remedial Alternative 1 footprint is provided in Figure 9.

The benefits of utilizing these two technologies are:

- Recovery and removal of mobile and residual LNAPL, impacted groundwater, and soil vapor from the areas with elevated hydrocarbon constituents within an existing trench infrastructure downgradient of AOC-16.
- Receptor protection of Missouri River via recovery and removal of hydrocarbon constituents from groundwater and saturated soils immediately north of North River Road.

Cost

Capital cost associated with DPE technology and AS/SVE within an engineered trench technology include design , Site preparation, well installation, system installation, and start-up. Total capital costs are estimated to be $1,708,000. Annual OM&M costs for Alternative 1 remedies are estimated to be approximately $159,000. A detailed breakdown of the costs associated with implementation of this alternative are provided in Appendix G.

7.5 REMEDIAL ALTERNATIVE 2 – DPE IN THE PRT WITH PRODUCT RECOVERY AND PASSIVE TREATMENT TRENCH

Remedial Alternative 2 includes the recovery and removal of mobile and residual LNAPL, impacted groundwater, and impacted soil vapor utilizing DPE technology installed in along the entire PRT and removal and recovery of hydrocarbon constituents from groundwater and saturated soils utilizing recovery wells and passive treatment technologies within a trench immediately north of North River Road (MW-41 Area). Remedial Alternative 2 footprint is provided in Figure 10.

The benefits of utilizing these two technologies are:

- Recovery and removal of mobile and residual LNAPL, impacted groundwater, and soil vapor from the areas with elevated hydrocarbon constituents within an existing trench infrastructure downgradient of AOC-16.
- Receptor protection of Missouri River via recovery and removal of hydrocarbon constituents and transformation of dissolved-phase LNAPL constituents from groundwater and saturated soils immediately north of North River Road.

Cost

Capital cost associated with DPE technology and product recovery and passive treatment trench technology include design, treatment amendment bench testing, Site preparation, well installation, system installation, and start-up. Total capital costs are estimated to be $1,483,000. Annual OM&M costs for Alternative 2 remedies are estimated to be approximately $120,000. A detailed breakdown of the costs associated with implementation of this alternative are provided in Appendix G.

7.6 RECOMMENDATIONS

Both Remedial Alternatives described in Section 7.4 and 7.5 are deemed viable alternative IM remedial approaches to address the petroleum related impacts associated with the AOC-16 area. As summarized in Table 13, Remedial Alternative 2 is deemed more economical than Remedial Alternative 1. Accordingly, Remedial Alternative 2 – DPE in the existing Truck Dock PRT with a product recovery and passive treatment trench along River Road – is recommended as the alternative IM remedial approach for the AOC-16 area.

A DPE system within the existing PRT is the recommended remedial option for the Truck Dock area to effectively address the NAPL and petroleum related constituents present within the vadose zone, variable saturated conditions of the perched materials, and presence of a more extensive LNAPL area than previously understood. The SVE pilot test of the MW-22 PRT demonstrated the effectiveness of the DPE approach in this portion of the site whereas the previously identified remedial approach of limited skimming with bio-sparging was determined to not be feasible due to the more widespread presence of LNAPL and the limited saturated thickness of perched materials.

A triplet of contingency product recovery wells immediately upgradient of a passive treatment trench is recommended to address petroleum impacted dissolved phase perched groundwater downgradient of the AOC-16 Truck Rack and upgradient of River Road and the Missouri River.8.

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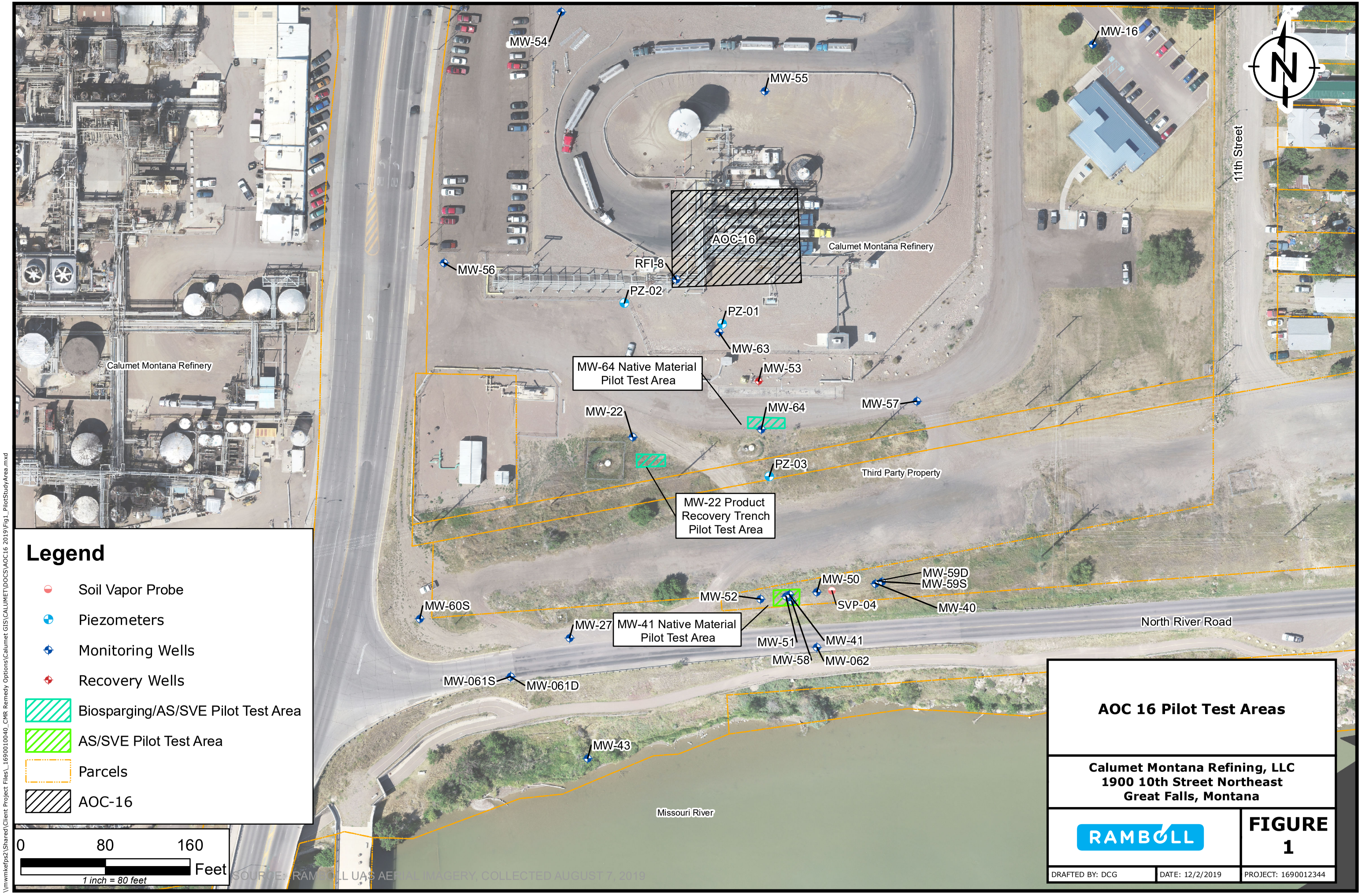
FIGURES



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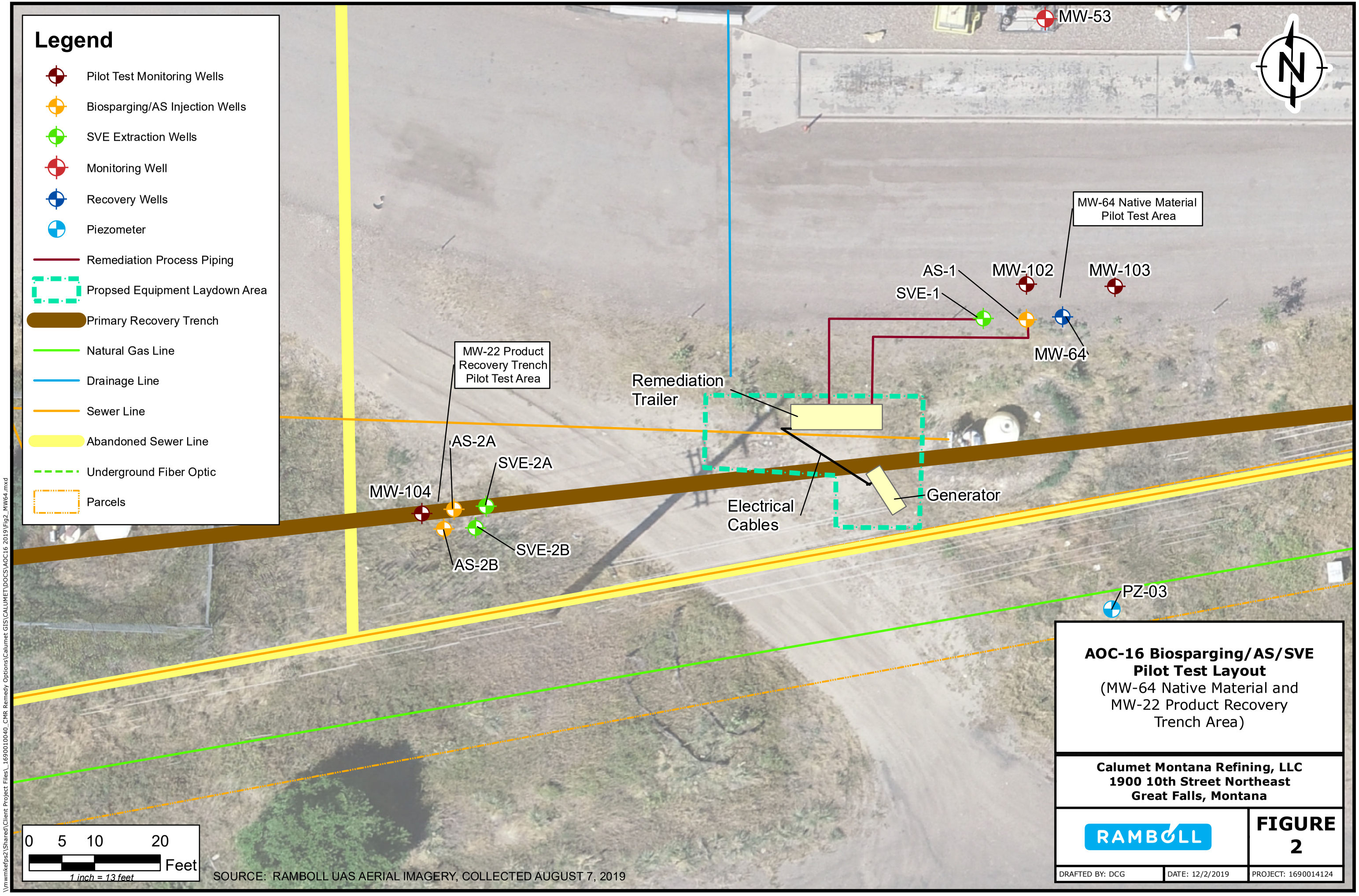
AOC 16 Pilot Test Areas

Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 1

DRAFTED BY: DCG	DATE: 12/2/2019	PROJECT: 1690012344



AOC-16 Biosparging/AS/SVE Pilot Test Layout
(MW-64 Native Material and MW-22 Product Recovery Trench Area)

Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

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FIGURE 2

DRAFTED BY: DCG	DATE: 12/2/2019	PROJECT: 1690014124

\\mwmkefps2\Shared\Client Project Files_1690010040_CMR Remedy Options\Calumet GIS\CALUMET\DOCS\AOC16 2019\Fig2_MW64.mxd

SOURCE: RAMBOLL UAS AERIAL IMAGERY, COLLECTED AUGUST 7, 2019

Third Party Property

MW-59D

MW-40

MW-59S

MW-50

SVP-04

MW-51

MW-41

SVE-3

MW-52

AS-3

MW-58

Remediation Trailer

Electrical Cables

Generator

MW-62

Legend

- Existing Soil Vapor Probe
- Monitoring Wells
- AS Injection Well
- SVE Extraction Well
- Remediation Process Piping
- Equipment Laydown Area
- Parcels
- Sewer Line
- Underground Fiber Optic

0 5 10 20 Feet

1 inch = 10 feet

AOC-16 AS/SVE Pilot Test Layout (MW-41 Area)

Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

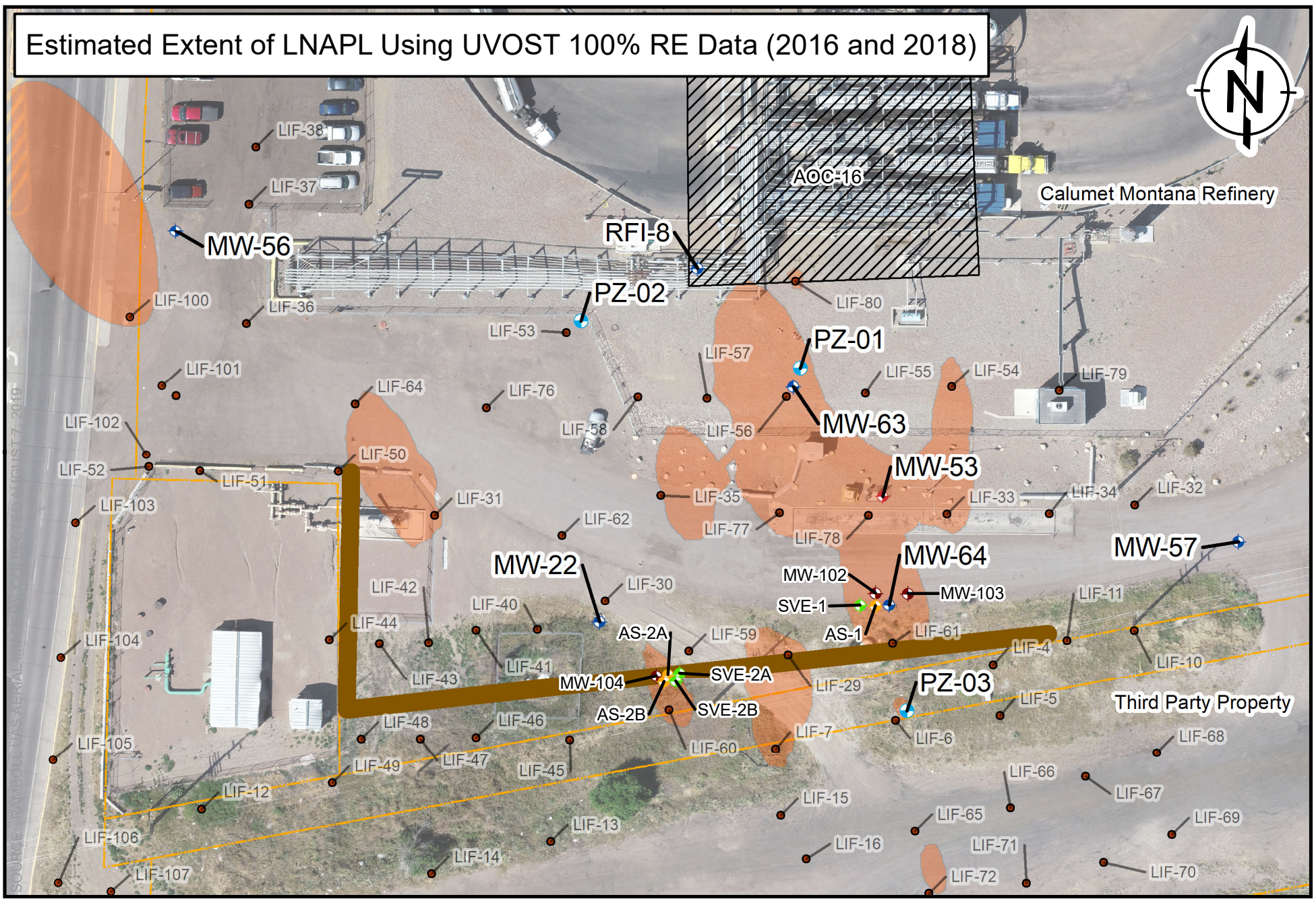
RAMBOLL

FIGURE 3

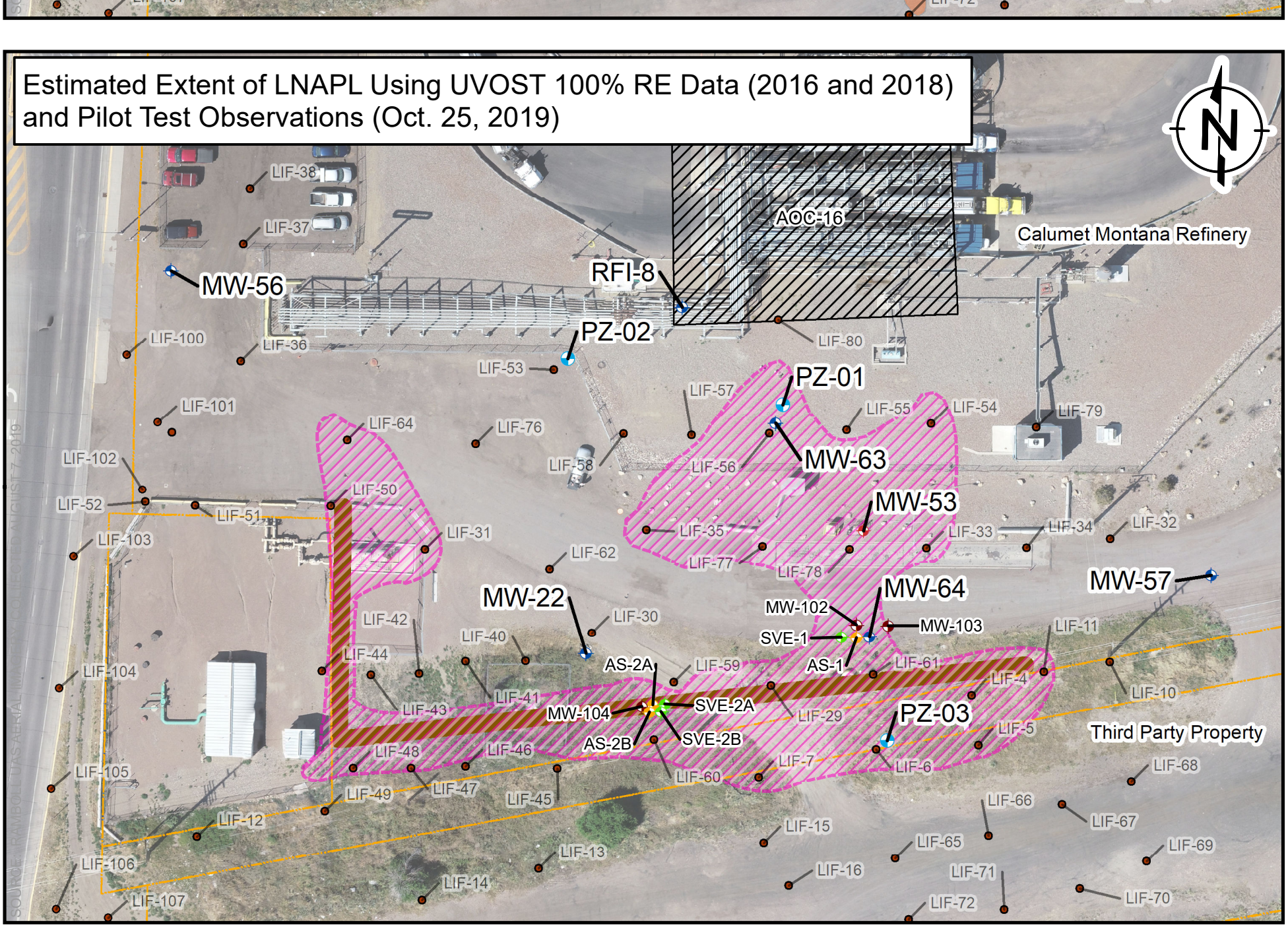
DRAFTED BY: DCG	DATE: 11/19/2019	PROJECT: 1690014124

M:\Client Project Files_1690010040_CMR Remedy Options\Calumet GIS\CALUMET\DOCS\AOC16 2019\Fig3_MW41area.mxd

Estimated Extent of LNAPL Using UVOST 100% RE Data (2016 and 2018)



Estimated Extent of LNAPL Using UVOST 100% RE Data (2016 and 2018) and Pilot Test Observations (Oct. 25, 2019)



- Monitoring Wells
- Biosparging/AS Pilot Test Wells
- SVE Pilot Test Wells
- LIF Borings
- Soil Vapor Probe
- Piezometers
- Monitoring Wells
- Recovery Wells

- Recovery Trench
- AOC-16
- Estimated Extent of LNAPL (Oct. 25, 2019)
- UVOST 100% RE
- Parcels

0 80 160 Feet

1 inch = 55 feet

Estimated Extent of LNAPL
October 25, 2019

Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

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FIGURE 4

DRAFTED BY: DCG | DATE: 12/2/2019 | PROJECT: 1690012344

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Figure 5: SVE-1 Step-Rate Test
Applied Vacuum-Flow Response Curve
MW-64 Native Material Pilot Test Area
CMR
Great Falls, Montana

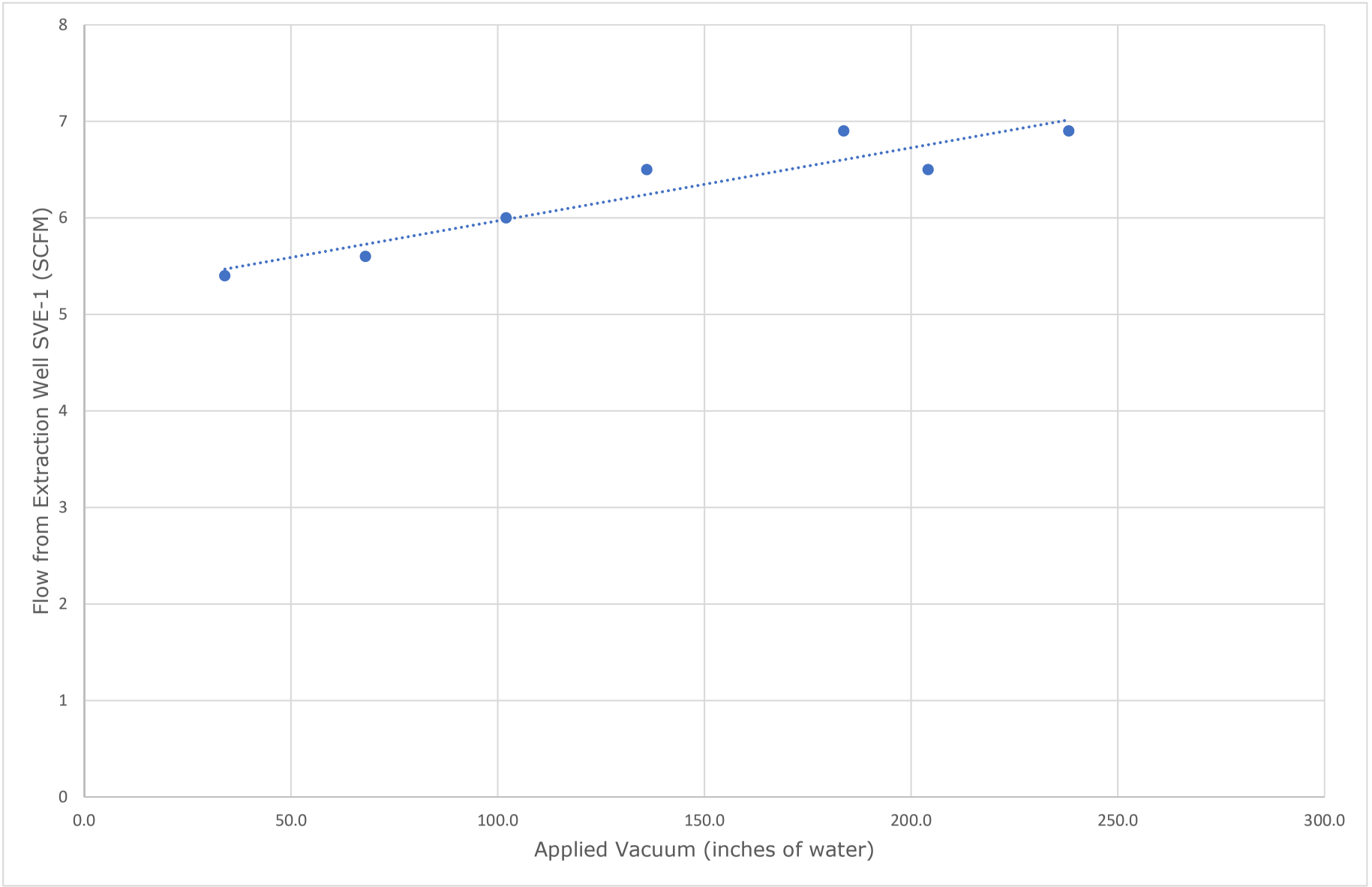
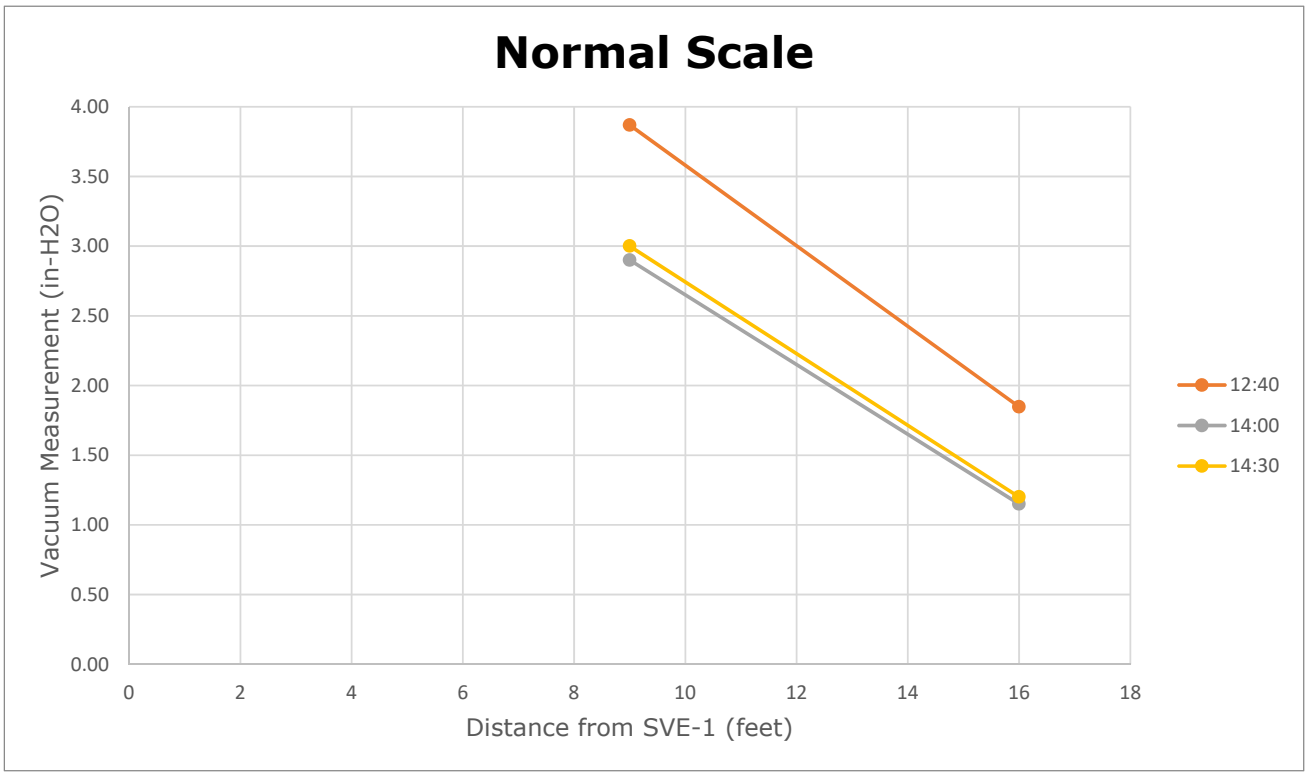


Figure 6 - SVE-1 Constant-Rate Test
Vacuum Radius of Influence
MW-64 Native Material Pilot Test Area
CMR
Great Falls, Montana



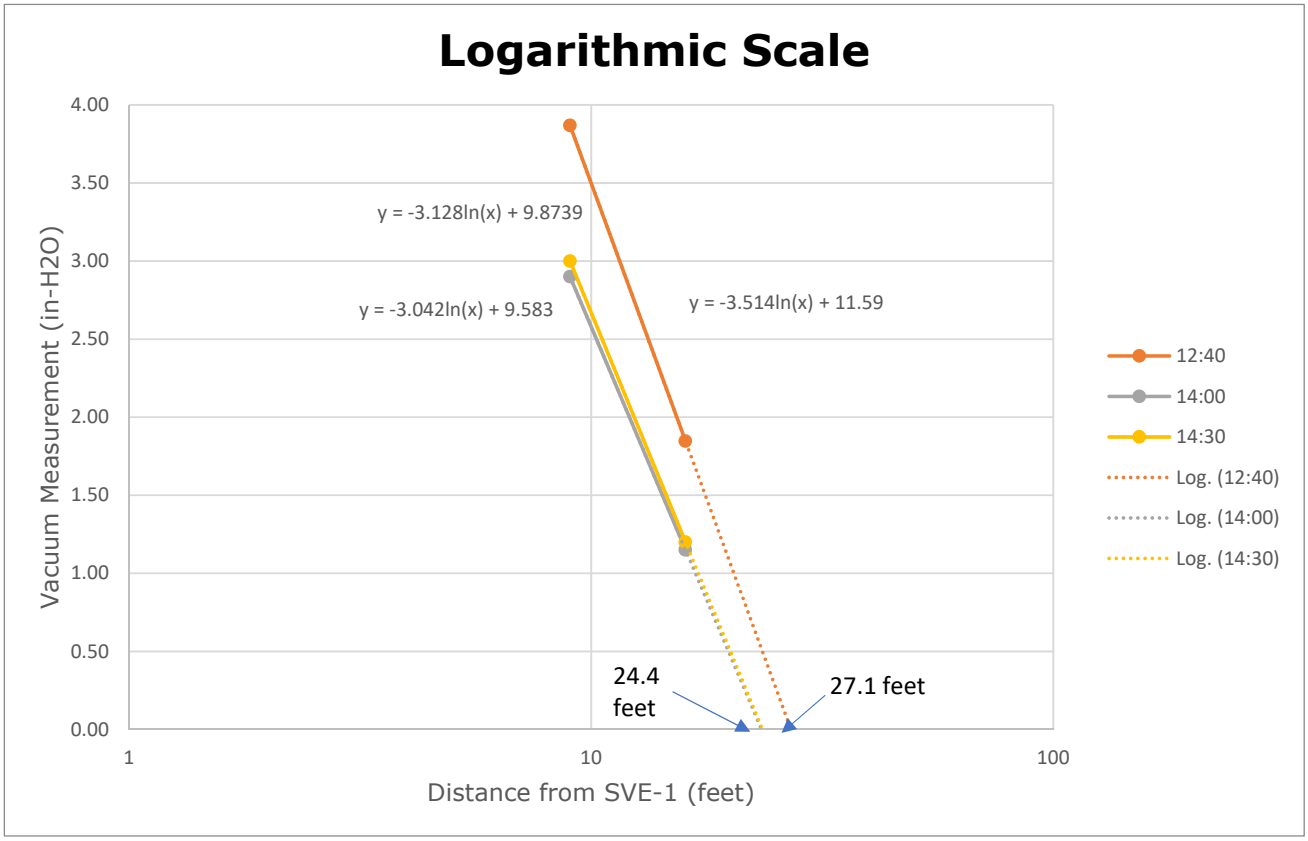


Figure 7 - SVE-2B Step-Rate Test
Applied Vacuum-Flow Response Curve
MW-22 PRT Pilot Test Area
CMR
Great Falls, Montana

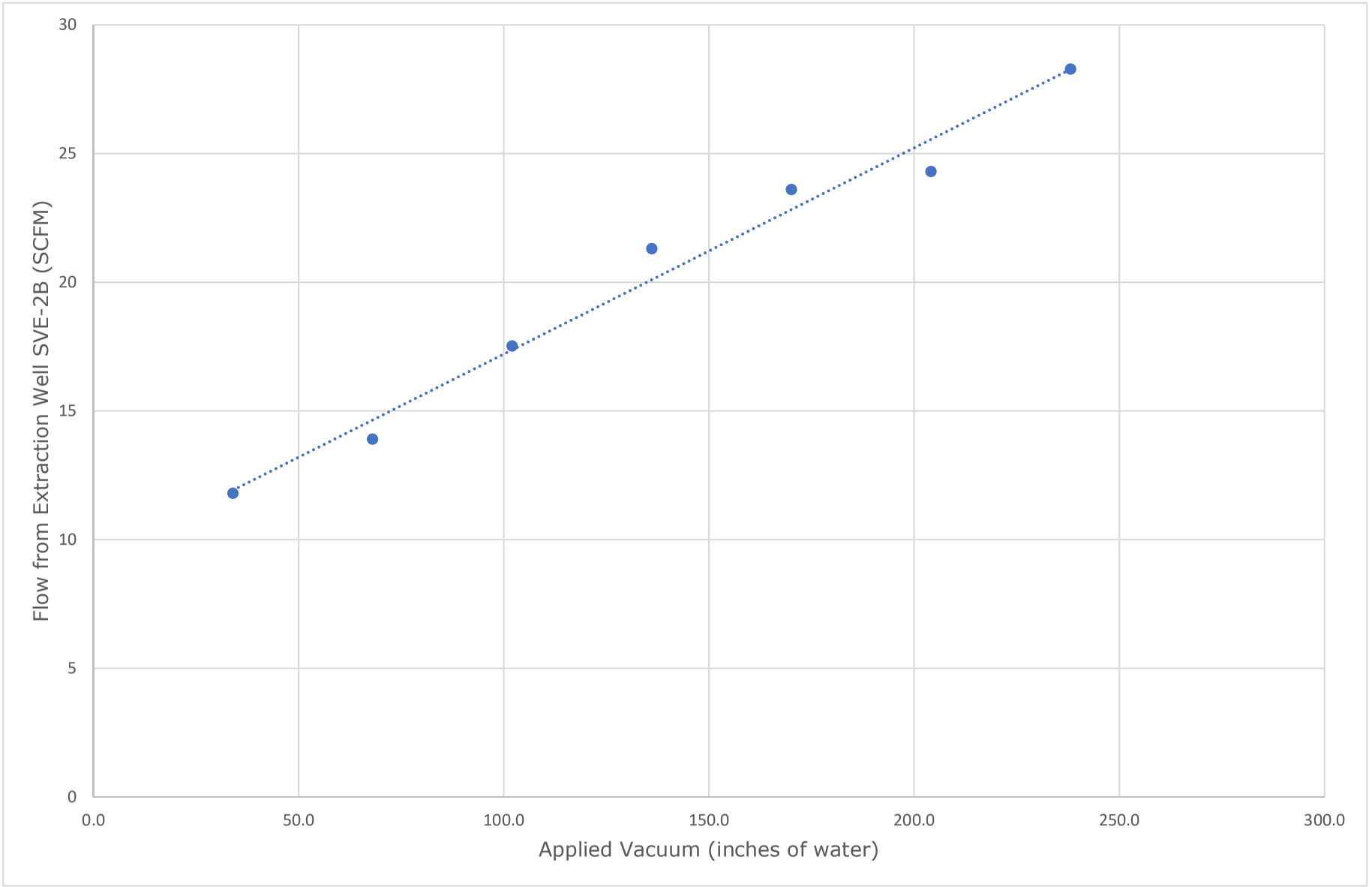
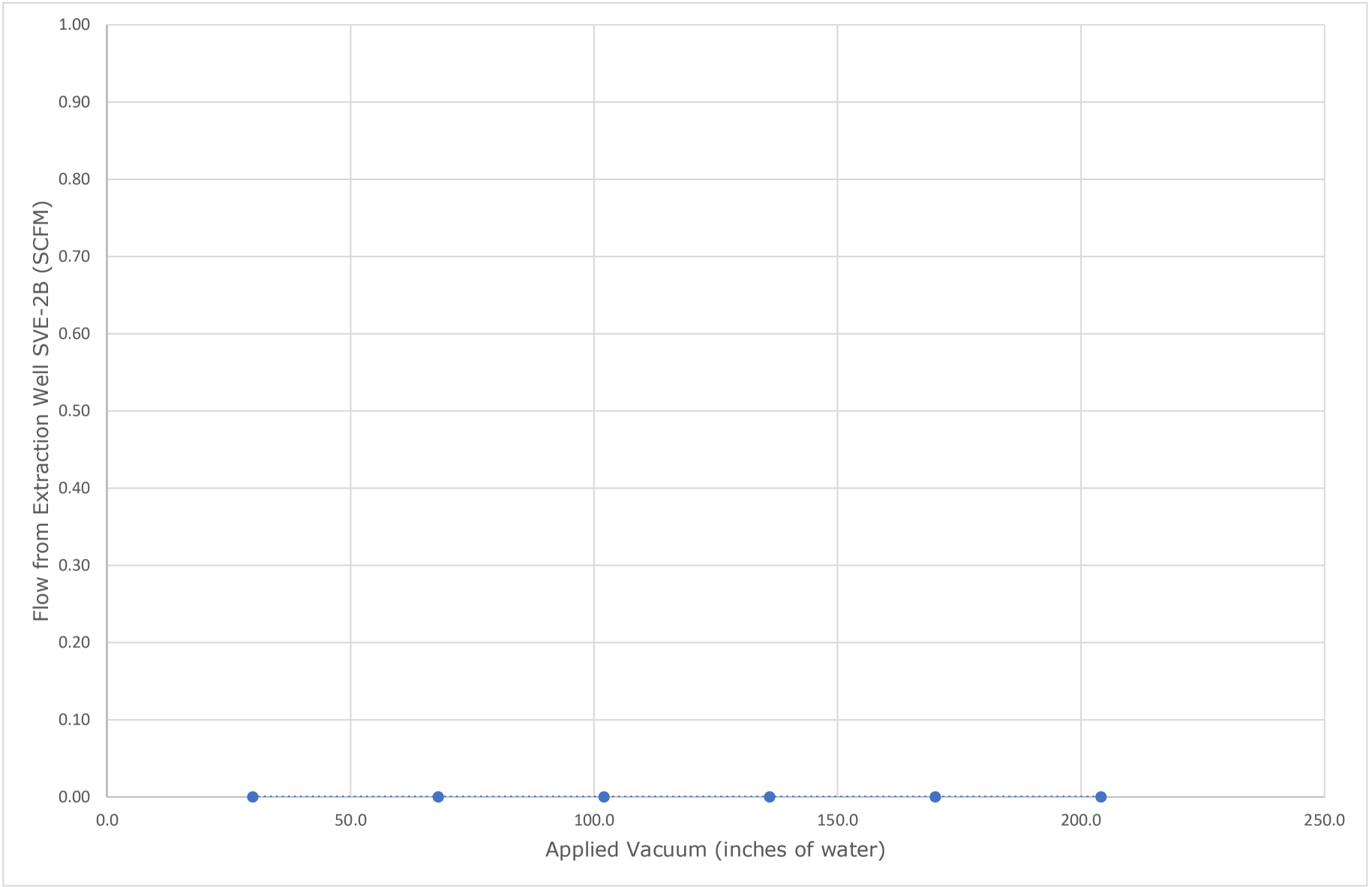
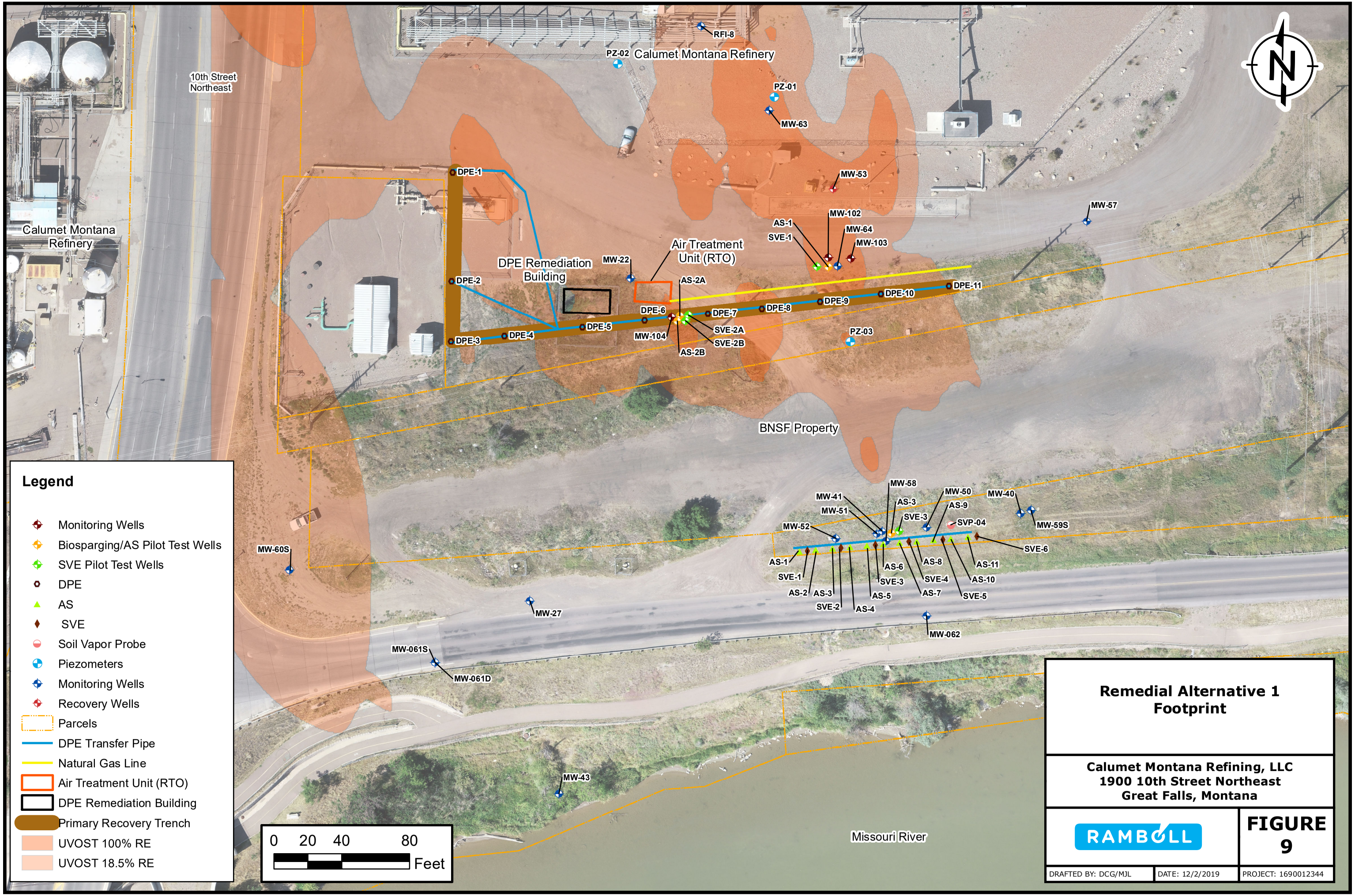


Figure 8 - SVE-3 Step-Rate Test
Applied Vacuum-Flow Response Curve
MW-41 Pilot Test Area
CMR
Great Falls, Montana





Legend

- Monitoring Wells
- Biosparging/AS Pilot Test Wells
- SVE Pilot Test Wells
- DPE
- AS
- SVE
- Soil Vapor Probe
- Piezometers
- Monitoring Wells
- Recovery Wells
- Parcels
- DPE Transfer Pipe
- Natural Gas Line
- Air Treatment Unit (RTO)
- DPE Remediation Building
- Primary Recovery Trench
- UVOST 100% RE
- UVOST 18.5% RE

Remedial Alternative 1 Footprint

Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 9

DRAFTED BY: DCG/MJL | DATE: 12/2/2019 | PROJECT: 1690012344

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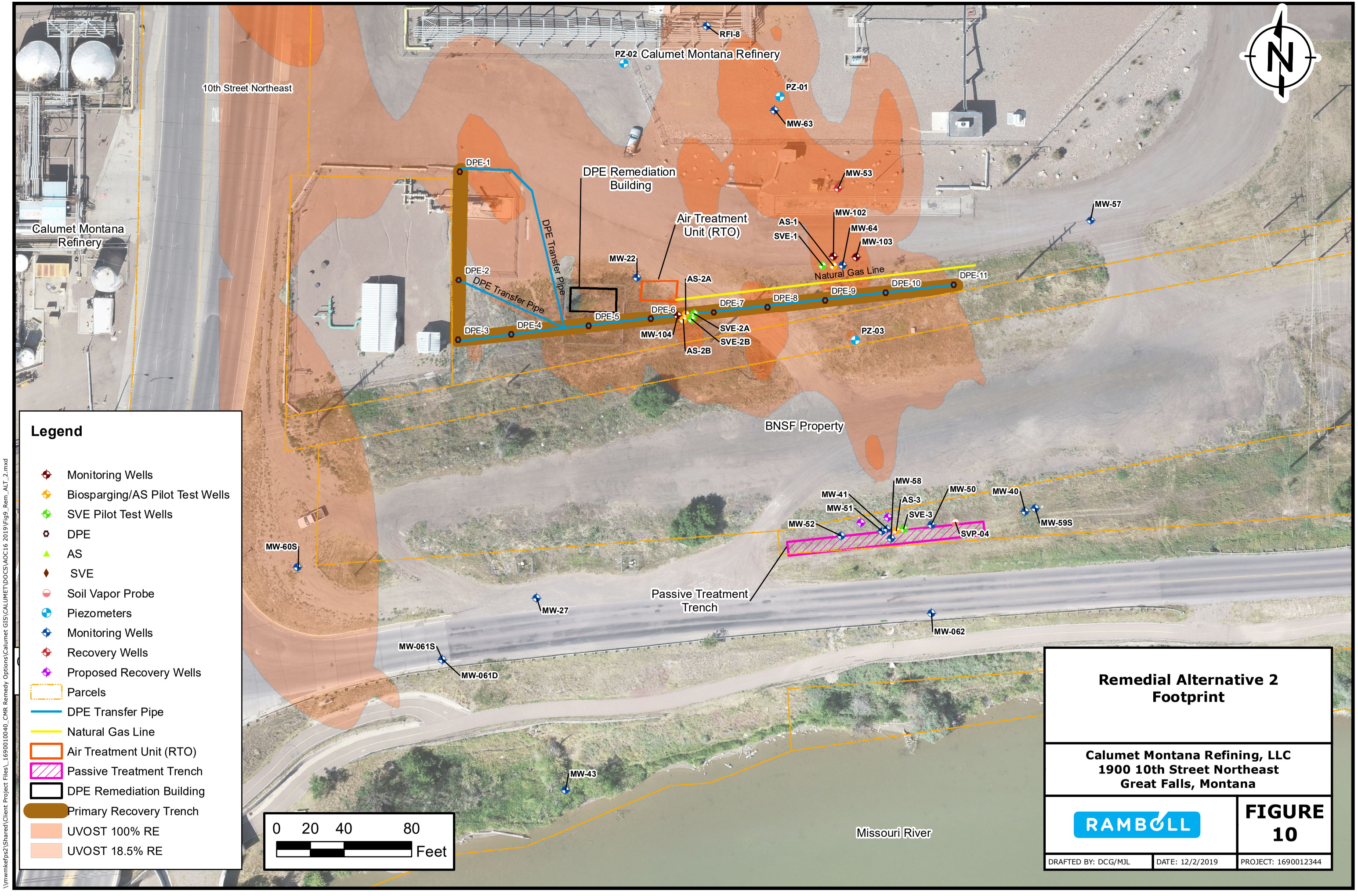


Remedial Alternative 2 Footprint

Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 10

DRAFTED BY: DCG/MJL | DATE: 12/2/2019 | PROJECT: 1690012344

\\nwmkefps2\Shared\Client Project Files_1690010040_CMR Remedy Options\Calumet GIS\CALUMET\DOCS\AOC16 2019\Fig9_Rem_ALT_2.mxd

TABLES

Table 1 - AOC-16 Pilot Test Well Construction Details and Horizontal Distance From Test Well

AOC-16
Calumet Montana Refining
Great Falls, Montana

Pilot Test Area Description	Well	Well Diameter (inches)	Depth To Bottom of Screen (feet bgs)	Length of Screen (feet)	Distance from Test Point (feet)
MW-64: Native Material	SVE-1	3	6	2	--
MW-64: Native Material	MW-102	2	14	10	9
MW-64: Native Material	MW-103	2	14	10	16
MW-64: Native Material	AS-1	2	11	2	5
MW-64: Native Material	MW-64	4	14	10	10
MW-22: PRT	SVE-2B	3	5	2	--
MW-22: PRT	MW-104	2	9	5	12
MW-22: PRT	AS-2A	2	9	2	4
MW-22: PRT	AS-2B	2	8.5	2	5
MW-22: PRT	SVE-2A	3	6	2	2
MW-22: PRT	MW-22	2	14	9	41
MW-41: Native Material	SVE-3	3	6	2	--
MW-41: Native Material	AS-3	2	10	2	5
MW-41: Native Material	MW-41	2	28	24	10
MW-41: Native Material	MW-51	6	8	4	8
MW-41: Native Material	MW-58	4	16	5	5

Notes:
bgs = below ground surface
MW = monitoring well
SVE = soil vapor extraction
AS = air sparging
PRT = Primary Recovery Trench

Table 2 - Geotechnical Analysis in AOC-16 Pilot Test Areas
AOC-16
Calumet Montana Refining
Great Falls, Montana

Pilot Test Area Description	Boring Location	Depth Interval (feet bgs)	Sieve Summary								Moisture Content (% Wt)	Dry Bulk Density (g/cm^3)	Total Porosity (%Vb)	TOC (mg/kg)	fOC (g/g)	Effective Perme-ability to Water (millidarcy)	Hydraulic Conductivity (cm/s)
					Sand Size												
			Grain Size Description	Gravel (%)	Very Coarse (%)	Coarse (%)	Medium (%)	Fine (%)	Very Fine (%)	Silt (%)	Clay (%)						
MW-22: PRT	AS-2B	5 - 7.5	Fine Grain Sand	0.0	0.81	3.91	36.10	27.14	13.59	13.90	4.55	18.1	1.74	34.4	10,700	0.0107	4.863	5.03E-06
MW-64: Native Material	AS-3	9 - 10	Very Fine Grain Sand	0.8	2.53	6.49	24.62	15.24	14.72	29.05	6.55	16.3	1.83	31.1	9,000	0.0090	1.0076	1.03E-06
MW-41: Native Material	MW-102	6 - 7	Silt	0	0	0	1.03	7.11	12.62	50.67	28.57	15.5	1.86	30	7,700	0.0077	<0.001	<10E-10

Notes:
bgs = below ground surface
% = percent
Wt = weight
g/cm3 = gram per cubic centimeter
Vb = bulk volume, cubic centimeter
TOC = total organic carbon
mg/kg = milligram per kilogram
fOC = fractional organic carbon
g/g = gram per gram
cm/s = centimeters per second

Table 3 - Microbial and Nutrient Analytical Results in MW-64 Pilot Test Area: Native Material

AOC-16

Calumet Montana Refining

Great Falls, Montana

Boring/Well Location	Media	Depth Interval (feet bgs)	Microbial	Nutrient			
			HDB Concentration	TOC[1]	Nitrate/Nitrite	Phosphorus	Nutrient Ratio
MW-102	Soil	10-12	505 cfu/g	9,000 mg/kg	1.3 mg/kg[2]	450 mg/kg	6923 : 1 : 346
MW-103	Soil	10-12	305 cfu/g	9,000 mg/kg	2.4 mg/kg[2]	410 mg/kg	3750 : 1 : 171
MW-103	Groundwater	--	255,000 cfu/mL	--	<0.020 mg/L	0.15 mg/L	--

Notes:

HDB concentrations greater than 1,000 cfu in soil and groundwater indicate optimal biosparging conditions.

Ideal nutrient ratios for biosparging are 100:10:1 to 100:1:0.5 (TOC:Nitrate/Nitrite:Phosphorus).

bgs = below ground surface

HDB = hydrocarbon-degrading bacteria

TOC = total organic carbon

cfu = colony forming units

g = gram

kg = kilogram

mg = milligram

mL = milliliter

[1] TOC values from the soil analytical data collected at MW-102.

[2] Nitrate/nitrite in soils is reported as soluable.

Table 4 - AS-1 Step-Rate Test
Performance Data
MW-64 Native Material Pilot Test Area
AOC-16
CMR
Great Falls, Montana

AS-1 Flow Rate (SCFM)	AS-1 Applied Pressure (PSI)	Measured Pressure (in-H2O)	
		MW-102	MW-103
		5 ft[(1)]	11 ft[(1)]
5	4	--	--
10	5	7	5
15	4	>10	6

Notes:
SCFM - standard cubic feet per minute
PSI - pound per square-inch
in-H2O - inches of water
ft - feet
[(1)] Distance from AS-1

Table 5 - SVE-1 Step-Rate Test Results
MW-64 Native Matieral Pilot Test Area
Performance Data
CMR
Great Falls, Montana

	Date and Time	SVE-1 Observed Vacuum (in-Hg)	SVE-1 Observed Vacuum (in-H_2O)	Temperature (degrees Fahrenheit)	Differential Pressure (in-H_2O)	Calculated Flow Rate (SCFM)
Step 1	10/24/2019 10:30	2.5	34.0	50	0.010	5.4
Step 2	10/24/2019 10:31	5.0	68.0	50	0.012	5.6
Step 3	10/24/2019 10:33	7.5	102.1	50	0.015	6.0
Step 4	10/24/2019 10:35	10.0	136.1	50	0.020	6.5
Step 5	10/24/2019 10:37	13.5	183.7	50	0.027	6.9
Step 6	10/24/2019 10:38	15.0	204.1	50	0.027	6.5
Step 7	10/24/2019 10:40	17.5	238.2	50	0.036	6.9

Notes

in-H_2O = inches of water

SCFM = standard cubic feet per minute

Table 6 - SVE-1 Constant-Rate Test
Performance Data
MW-64 Native Material Pilot Test Area
CMR
Great Falls, Montana

	Distance (Feet)	Vacuum Observations (inches of H2O)						
		10/24/19 12:16	10/24/19 12:20	10/24/19 12:30	10/24/19 12:35	10/24/19 12:40	10/24/19 14:00	10/24/19 14:30
AS-1	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MW-64	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MW-102	9	1.86	2.99	3.58	3.90	3.87	2.90	3.00
MW-103	16	0.42	1.16	1.73	1.83	1.85	1.15	1.20

Notes: H2O = water

Table 7 - AS-2B Step-Rate Test
Performance Data
MW-22 PRT Pilot Test Area
CMR
Great Falls, Montana

AS-2B Flow Rate (SCFM)	AS-2B Applied Pressure (PSI)	Measured Pressure (in-H2O)	
		MW-104	SVE-2B
		4 ft[(1)]	5 ft[(1)]
5	3	--	--
10	5	--	--
12.5	6	--	--
15	8	9.1	--
20	9	>10	2.9

Notes:
SCFM = standard cubic feet per minute
PSI = pounds per square-inch
in-H2O = inches of water
ft - feet
[(1)] Distance from AS-2B

Table 8 - SVE-2B Step-Rate Test Results
Performance Data
MW-22 PRT Pilot Test Area
CMR
Great Falls, Montana

	Date and Time	SVE-2B Observed Vacuum (in-Hg)	SVE-2B Observed Vacuum (in-H_2O)	Temperature (degrees Fahrenheit)	Differential Pressure (in-H_2O)	Calculated Flow Rate (SCFM)
Step 1	10/23/2019 13:35	2.5	34.0	45	0.044	11.8
Step 2	10/23/2019 13:33	5.0	68.0	45	0.065	13.9
Step 3	10/23/2019 13:40	7.5	102.1	45	0.115	17.5
Step 4	10/23/2019 13:45	10.0	136.1	45	0.190	21.3
Step 5	10/23/2019 13:50	12.5	170.1	45	0.291	23.6
Step 6	10/23/2019 13:55	15	204.1	45	0.36	24.3
Step 7	10/23/2019 14:00	17.5	238.2	45	0.58	28.3

Notes

in-H_2O = inches of water

SCFM = standard cubic feet per minute

Table 9 - AS Step-Rate Test
Performance Data
MW-41 Pilot Test Area
CMR
Great Falls, Montana

	Flow Rate (SCFM)	Applied Pressure (PSI)
AS-3	0	13
MW-41	10	3
	15	8
	20	9
MW-58	0	13

Notes:
SCFM = standard cubic feet per minute
PSI = pounds per square-inch

Table 10 - SVE-3 Step-Rate Test
Performance Data
MW-41 Pilot Test Area
CMR
Great Falls, Montana

	Date and Time	SVE-3 Observed Vacuum (in-Hg)	SVE-3 Observed Vacuum (in-H_2O)	Temperature (degrees Fahrenheit)	Differential Pressure (in-H_2O)	Calculated Flow Rate (SCFM)
Step 1	10/22/2019 14:35	2.2	29.9	60	0.00	0.00
Step 2	10/22/2019 14:40	5.0	68.0	60	0.00	0.00
Step 3	10/22/2019 14:45	7.5	102.1	60	0.00	0.00
Step 4	10/22/2019 14:50	10.0	136.1	60	0.00	0.00
Step 5	10/22/2019 14:55	12.5	170.1	60	0.00	0.00
Step 6	10/22/2019 15:00	15	204.1	60	0.00	0.00
Step 7	10/22/2019 15:05	17.5	238.2	60	0.05	9.82
Step 8	10/22/2019 15:10	20	272.2	60	0.08	11.5

Notes

in-H_2O = inches of water

SCFM = standard cubic feet per minute

Table 11 - Summary of VOC Vapor Analytical Results
AOC-16 Pilot Test
CMR
Great Falls, Montana

	Effluent Vapor Sample Date and Time	Name	Vapor Flow Rate (SCFM)	Acetone	Benzene	Benzyl Chloride	Bromo-dichloro-methane	Bromoform	Bromo-methane	1,3-Butadiene	2-Butanone (MEK)	Carbon Disulfide	Carbon Tetra-chloride	Chloro-benzene	Chloro-ethane
SVE	6/28/2018 8:45	SVE-1 20191024	6.5	25,900 U	**46,100**	28,300 U	14,600 U	56,400 U	8,480 U	4,840 U	32,300 U	6,810 U	13,800 U	10,100 U	5,760 U
	6/28/2018 10:05	SVE-2B 20191023	24.3	27,000 U	**481,000**	29,500 U	15,200 U	58,900 U	8,850 U	5,050 U	33,600 U	7,100 U	14,400 U	10,500 U	6010.0 U

				Chloroform	Chloro-methane	Cyclo-hexane	Dibromo-chloro-methane	1,2-Dibromo-ethane (EDB)	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	Dichloro-difluoro-methane	1,1-Dichloro-ethane	1,2-Dichloro-ethane	1,1-Dichloro-ethene
SVE	6/28/2018 8:45	SVE-1 20191024	6.5	5,300 U	4,520 U	**285,000**	18,600 U	8,400 U	13,100 U	13,100 U	32,900 U	10,900 U	8,850 U	4,420 U	8,670 U
	6/28/2018 10:05	SVE-2B 20191023	24.3	5,560 U	4,710 U	**2,920,000 E**	19,400 U	8,760 U	13,700 U	13,700 U	34,300 U	11,300 U	9,230 U	4,610 U	9,230 U

				Cis-1,2-Dichloro-ethene	Trans-1,2-Dichloro-ethene	1,2-Dichloro-propane	Cis-1,3-Dichloro-propene	Trans-1,3-Dichloro-propene	Dichloro-tetrafluoro-ethane	Ethanol	Ethyl Acetate	Ethyl-benzene	4-Ethyl-toluene	n-Heptane	Hexachloro-1,3-butadiene
SVE	6/28/2018 8:45	SVE-1 20191024	6.5	8,670 U	8,670 U	10,100 U	9,920 U	9,920 U	15,300 U	20,600 U	7,880 U	9,490 U	26,900 U	**18,000**	58,300 U
	6/28/2018 10:05	SVE-2B 20191023	24.3	9,040 U	9,040 U	10,500 U	10,300 U	10,300 U	15,900 U	21,500 U	8,220 U	9,900 U	28,000 U	**195,000**	46,600 U

				n-Hexane	2-Hexanone	Methylene Chloride	4-Methyl-2-Pentanone (MIBK)	Methyl-Tert-Butyl Ether	Naphthalene	2-Propanol	Propylene	Styrene	1,1,2,2-Tetrachloro-ethane	Tetrachloro-ethene	Tetrahydro-furan
SVE	6/28/2018 8:45	SVE-1 20191024	6.5	**434,000**	44,700 U	38,000 U	44,700 U	39,400 U	28,600 U	26,900 U	3,760 U	9,310 U	7,500 U	7,410 U	6,450 U
	6/28/2018 10:05	SVE-2B 20191023	24.3	**4,120,000 E**	46,600 U	39,600 U	46,600 U	41,000 U	29,800 U	28,000 U	3,920 U	9,710 U	7,830 U	7,730 U	6,730 U

				Toluene	1,2,4-Trichloro-benzene	1,1,1-Trichloro-ethane	1,1,2-Trichloro-ethane	Trichloro-ethene	Trichloro-fluoro-methane	1,1,2-Trichloro-trifluoro-ethane	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Vinyl Acetate	Vinyl Chloride	m&p-Xylene
SVE	6/28/2018 8:45	SVE-1 20191024	6.5	**10,900**	81,100 U	11,900 U	5,990 U	5,870 U	12,300 U	16,800 U	10,700 U	10,700 U	7,700 U	2,800 U	19,000 U
	6/28/2018 10:05	SVE-2B 20191023	24.3	**23,400**	84,500 U	12,400 U	6,200 U	6,120 U	12,800 U	17,500.0 U	11,200 U	11,200.0 U	8,030 U	2,920 U	19,800 U

				o-Xylene	Total VOCs
SVE	6/28/2018 8:45	SVE-1 20191024	6.5	9,490 U	**794,000**
	6/28/2018 10:05	SVE-2B 20191023	24.3	9,900 U	**7,739,400**

Notes:
SCFM = standard cubic feet per minute.
U = indicates the compound was analyzed for, but not detected.
E = Analyte concentration exceeded the calibration range.
The result is estimated.
Bold indicates the compound was detected.

Table 12
VOC Mass Removal Rates and Quantities
AOC-16 Pilot Tests
CMR
Great Falls, Montana

	Sample Date and Time	Run Hours (Hours)	Influent Flow Rate (SCFM)	Compound	Benzene	Cyclo-hexane	n-Heptane	n-Hexane	Toluene	Total VOCs
SVE-1 20191024	10/24/2019 14:25	2.17	6.5	Vapor Concentration (µg/m^3)	**46,100**	**285,000**	**18,000**	**434,000**	**10,900**	**794,000** µg/m^3
				Mass Loading (lbs/day)	0.0269	0.1665	0.0105	0.2536	0.0064	0.4640 lbs/day
				Mass Removed (lbs)	0.0024	0.0150	0.0009	0.0229	0.0006	0.0419 lbs
SVE-2B 20191023	10/23/2019 14:20	1.08	24.3	Vapor Concentration (µg/m^3)	**481,000**	**2,920,000**	**195,000**	**4,120,000**	**23,400**	**7,739,400** µg/m^3
				Mass Loading (lbs/day)	1.0516	6.3839	0.4263	9.0075	0.0512	16.9205 lbs/day
				Mass Removed (lbs)	0.0475	0.2882	0.0192	0.4066	0.0023	0.7638 lbs
				Total Mass Removed (lbs)	**0.0499**	**0.3032**	**0.0202**	**0.4295**	**0.0029**	**0.8057 lbs**

Notes:
SCFM = standard cubic feet per minute
SVE = soil vapor extraction
µg/m^3 = micrograms per cubic meter
lbs = pounds
VOC = volatile organic compound

Table 13 - AOC-16 Summary of
Remedial Action Alternative Costs
CMR
Great Falls, Montana

	Alternative 1		Alternative 2	
	MW-22 PRT Area	MW-41 Area	MW-22 PRT Area	MW-41 Area
	Dual Phase Extraction	Air Sparge/Soil Vapor Extraction within Engineered Trench	Dual Phase Extraction	Product Recovery and Passive Treatment Trench Technology
Engineering: Design and Planning	$ 220,000	$ 80,000	$ 220,000	$ 100,000
Capital Costs	$ 1,209,000	$ 499,000	$ 1,209,000	$ 274,000
Annual OM&M Costs	$ 95,000	$ 64,000	$ 95,000	$ 25,000
Present Value Cost Range (-30%/+50%)	$1,517,000 to $3,251,000		$1,346,000 to $2,885,000	

Notes:
OM&M = operation, monitoring, and maintenance
PRT = Primary Recovery Trench

APPENDIX A
AOC-16 Pilot Test Boring Logs and Well Construction Diagrams

Trihydro CORPORATION

Lithology Log Sheet 1 of 2

LOCATION ID: MW-64

Project Name: AOC 16 Groundwater Investigation	Project Number: 477-018-002		Site ID: Calumet Refinery, Great Falls, MT
Drilling Company: Boland Environmental Drilling	Driller:	Ground Elevation:	Total Drilled Depth: 14 feet-bgs
Drilling Equipment: CME Truck Mounted Rotary rig	Drilling Method: Hollow Stem Auger	Borehole Diameter: 10"	Date/Time Drilling Started: 3-Apr-17	Date/Time Total Depth Reached: 3-Apr-17
Type of Sampling Device: Split-Spoon		Water Level (bgs): First 7 feet-bgs	Final
Sample Hammer: 140 lbs; Type: Safety hammer; Driving Weight; Drop = 30"		Geologist: W. Coles	Checked by/Date
Location Description (include sketch in field logbook)			

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0				Brown, fine to coarse grained SAND and Gravel, damp, no odor.							
3				Black, silty, clayey fine to coarse grained SAND, moist, hydrocarbon odor.							
6				Gray, fine to coarse grained SAND, wet, strong hydrocarbon odor.							
10											

Trihydro CORPORATION

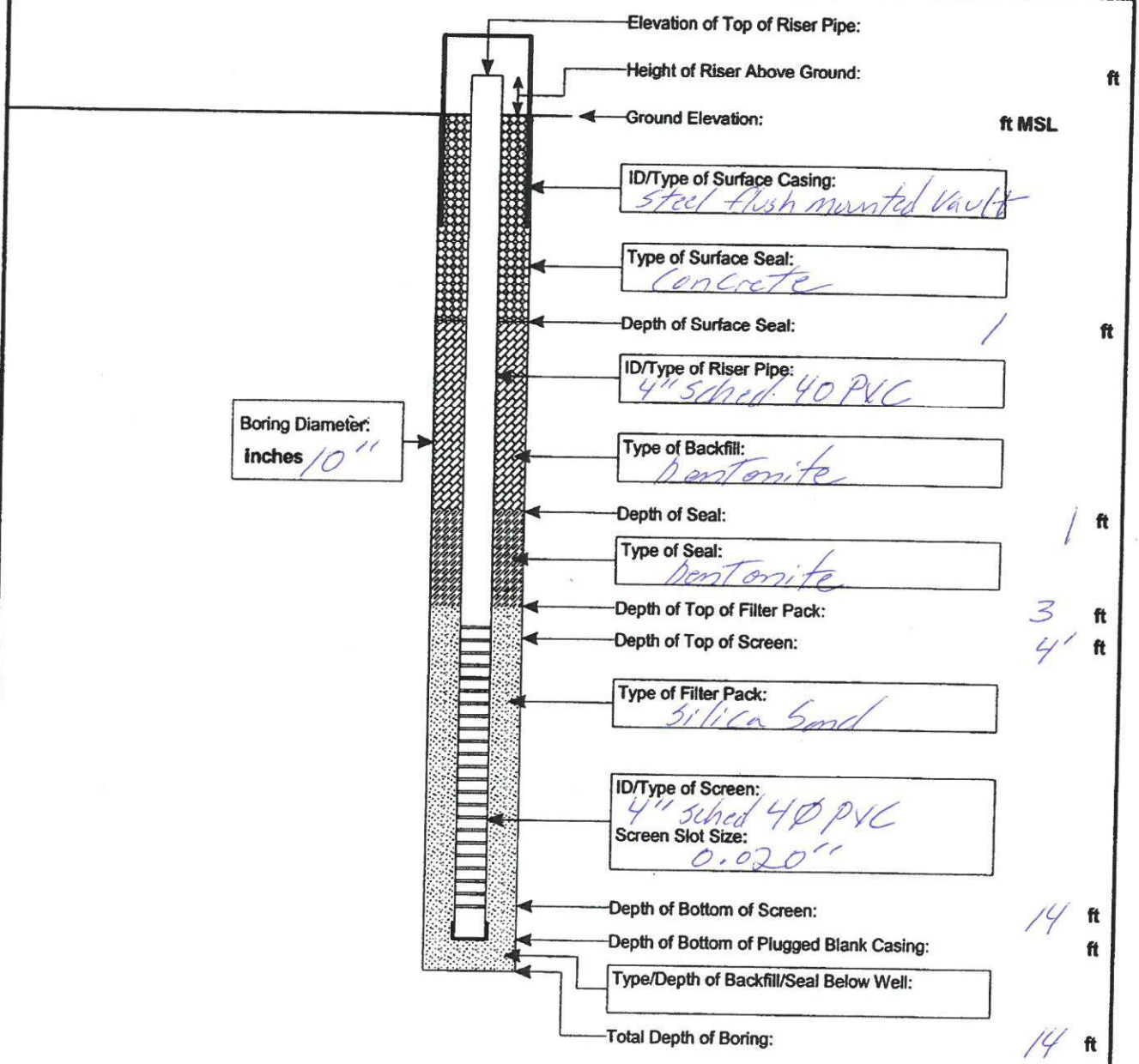
Lithology Log (continued) Sheet 2 of 2

LOCATION ID: MW-64

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
10				Same as above.							
11											
12											
13				TD @ 14' bgs							
14				Well installed @ 14' bgs							
15											
16											
17											
18											
19											
20											
21											
22											
23											

Project: AOC 16, Interim Measures Project Location: Great Falls, MT Project Number: 477-018-002	**MONITORING WELL CONSTRUCTION LOG FOR MW-64**

Well Location MW-64		Date(s) Installed 4-3-17	Time
Installed By Boland Drilling	Observed By W. Coles	Total Depth 14'	
Method of Installation Hollow Stem Auger			
Screened Interval 4'-14'	Completion Zone		
Remarks			



NOTE: DIAGRAM IS NOT TO SCALE

Trihydro CORPORATION

Report: ENV_WELL_CONSTR_ABOVE_GROUND; File: DUMMY.GPJ; 11/2/2001 1

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

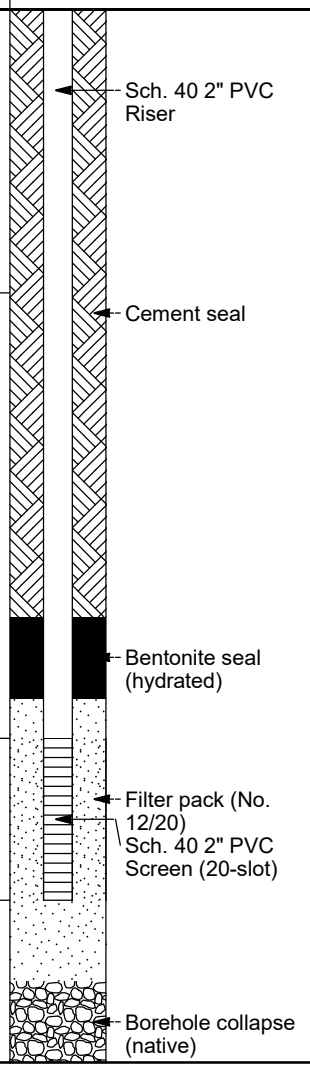
WELL ID: **AS-1**
BORING NUMBER: **AS-1**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/18/19 **COMPLETED** 10/18/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 11 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 13 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 13 ft bgs **SCREEN INTERVAL** 9 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
						SAND AND GRAVEL FILL, yellowish brown (10YR 6/4), fine to medium sand, subrounded to subangular gravel, loose, moist.
2.5		0.4				
						3.5
						(SP) **SAND**, dark grayish brown (10YR 4/2) to very dark gray (10YR 3/1), very fine to fine sand, trace silt, trace rootlets, medium dense to dense, slightly moist, hydrocarbon staining intermixed with dark grayish brown sand, slight hydrocarbon odor.
5.0	7	280.4				
7.5						
						SAME AS ABOVE, weakly to moderately laminated with thin clay-rich layers.
						9.0
		1269				(SW) **SAND**, very dark gray (10YR 3/1), very fine to fine sand, trace medium sand, loose, moist to very moist, strong hydrocarbon staining, strong hydrocarbon odor.
10.0						**SAME AS ABOVE**, trace to little gravel, subrounded to subangular, moist to very moist.
						11.0
		488.5				(SP) **VERY FINE TO FINE SAND WITH SILT**, gray (10YR 6/1) with trace yellow mottling, trace gravel, weakly laminated, dense, slightly moist.
	3					**SAME AS ABOVE**, dry.
12.5		11.9				
						13.0

Bottom of borehole at 13.0 feet.

WELL CONSTRUCTION



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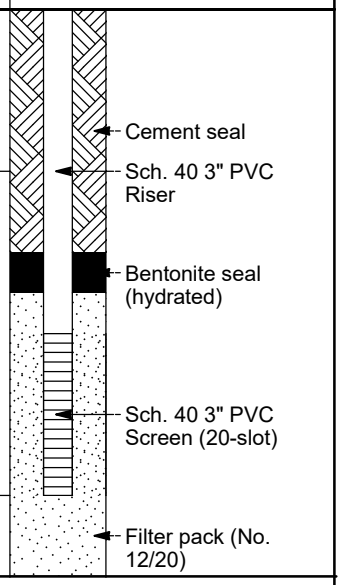
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **SVE-1**
BORING NUMBER: **SVE-1**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/18/19 **COMPLETED** 10/18/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 6 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 7 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 7 ft bgs **SCREEN INTERVAL** 4 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
		2.4				**SAND AND GRAVEL**, yellowish brown (10YR 6/4), fine to medium sand, subrounded to subangular gravel, loose, moist, no odor.
						2.0
2.5						(SP) **SAND**, very dark gray (10YR 3/1), fine sand, trace gravel, trace rootlets, medium dense to dense, slightly moist, hydrocarbon staining, slight to moderate hydrocarbon odor.
	5.5	329.7				
						(SP) **SAME AS ABOVE**, very dark gray (10YR 3/1) to grayish brown (10YR 6/2), hydrocarbon staining appears in dense pockets from 4 to 6 ft bgs.
5.0		302.9				
						6.0
						BLIND DRILLED.
						7.0



Bottom of borehole at 7.0 feet.

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

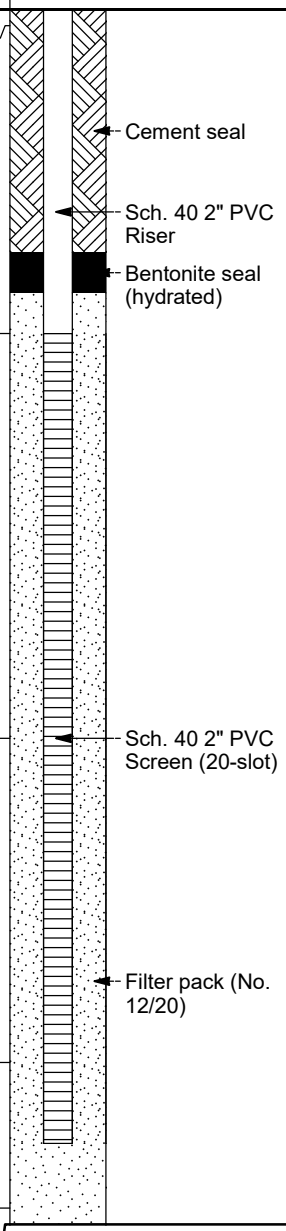
WELL ID: **MW-102**
BORING NUMBER: **MW-102**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/18/19 **COMPLETED** 10/18/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 14 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 15 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 15 ft bgs **SCREEN INTERVAL** 4 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
		1.9				0.2 **ASPHALT**. **SAND AND GRAVEL FILL**, yellowish brown (10YR 6/4), fine to medium sand, medium dense, moist.
2.5						
						4.0 (SP) **SAND**, weak red (2.5YR 5/2), very fine to fine sand, trace to some fines, weakly laminated with very dark gray (10YR 3/1) sand, medium dense to dense, slightly moist, slight hydrocarbon odor.
5.0	5	306.6				
7.5						
		216.5	CMR-SB102-9.0-10-191019			9.0 (SW) **SAND**, dark grayish brown (10YR 4/2), fine sand, trace reddish clay inclusions (2-3 cm diameter), trace gravel, loose to medium dense, very moist, strong hydrocarbon odor.
10.0						
		869.1				**SAND**, gravel increases with depth from 12 to 13 ft bgs.
12.5	5					13.0 (SP) **VERY FINE TO FINE SAND WITH SILT**, gray (10YR 6/1) with trace yellow mottling, weakly to moderately laminated, hard, dry.
		173.5				14.8
15.0						15.0 (ML) **SILT**, dusky red (10R 3/3), some very fine to fine sand, medium stiff, moist.

Bottom of borehole at 15.0 feet.

WELL CONSTRUCTION



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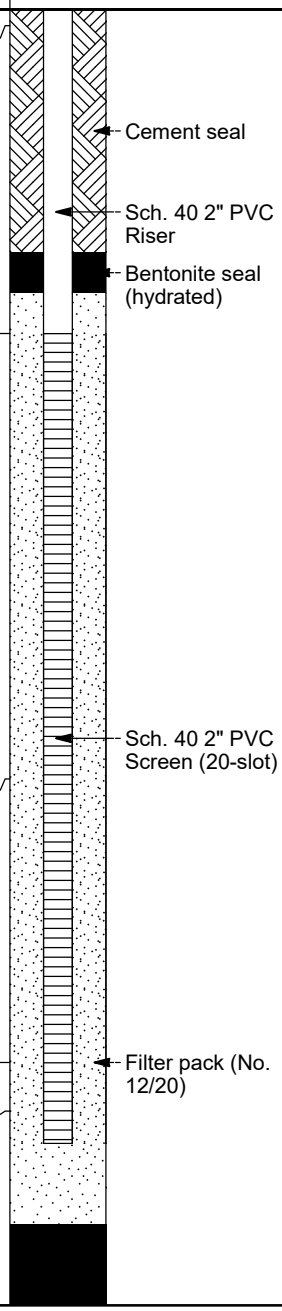
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **MW-103**
BORING NUMBER: **MW-103**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/18/19 **COMPLETED** 10/18/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 14 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 29 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 29 ft bgs **SCREEN INTERVAL** 4 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						0.2 **ASPHALT**.
		0				**SAND AND GRAVEL FILL**, dark yellowish brown (10YR 4/4), fine to medium sand, subrounded to subangular gravel, loose, moist.
2.5						
		10.5				4.0 (SP) **SAND**, very dark gray (10YR 3/1), very fine to fine sand, little fines, trace rootlets, medium dense, moist, strong hydrocarbon staining, moderate hydrocarbon odor.
5.0	7					**SAME AS ABOVE**, dark grayish brown (10YR 4/2) from 4.75 to 9.0 ft bgs, hydrocarbon staining intermixed with brown sand.
		111.7				
7.5						
		133				9.5 **SAME AS ABOVE**, very dark gray (10YR 3/1) from 9.0 to 9.5 ft bgs, strong hydrocarbon staining.
10.0						(SP) **SAND**, dark grayish brown (10YR 4/2), fine sand, trace gravel, loose to medium dense, very moist, strong hydrocarbon staining from 9.5 to 11 ft bgs, strong hydrocarbon odor.
12.5	8					**SAME AS ABOVE**, gravel increases with depth from 12 to 13 ft bgs.
		192				13.0 **SANDSTONE**, gray (10YR 5/1), very fine to medium sand, thinnly bedded, some iron oxide weathering on bedding surfaces, hard, dry.
						13.6 (SP) **VERY FINE TO FINE SAND WITH SILT**, gray (10YR 6/1) with trace yellow mottling, moderately laminated, medium dense to dense, slightly moist.
15.0						
		144.5				16.0

WELL CONSTRUCTION



RAMBOLL BASIC SB & WELL LOG - GINT STD US LAB.GDT - 11/1/19 14:33 - C:\USERS\KCARSON\DESKTOP\CMR_AOC16 PILOT STUDY.GPJ

(Continued Next Page)

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID:**MW-103**
BORING NUMBER:**MW-103**

CLIENT Calumet Montana Refining, LLC **PROJECT NAME** AOC-16 Pilot Study
PROJECT NUMBER **PROJECT LOCATION** Great Falls, Montana

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION	WELL CONSTRUCTION
17.5	8	131.8				(ML) **SILT**, dusky red (10R 3/3), some very fine to fine sand, some gray (10YR 6/1) sand inclusions (5 to 12 cm diameter), medium stiff, dry, no odor.	
20.0	2					**SAME AS ABOVE**, dusky red (10YR 3/2), no sand inclusions, non to very weakly laminated, increasing very fine to fine sand with depth.	
22.5	5	7.6					
25.0		47.5					
27.5	4	48.5					
						21.0	
						(SP) **VERY DENSE SAND**, weak red (10R 5/3), very fine to fine sand, hard, dry, no odor.	Bentonite seal (hydrated)
						24.0	
						(SP) **VERY FINE TO FINE SAND WITH SILT**, weak red (10R 5/3) with trace yellow mottling, trace clay, weakly to moderately laminated, hard, dry, no odor.	
						29.0	

Bottom of borehole at 29.0 feet.

MONTANA REFINING COMPANY
GROUNDWATER WELL INSTALLATION REPORT

DWG No. 66-A-205W MRC Well No. MW-22 State Well No. _____
Project RFI Location SOUTH LOADING RACK
Project No. _____ Installed By R. HAHN Date 10/8/99 Time 8:00
Easting 430.93 Northing -405.43 Zone 12 Elevation 3328.45
SECTION 1 TOWNSHIP 20 N RANGE 3 E
Method of Installation B-59 AUGER

LOG OF BORING AND WELL

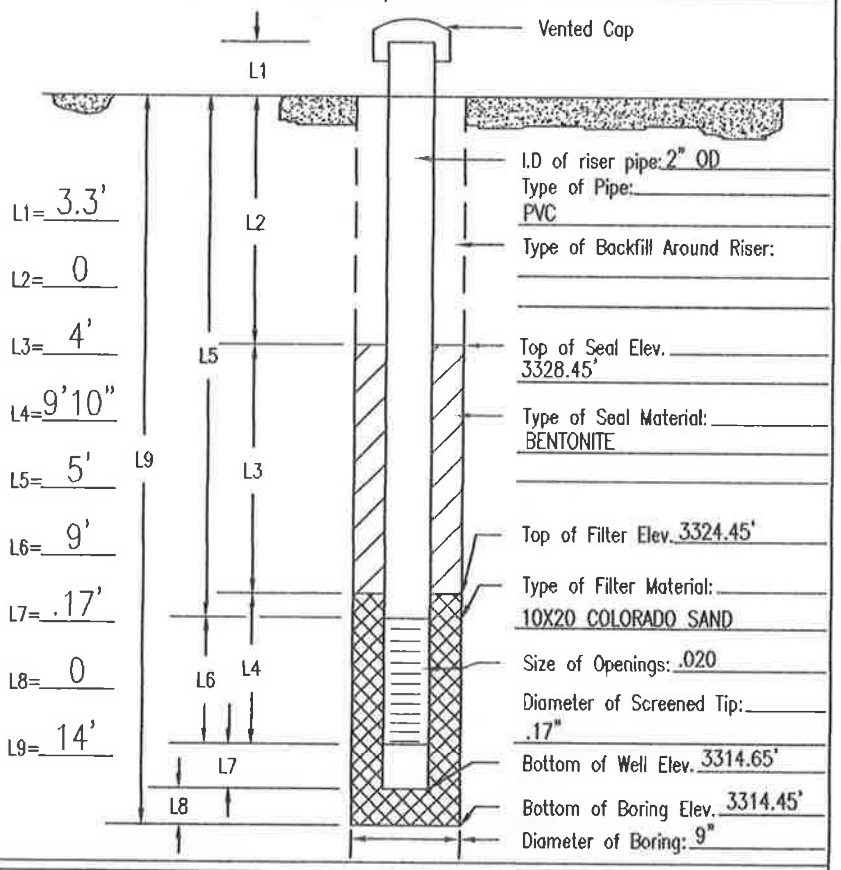
BORING

Depth in ft.	Graphic Log	Description	H-Nu Reading
		TOPSOIL, SILTY CLAY	
2.5'		CL, LEAN CLAY, DRY, STIFF, BROWN, 10YR 4/3, ODOR 2.2'-4.2'	
5.0'		SP, POORLY, GRADED SAND, MOIST, LOOSE, 10YR 4/3, 5.3-6.3' 6.3'-7.3' GLEY1 3/10Y, ODOR, STAINING	
7.5'		SP, POORLY GRADED SAND, MOIST, LOOSE, OLIVE GREY, ODOR, 7.5'-9.5'	
10'		CL, LEAN CLAY, DRY, STIFF, GRAY, 12.4'-14.4'	
12.5'			

OBSERVATION WELL INFORMATION

Type of Well: MONITORING WELL

Ground Elev. 3328.45' Top of Riser Elev. 3331.75'



L1= 3.3'
L2= 0
L3= 4'
L4= 9'10"
L5= 5'
L6= 9'
L7= .17'
L8= 0
L9= 14'

I.D of riser pipe: 2" OD
Type of Pipe: PVC
Type of Backfill Around Riser:
Top of Seal Elev. 3328.45'
Type of Seal Material: BENTONITE
Top of Filter Elev. 3324.45'
Type of Filter Material: 10X20 COLORADO SAND
Size of Openings: .020
Diameter of Screened Tip: .17"
Bottom of Well Elev. 3314.65'
Bottom of Boring Elev. 3314.45'
Diameter of Boring: 9"

Remarks:
COORDINATES=REFINERY GRID

Prepared By: R. HAHN
Logged By: D. FISHBAUGH
DRILLER: MW #043
Drilling Company: O'KEFFE ENVIRONMENTAL DRILLING

MONTANA REFINING COMPANY
GROUNDWATER WELL INSTALLATION REPORT

DWG No. 66-A-205.1W MRC Well No. MW-22 State Well No. _____
Project RFI Location SOUTH LOADING RACK
Project No. _____ Installed By R. HAHN Date 10/8/99 Time 8:00
Easting 430.93 Northing -405.43 Zone 12 Elevation 3328.45
SECTION 1 TOWNSHIP 20 N RANGE 3 E
Method of Installation B-59 AUGER

LOG OF BORING AND WELL

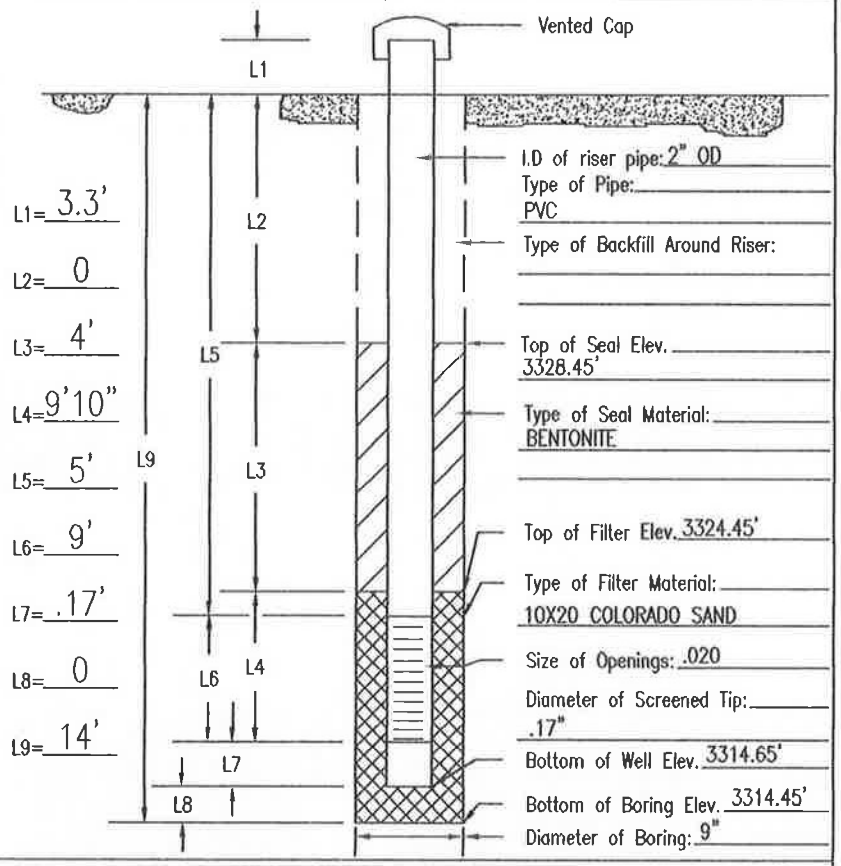
BORING

Depth in ft.	Graphic Log	Description	H-Nu Reading
		CL, LEAN CLAY, DRY, STIFF, GRAY	
15'		BEDROCK, RED SHALE, DRY, BEDROCK 13.8' T.D.=14'	

OBSERVATION WELL INFORMATION

Type of Well: MONITORING WELL

Ground Elev. 3328.45' Top of Riser Elev. 3331.75'



Remarks:
COORDINATES=REFINERY GRID

Prepared By: R. HAHN
Logged By: D. FISHBAUGH
DRILLER: MW #043
Drilling Company: O'KEFFE ENVIRONMENTAL DRILLING

C:\DWG\RFI\WELLS\66-A-205A.dwg Thu Jan 20 11:11:15 2000

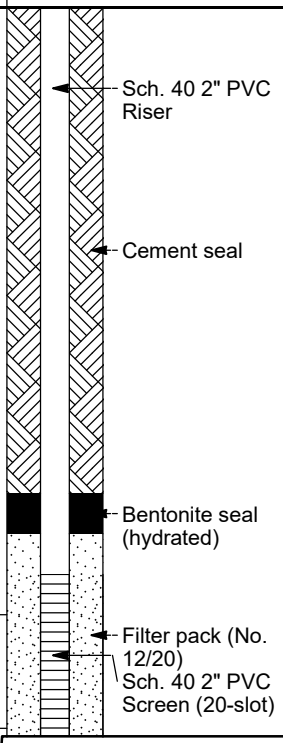
Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **AS-2a**
BORING NUMBER: **AS-2a**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/19/19 **COMPLETED** 10/19/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 9 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 9 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 9 ft bgs **SCREEN INTERVAL** 7 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0	7	18.3				(SP) **SAND**, dark yellowish brown (10YR 4/4), fine sand with trace medium sand, trace fines, trace rootlets, loose, slightly moist to moist.
2.5		10.9				**SAME AS ABOVE**, slightly moist from 3 to 5 ft bgs.
5.0		982.1				**SAME AS ABOVE**, medium dense to dense, slightly moist from 5 to 6 ft bgs.
7.5		749.7			7.5	**SAME AS ABOVE**, very dark grayish brown (10YR 3/2) to yellowish brown (10YR 6/4), trace white precipitate, medium dense to dense, slightly moist to moist, hydrocarbon staining intermixed with yellowish brown sand, slight hydrocarbon odor.
		371.2			8.9	(SW) **SAND**, dark gray (10YR 4/1), unconsolidated fill, loose, very moist to wet, strong hydrocarbon staining, strong hydrocarbon odor.
					9.0	(SP) **VERY FINE TO FINE SAND WITH SILT**, gray (5Y 6/1) with trace yellow mottling, weakly laminated, medium dense, slightly moist to moist.

Bottom of borehole at 9.0 feet.



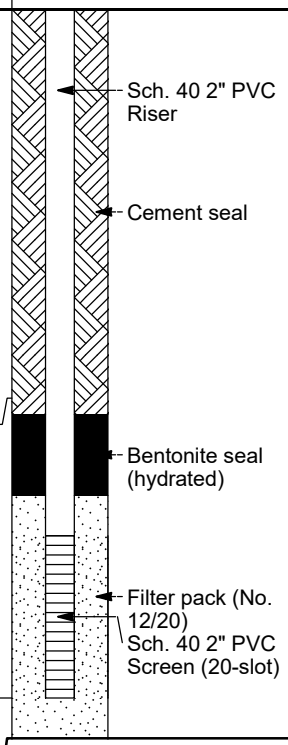
Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **AS-2b**
BORING NUMBER: **AS-2b**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/19/19 **COMPLETED** 10/19/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 8.5 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 9 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 9 ft bgs **SCREEN INTERVAL** 6.5 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
	5	14.6				(SP) **SAND**, dark brown (10YR 3/3), fine sand with trace medium sand, trace fines, trace rootlets, loose, slightly moist to moist.
2.5						**SAME AS ABOVE**, dark yellowish brown (10YR 4/4) from 2.5 to 4.2 ft bgs.
		410.2				**SAME AS ABOVE**, very dark grayish brown (10YR 3/2) to yellowish brown (10YR 6/4), moderate hydrocarbon staining, moderate hydrocarbon odor.
4.8						
5.0	4	1069	CMR-AS2b-5.0-7.5-191019			(SW) **SAND**, black (10YR 2/1), unconsolidated fill, fine to medium sand, moist, strong hydrocarbon staining, strong hydrocarbon odor.
7.5						
8.5						
9.0						(SP) **VERY FINE TO FINE SAND WITH SILT**, gray (5Y 6/1) with trace yellow mottling, weakly laminated, medium dense, slightly moist to moist.

Bottom of borehole at 9.0 feet.



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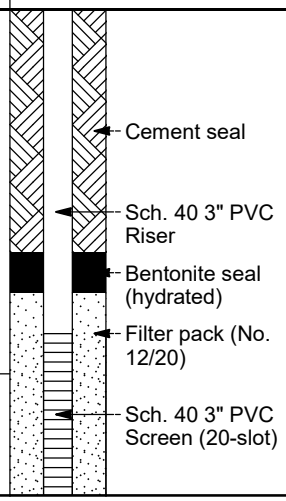
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **SVE-2a**
BORING NUMBER: **SVE-2a**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/19/19 **COMPLETED** 10/19/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 6 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 6 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 6 ft bgs **SCREEN INTERVAL** 4 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
	5	25.9				(SP) **SAND**, dark yellowish brown (10YR 4/4), trace fines, loose to medium dense, dry to slightly moist, no odor.
2.5		43.3				
4.5						
5.0	1	1192				(SW) **SAND**, very dark gray (10YR 3/1), unconsolidated fill, loose, slightly moist to moist, hydrocarbon staining, strong hydrocarbon odor.
6.0						

WELL CONSTRUCTION



Bottom of borehole at 6.0 feet.

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **SVE-2b**
BORING NUMBER: **SVE-2b**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/20/19 **COMPLETED** 10/20/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 4.75 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 5 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 5 ft bgs **SCREEN INTERVAL** 2.75 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
		109.9				(SP) **SAND**, dark yellowish brown (10YR 4/4), fine sand, trace fines, loose to medium dense, dry to slightly moist, no odor.
2.5	5					
		936.4				**SAME AS ABOVE**, medium dense to dense, little fines from 3.6 to 4.6 ft bgs.
		1046				**SAME AS ABOVE**, hydrocarbon staining begins at 3.9 ft bgs, increases with depth, hydrocarbon odor.
5.0						(SW) **SAND**, very dark gray (10YR 3/1), unconsolidated fill, fine to medium sand, moist, strong hydrocarbon staining, strong hydrocarbon odor.

4.6
5.0

Bottom of borehole at 5.0 feet.

WELL CONSTRUCTION

- Cement seal
- Sch. 40 3" PVC Riser
- Dry cement seal
- Filter pack (No. 12/20)
- Sch. 40 3" PVC Screen (20-slot)

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **MW-104**
BORING NUMBER: **MW-104**

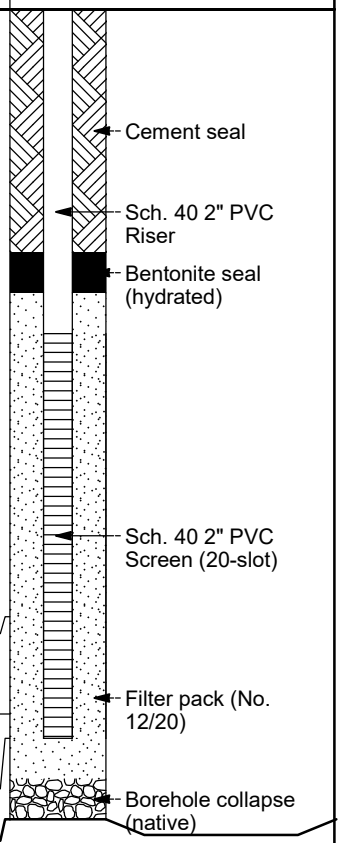
CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/19/19 **COMPLETED** 10/19/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 9 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 10 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 10 ft bgs **SCREEN INTERVAL** 4 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
		5.4				(SP) **SAND**, dark yellowish brown (10YR 4/4), mostly fine to trace medium sand, trace fines, trace rootlets from 0 to 1 ft bgs, loose, moist.
2.5						
		5				
	7					**SAME AS ABOVE**, pale brown (10YR 6/3), dry.
5.0						
		312.8				**SAME AS ABOVE**, very dark grayish brown (10YR 3/2), trace rootlets, white precipitate from 5.5 to 6.5 ft bgs, very dense, dry.
7.5						**SAME AS ABOVE**, very dark grayish brown (10YR 3/2) to light yellowish brown (10YR 6/4), little fines, loose to medium dense, moist, hydocarbon staining intermixed with light yellowish brown sand from 6.5 to 7.5 ft bgs.
		946				(SW) **SAND**, dark gray (10YR 4/1), unconsolidated fill, fine to medium sand, very moist to wet, strong hydrocarbon staining, strong hydrocarbon odor.
						(SP) **VERY FINE TO FINE SAND WITH SILT**, gray (5Y 6/1) with trace yellow mottling, weakly laminated, medium dense, slightly moist to moist, slight hydrocarbon odor.
10.0	1	297.1				**SANDSTONE**, gray (10YR 6/1), very fine to medium sand, thinnly bedded, iron oxide weathering on bedding surfaces, hard, dry.

7.5
8.7
9.0
10.0

Bottom of borehole at 10.0 feet.

WELL CONSTRUCTION



GLACIER ENGINEERING, P.C.

ENVIRONMENTAL BOREHOLE LOG

BOREHOLE NO.: **IM-West/MW-41**

TOTAL DEPTH: **29 ft bgs**

PROJECT INFORMATION

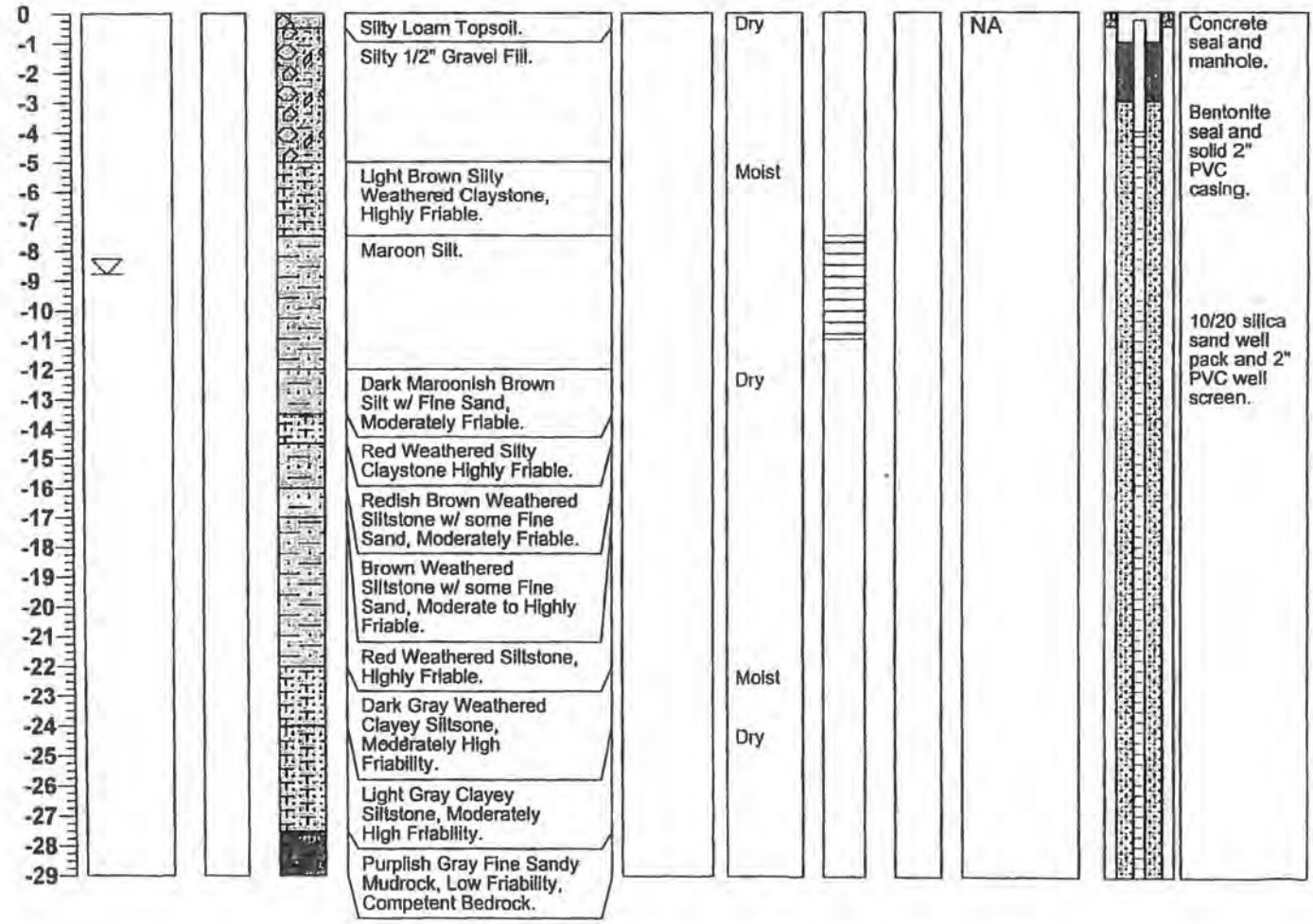
PROJECT:	**MRC Interim Measures**
SITE LOCATION:	**MRC, Great Falls**
JOB NO.:	**01-367**
LOGGED BY:	**Paul Skubinna**
PROJECT MANAGER:	**Alan Frohberg**
DATES DRILLED:	**4-25-03**

DRILLING INFORMATION

DRILLING CO.:	**Boland Drilling Co.**
DRILLER:	**Ben Boland**
RIG TYPE:	**Air Rotary**
METHOD OF DRILLING:	**Air Rotary**
SAMPLING METHODS:	**Screen/Shovel**

NOTES: Static Water 8.78 ft below top of north side of casing.

FIELD DATA



Trihydro Corporation

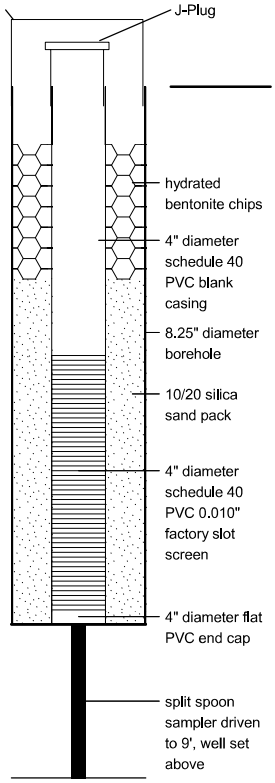
Well Log

Well: **MW-50**

Client: **Calumet Montana Refining, Great Falls, Montana**		
Date Started: **Oct 17, 16**	Date Completed: **Oct 17, 16**	Permit Number:
Logged By: **Wallace Coles**	Driller: **Boland**	1/4, 1/4, S, T, R: **T20N, R03E**
Drilling Co.: **Boland Drilling**	Drilling Rig: **CME 55**	Borehole Diameter: **8.25"**
Method: **Hollow stem auger**	Measuring Point Elev. (ft.-msl):	Sample Type: **Cuttings**
Total Depth (ft): **9**	Ground Surface Elev. (ft.-msl):	Location:

N

CONSTRUCTION | **SAMPLING DATA** | **LITHOLOGY**



Depth, feet	Blow Count	Graphic Log	TOV Values (ppm)	pH Values	Visual Description
					Sandy, SILT, brown, sand fine grained, wet, no odor
					SANDSTONE, brown
			11.2		Sandy SILT, brown, sand fine grained, hydrocarbon odor, Weathered Shale, dry
5					
					Red shale - dry

Sample Retained ■

Trihydro Corporation

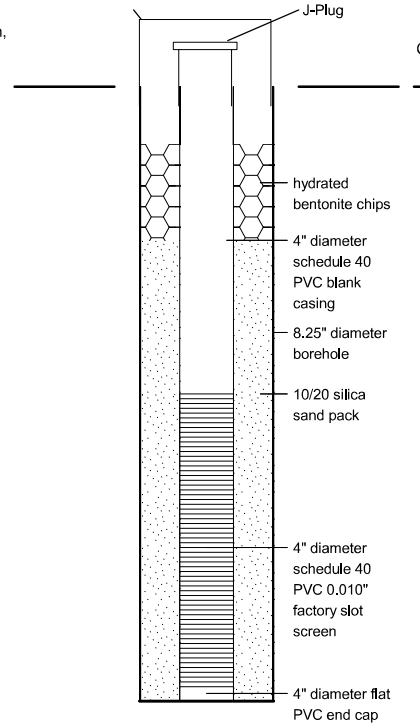
Well Log

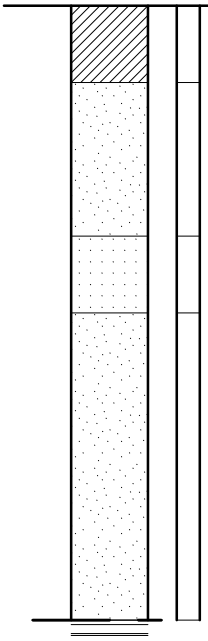
Well: **MW-51**

Client: **Calumet Montana Refining, Great Falls, Montana**		
Date Started: **Oct 17, 16**	Date Completed: **Oct 17, 16**	Permit Number:
Logged By: **Wallace Coles**	Driller: **Boland**	1/4, 1/4, S, T, R: **T20N, R03E**
Drilling Co.: **Boland Drilling**	Drilling Rig: **CME 55**	Borehole Diameter: **8.25"**
Method: **Hollow stem auger**	Measuring Point Elev. (ft.-msl):	Sample Type: **Cuttings**
Total Depth (ft): **8**	Ground Surface Elev. (ft.-msl):	Location:

N

CONSTRUCTION **SAMPLING DATA** **LITHOLOGY**





Depth, feet	Blow Count	TOV Values (ppm)	pH Values	Visual Description
				Topsoil, brown silty clay, some fine to coarse grained sand, moist
		0.3		Sand, brown, fine grained, moist to wet, no odor
				Red sandstone, dry, no odor
		5.1		Sand, brown, fine grained, strong hydrocarbon odor, dry
5				
				Red shale

Sample Retained ■

Trihydro CORPORATION

Lithology Log Sheet 1 of 3

LOCATION ID: MW-58

Project Name	Project Number	Site ID
AOC 16 Groundwater Investigation	477-018-002	Calumet Refinery, Great Falls, MT

Drilling Company	Driller	Ground Elevation	Total Drilled Depth
Boland Environmental Drilling			30 feet-bgs

Drilling Equipment	Drilling Method	Borehole Diameter	Date/Time Drilling Started	Date/Time Total Depth Reached
CME Truck Mount Rotary Rig	HS Augers/Air Rotary	10" / 6"	5-Apr-17	5-Apr-17

Type of Sampling Device	Water Level (bgs)
Split-Spoon to 9.5'. 15' Core Barrel below 9.5'	First feet-bgs Final

Sample Hammer	Geologist	Checked by/Date
Type Safety Hammer, 140 lbs, Driving Weight Drop = 30"	W. Coles	

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0				Topsoil							
0.5											
1				Brown silty, fine to coarse grained SAND, damp, no odor.							
2											
3				Brown silty, fine to coarse grained SAND, damp, hydrocarbon odor.							
4											
5				Gray silty CLAY, damp, hydrocarbon odor.							
6				Brown/gray silty CLAY, damp, slight hydrocarbon odor.							
7											
8				Dark brown/red, silty CLAY, damp to moist, no odor.							
8.5											
9				Dark brown/red, silty fine grained SAND, damp, no odor.							
9.5											
10				Red SHALE							

Trihydro CORPORATION

Lithology Log (continued) Sheet 2 of 3

LOCATION ID: MW-58

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
10				Red SHALE, massive layers interbedded with thin friable, laminated, bedding planes. Hydrocarbon odor present in fractures at 10.6'.							
11				Brown SANDSTONE, massive layers interbedded with thin friable, laminated, bedding planes. Hydrocarbon odor and staining present in fractures at 11.6' and 13.5'							
12											
13											
14											
###											
15				Red SHALE, massive layers interbedded with thin friable, laminated, bedding planes. Becomes less competent with increasing depth. Fractured and friable at 18', no odor.							
16											
17											
18											
19				Gray MUDSTONE, no staining, no odor.							
20											
21											
22											
23											

Trihydro CORPORATION

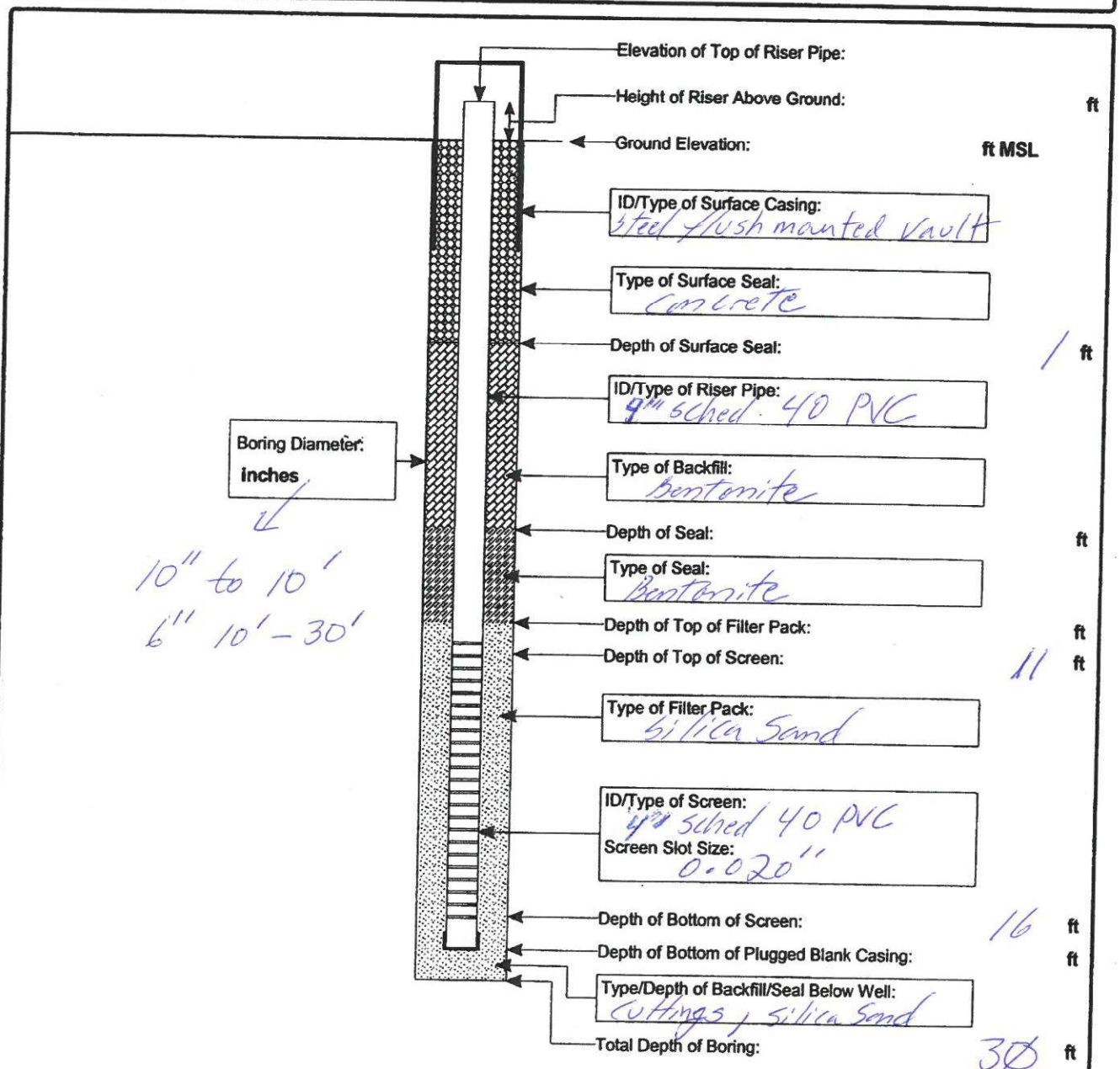
Lithology Log (continued) Sheet 3 of 3

LOCATION ID: MW-58

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
23				Same as above.							
24											
25											
26											
27											
28											
29											
30											
				TD @ 30' bgs.							
31				Well installed @ 16' bgs							
32											
33											
34											
35											
36											

Project: AOC 16, Interim Measures Project Location: Great Falls, MT Project Number: 477-018-002	**MONITORING WELL CONSTRUCTION LOG FOR MW-58**

Well Location MW-58		Date(s) Installed 4-5-17 Time
Installed By Boland Drilling	Observed By W. Coles	Total Depth
Method of Installation		
Screened Interval	Completion Zone	
Remarks		



NOTE: DIAGRAM IS NOT TO SCALE

Trihydro CORPORATION

Report: ENV_WELL_CONSTR_ABOVE_GROUND; File: DUMMY.GPJ; 11/2/2001 1

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **AS-3**
BORING NUMBER: **AS-3**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/18/19 **COMPLETED** 10/16/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 10 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 30 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 30 ft bgs **SCREEN INTERVAL** 8 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION
0.0						
		7.6				(SM) **SILTY SAND**, dark yellowish brown (10YR 4/4) with red mottling, trace clay lenses, trace rootlets, moist.
2.5						3.0
		316.7				**SANDSTONE**, gray (10YR 6/1), very fine to medium sand, thinly bedded, iron oxide weathering on bedding surfaces, hard, dry, slight hydrocarbon odor.
						4.0
5.0	7	143.9				(SP) **VERY FINE TO FINE SAND**, dark reddish gray (10R 3/2) to reddish gray (10R 5/1), some silt, weakly laminated, very dense, dry, slight hydrocarbon odor.
7.5		8				**SAME AS ABOVE**, weak red (10R 5/2), trace reddish gray (10R 4/1) clay lenses, medium dense, dry.
10.0						**SAME AS ABOVE**, slightly moist.
						10.0
		1.6				(SP) **VERY DENSE SAND**, gray (5YR 5/1), very fine to fine sand, trace fines, weakly laminated, very dense to hard, dry.
						11.0
12.5	10	0.2				(CL) **CLAY WITH SILT**, dusky red (10R 3/2), weakly laminted, very stiff to hard, dry.
						SAME AS ABOVE, olive gray (5Y 5/2).
						13.5
15.0		0.2				(SP) **VERY FINE TO FINE SAND WITH SILT**, reddish gray (2.5YR 5/1) with trace yellow mottling, very dense to hard, dry to very slightly moist.
						16.0

WELL CONSTRUCTION

- Sch. 40 2" PVC Riser
- Cement seal
- Bentonite seal (hydrated)
- Filter pack (No. 12/20)
- Sch. 40 2" PVC Screen (20-slot)
- Bentonite seal (hydrated)

RAMBOLL BASIC SB & WELL LOG - GINT STD US LAB.GDT - 11/1/19 14:33 - C:\USERS\KCARSON\DESKTOP\CMR_AOC16 PILOT STUDY.GPJ

(Continued Next Page)

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **AS-3**
BORING NUMBER: **AS-3**

CLIENT Calumet Montana Refining, LLC **PROJECT NAME** AOC-16 Pilot Study
PROJECT NUMBER **PROJECT LOCATION** Great Falls, Montana

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION	WELL CONSTRUCTION
		0.2				**SILT WITH SAND**, dusky red (10R 3/2), very fine to fine sand, stiff, dry.	
17.5	*10*					17.0 (SP) **VERY FINE TO FINE SAND WITH SILT**, gray (10YR 5/1) with trace yellow mottling, dense, dry to very slightly moist.	
		0.1				18.0 (ML) **SILT WITH VERY FINE TO FINE SAND**, dusky red (10R 3/2) to dark gray (10YR 4/1), colors intermixed, stiff, dry.	
20.0							
		0.2				21.0 (SP) **VERY FINE TO FINE SAND**, gray (GLEY 1 6/1), trace to little fines, trace layers (1-2 mm) of light gray sand, very dense to hard, dry.	
22.5	*5*	0.2					
25.0		0.5					Bentonite seal (hydrated)
						SAME AS ABOVE, very dark gray (10YR 3/1).	
		0.6					
27.5	*5*						
		0.6					
30.0						30.0	

Bottom of borehole at 30.0 feet.

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5482

WELL ID: **SVE-3**
BORING NUMBER: **SVE-3**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME AOC-16 Pilot Study
PROJECT NUMBER
PROJECT LOCATION Great Falls, Montana
DATE STARTED 10/18/19 **COMPLETED** 10/17/19
LOGGED BY Kit Carson **CHECKED BY**
DRILLING CONTRACTOR Cascade Drilling LP
GROUND ELEVATION Not Measured **TOC ELEVATION** 6 ft
DRILLING EQUIPMENT Mini Sonic FF5U53
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 7 ft bgs **BOREHOLE SIZE** 6.25 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 7 ft bgs **SCREEN INTERVAL** 4 ft
SAMPLING METHOD Continuous
GROUNDWATER LEVEL AT TIME OF DRILLING N/A

DEPTH (ft bgs)	RECOVERY (ft)	PID (ppm)	LABORATORY ID	WATER LEVEL	GRAPHIC LOG	SAMPLE DESCRIPTION	WELL CONSTRUCTION
0.0							
	7	8.3				(SM) **SILTY SAND**, brown (10YR 4/3), trace rootlets, trace iron oxide mottling, medium dense, moist, no odor.	Cement seal
2.5							Sch. 40 3" PVC Riser
		88.5					
						3.0 **SANDSTONE**, gray (10YR 6/1), very fine to medium sand, trace iron oxide weathering on bedding surfaces, hard, dry, slight hydrocarbon odor.	Bentonite seal (hydrated)
						4.0 (SP) **VERY FINE TO FINE SAND**, grayish brown (10YR 5/2) with trace yellow mottling, trace to little silt, weakly laminated, medium dense, dry, no odor.	
5.0		5				**SAME AS ABOVE**, slightly moist starting between 5.0 to 5.5 ft bgs.	Sch. 40 3" PVC Screen (20-slot)
		4.9	CMR-SVE3-6.0-7.0-191019				Filter pack (No. 12/20)
						7.0	

Bottom of borehole at 7.0 feet.

APPENDIX B
Geotechnical Laboratory Report

Petroleum Services Division
3437 Landco Dr.
Bakersfield, California 93308
Tel: 661-325-5657
Fax: 661-325-5808
www.corelab.com

November 18, 2019

David Heidlauf
Ramboll US Corporation
333 W. Wacker Dr., Ste 2700
Chicago, IL 60606

Subject: Physical Properties Analysis
Project: Calumet (CMR)
CL File No: 1903777

Dear Mr.Heidlauf:

The attached file presents the final physical properties determination results for the samples submitted from your Calumet (CMR) Project.

Appropriate ASTM, EPA or API methodologies were used for this project and SOP's are available on request. The samples for this project are currently in storage and will be retained for thirty days past completion of testing at no charge. At the end of thirty days, the samples will be disposed. You may contact me regarding continued storage, disoposal, or return of the samples.

Thank you for this opportunity to be of service to Ramboll US Corporation. Please do not hesitate to contact us at (661-325-5657) if you have any questions regarding these results or if we can be of any additional service.

Sincerely,
Core Laboratories

Eva Lopez
Core Analyst

Physical Properties Data

Core Lab
RESERVOIR OPTIMIZATION

Petroleum Services

Ramboll US Corporation
Project Name: Calumet (CMR)

Core Lab File No.: 1903777

		METHODS:	API RP40 ASTM D2216		API RP40 D5550	API RP 40 ASTM D425M	Walkley-Black		API RP 40; ASTM D5084; EPA 9100 100 psi Net Confining Stress	
Sample ID.	Depth ft.	Sample [1] Orientation	Mositure Content % weight	Mositure Content cm^3/cm^3	Density Dry Bulk g/cm^3	Total Porosity[2] %Vb [3]	Total Organic Carbon mg/kg	Fractional Organic Carbon g/g	Effective [4,5] Permeability to Water millidarcy	Hydraulic [4,5] Conductivity cm/s
CMR-AS2B-5.0-7.5-191018-ST	5.0-7.5	V	18.1	0.314	1.74	34.4	10700	1.07E-02	4.863	5.03E-06
CMR-AS3-6.0-7.0-191018-ST	6.0-7.0	V	15.5	0.289	1.86	30.0	7700	7.70E-03	<0.001	<10E-10
CMR-SB102-9.0-10-191018-ST	9.0-10	V	16.3	0.299	1.83	31.1	9000	9.00E-03	1.0076	1.03E-06

(1) Sample Orientation: H = horizontal; V = vertical.
(2) Total Porosity = no pore fluids in place; all interconnected pore channels.
(3) Vb = Bulk Volume, cc.
(4) Native State or Effective = With as-received pore fluids in place.
(5) Permeability to water and hydraulic conductivity measured at saturated conditions.

SIEVE and LASER PARTICLE SIZE SUMMARY

(METHODOLOGY: ASTM D422/D4464M)

Petroleum Services

Company: Ramboll US Corporation
Project Name: Calumet (CMR)

CL File No.: 1903777
Date: 11/18/2019

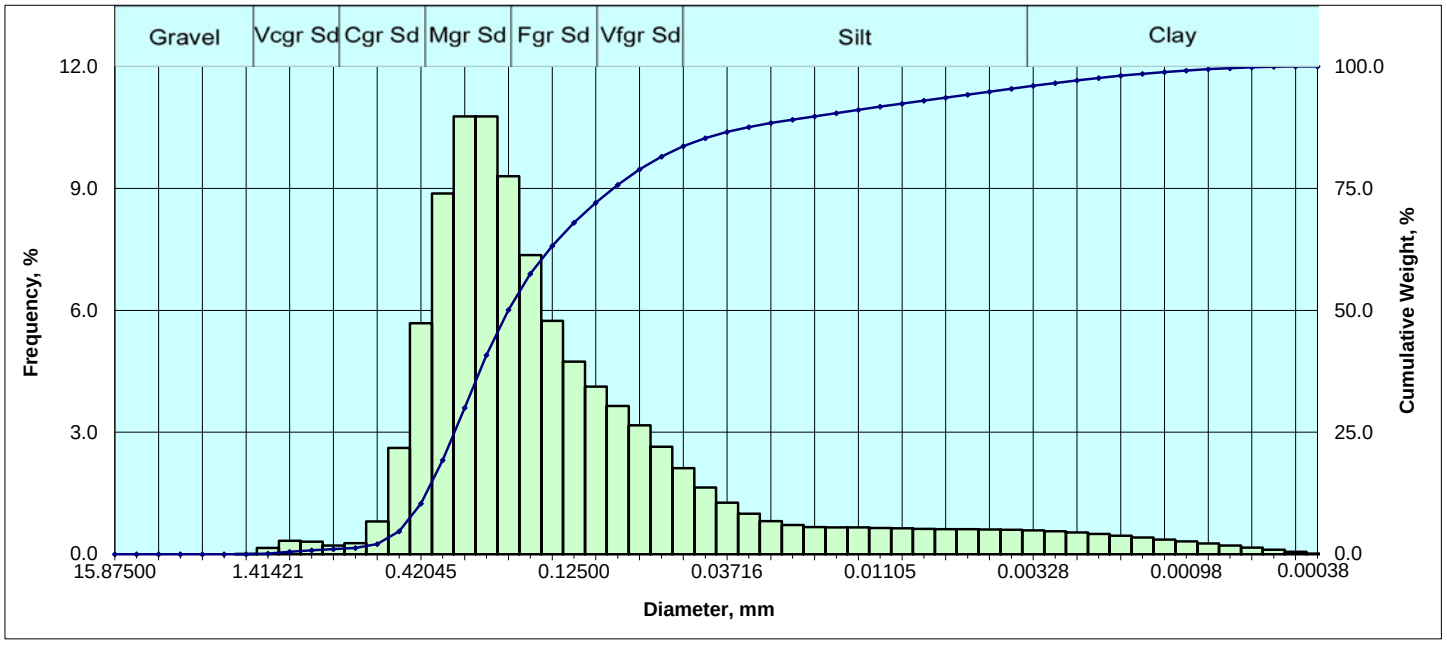
Sample ID	Grain Size Description** (Mean from Folk)	Median Grain Size, mm	Component Percentages								
				Sand Size							
			Gravel	VCoarse	Coarse	Medium	Fine	VFine	Silt	Clay	Silt & Clay
CMR-AS2B-5.0-7.5-191018-ST	Fine Grain Sand	0.2107	0.00	0.81	3.91	36.10	27.14	13.59	13.90	4.55	18.45
CMR-AS3-6.0-7.0-191018-ST	Silt	0.0129	0.00	0.00	0.00	1.03	7.11	12.62	50.67	28.57	79.24
CMR-SB102-9.0-10.0-191018-ST	Very Fine Grain Sand	0.1232	0.80	2.53	6.49	24.62	15.24	14.72	29.05	6.55	35.60

**Wentworth Scale

Company: Ramboll US Corporation
Project Name: Calumet(CMR)

CL File No.: 1903777
Sample ID: CMR-AS2B-5.0-7.5

Sieve and Laser Particle Size Analysis



Particle Size Distribution						
	Diameter				Weight %	
	[US Mesh]	[in.]	[mm]	[ϕ]	[Incl.]	[Cum.]
Gravel	5/8 in.	0.625000	15.87500	-4.00	0.000	0.00
	3/8 in.	0.375000	9.50000	-3.25	0.000	0.00
	4	0.187008	4.75000	-2.25	0.000	0.00
	6	0.131890	3.35000	-1.75	0.000	0.00
	8	0.092913	2.36000	-1.25	0.000	0.00
	10	0.078740	2.00000	-1.00	0.000	0.00
V Crse Sand	12	0.066212	1.68179	-0.75	0.011	0.01
	14	0.055678	1.41421	-0.50	0.152	0.16
	16	0.046819	1.18921	-0.25	0.335	0.50
	18	0.039370	1.00000	0.00	0.309	0.81
Coarse Sand	20	0.033106	0.84090	0.25	0.217	1.02
	25	0.027839	0.70711	0.50	0.275	1.30
	30	0.023410	0.59460	0.75	0.809	2.11
	35	0.019685	0.50000	1.00	2.613	4.72
Medium Sand	40	0.016553	0.42045	1.25	5.681	10.40
	45	0.013919	0.35355	1.50	8.876	19.28
	50	0.011705	0.29730	1.75	10.772	30.05
	60	0.009843	0.25000	2.00	10.769	40.82
Fine Sand	70	0.008277	0.21022	2.25	9.303	50.12
	80	0.006960	0.17678	2.50	7.356	57.48
	100	0.005852	0.14865	2.75	5.742	63.22
	120	0.004921	0.12500	3.00	4.741	67.96
V. Fine Sand	140	0.004138	0.10511	3.25	4.123	72.08
	170	0.003480	0.08839	3.50	3.649	75.73
	200	0.002926	0.07433	3.75	3.170	78.90
	230	0.002461	0.06250	4.00	2.645	81.55
Silt	270	0.002069	0.05256	4.25	2.118	83.67
	325	0.001740	0.04419	4.50	1.644	85.31
	400	0.001463	0.03716	4.75	1.268	86.58
	450	0.001230	0.03125	5.00	0.995	87.57
	500	0.001035	0.02628	5.25	0.817	88.39
	635	0.000870	0.02210	5.50	0.717	89.11
		0.000732	0.01858	5.75	0.671	89.78
		0.000615	0.01562	6.00	0.659	90.44
		0.000517	0.01314	6.25	0.658	91.09
		0.000435	0.01105	6.50	0.648	91.74
		0.000366	0.00929	6.75	0.636	92.38
		0.000308	0.00781	7.00	0.626	93.01
		0.000259	0.00657	7.25	0.619	93.62
		0.000217	0.00552	7.50	0.614	94.24
		0.000183	0.00465	7.75	0.608	94.85
		0.000154	0.00391	8.00	0.602	95.45
Clay		0.000129	0.00328	8.25	0.588	96.04
		0.000109	0.00276	8.50	0.565	96.60
		0.000091	0.00232	8.75	0.535	97.14
		0.000077	0.00195	9.00	0.498	97.63
		0.000065	0.00164	9.25	0.456	98.09
		0.000054	0.00138	9.50	0.410	98.50
		0.000046	0.00116	9.75	0.363	98.86
		0.000038	0.00098	10.00	0.314	99.18
		0.000032	0.00082	10.25	0.264	99.44
		0.000027	0.00069	10.50	0.214	99.65
		0.000023	0.00058	10.75	0.163	99.82
		0.000019	0.00049	11.00	0.111	99.93
		0.000016	0.00041	11.25	0.059	99.99
		0.000015	0.00038	11.50	0.014	100.00

Sorting Statistics (Folk)			
Parameter	Trask	Inman	Folk
Median	Fine sand sized		
(in)	0.0083	0.0083	0.0083
(mm)	0.2107	0.2107	0.2107
Mean	Fine sand sized		
(in)	0.0082	0.0055	0.0063
(mm)	0.2077	0.1387	0.1595
Sorting	Poor		
	1.878	1.447	1.754
Skewness	Strongly fine skewed		
	0.818	1.495	0.527
Kurtosis	Very leptokurtic		
	0.284	1.349	1.532

Component Percentages				
Gravel	Sand	Silt	Clay	Silt + Clay
0.00	81.55	13.90	4.55	18.45

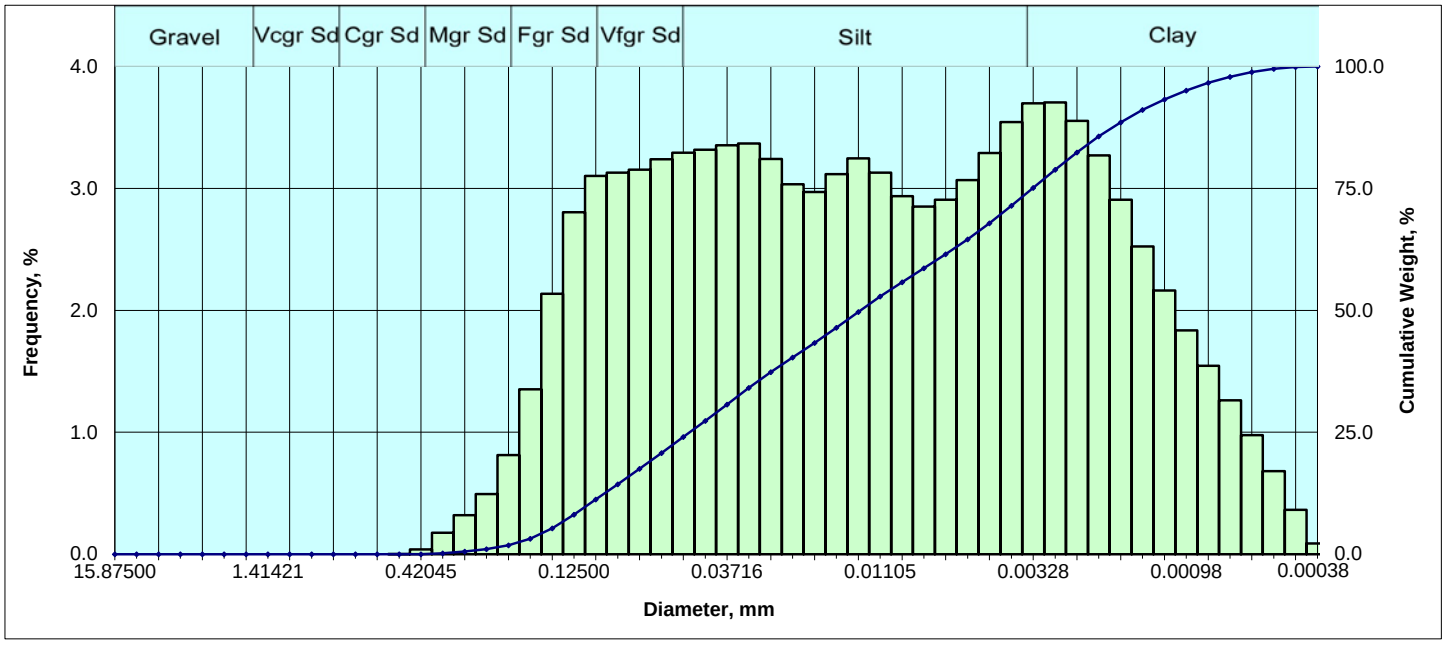
Percentile [Weight, %]	Particle Diameter		
	[in.]	[mm]	[phi]
5	0.0195	0.4961	1.0113
10	0.0168	0.4261	1.2308
16	0.0149	0.3783	1.4026
25	0.0127	0.3237	1.6274
40	0.0100	0.2536	1.9794
50	0.0083	0.2107	2.2464
70	0.0045	0.1152	3.1182
75	0.0036	0.0917	3.4462
84	0.0020	0.0509	4.2974
90	0.0007	0.0176	5.8294
95	0.0002	0.0045	7.8100

**All Grain Sizes Classed Using Wentworth Scale

Company: Ramboll US Corporation
Project Name: Calumet(CMR)

CL File No.: 1903777
Sample ID: CMR-AS3-6.0-7.0

Sieve and Laser Particle Size Analysis



	Particle Size Distribution					
	Diameter				Weight %	
	[US Mesh]	[in.]	[mm]	[ϕ]	[Incl.]	[Cum.]
Gravel	5/8 in.	0.625000	15.87500	-4.00	0.000	0.00
	3/8 in.	0.375000	9.50000	-3.25	0.000	0.00
	4	0.187008	4.75000	-2.25	0.000	0.00
	6	0.131890	3.35000	-1.75	0.000	0.00
	8	0.092913	2.36000	-1.25	0.000	0.00
	10	0.078740	2.00000	-1.00	0.000	0.00
V Crse Sand	12	0.066212	1.68179	-0.75	0.000	0.00
	14	0.055678	1.41421	-0.50	0.000	0.00
	16	0.046819	1.18921	-0.25	0.000	0.00
	18	0.039370	1.00000	0.00	0.000	0.00
Coarse Sand	20	0.033106	0.84090	0.25	0.000	0.00
	25	0.027839	0.70711	0.50	0.000	0.00
	30	0.023410	0.59460	0.75	0.000	0.00
	35	0.019685	0.50000	1.00	0.001	0.00
Medium Sand	40	0.016553	0.42045	1.25	0.039	0.04
	45	0.013919	0.35355	1.50	0.177	0.22
	50	0.011705	0.29730	1.75	0.320	0.54
	60	0.009843	0.25000	2.00	0.493	1.03
Fine Sand	70	0.008277	0.21022	2.25	0.814	1.84
	80	0.006960	0.17678	2.50	1.353	3.20
	100	0.005852	0.14865	2.75	2.135	5.33
	120	0.004921	0.12500	3.00	2.804	8.14
V. Fine Sand	140	0.004138	0.10511	3.25	3.101	11.24
	170	0.003480	0.08839	3.50	3.129	14.37
	200	0.002926	0.07433	3.75	3.153	17.52
	230	0.002461	0.06250	4.00	3.240	20.76
Silt	270	0.002069	0.05256	4.25	3.293	24.05
	325	0.001740	0.04419	4.50	3.318	27.37
	400	0.001463	0.03716	4.75	3.353	30.72
	450	0.001230	0.03125	5.00	3.367	34.09
	500	0.001035	0.02628	5.25	3.242	37.33
	635	0.000870	0.02210	5.50	3.035	40.37
		0.000732	0.01858	5.75	2.971	43.34
		0.000615	0.01562	6.00	3.116	46.46
		0.000517	0.01314	6.25	3.245	49.70
		0.000435	0.01105	6.50	3.128	52.83
		0.000366	0.00929	6.75	2.937	55.77
		0.000308	0.00781	7.00	2.851	58.62
		0.000259	0.00657	7.25	2.906	61.52
		0.000217	0.00552	7.50	3.068	64.59
		0.000183	0.00465	7.75	3.291	67.88
		0.000154	0.00391	8.00	3.544	71.43
Clay		0.000129	0.00328	8.25	3.697	75.12
		0.000109	0.00276	8.50	3.705	78.83
		0.000091	0.00232	8.75	3.554	82.38
		0.000077	0.00195	9.00	3.270	85.65
		0.000065	0.00164	9.25	2.906	88.56
		0.000054	0.00138	9.50	2.524	91.08
		0.000046	0.00116	9.75	2.163	93.25
		0.000038	0.00098	10.00	1.835	95.08
		0.000032	0.00082	10.25	1.545	96.63
		0.000027	0.00069	10.50	1.262	97.89
		0.000023	0.00058	10.75	0.977	98.87
		0.000019	0.00049	11.00	0.681	99.55
		0.000016	0.00041	11.25	0.364	99.91
		0.000015	0.00038	11.50	0.089	100.00

Sorting Statistics (Folk)			
Parameter	Trask	Inman	Folk
Median	Silt sized		
(in)	0.0005	0.0005	0.0005
(mm)	0.0129	0.0129	0.0129
Mean	Silt sized		
(in)	0.0011	0.0005	0.0005
(mm)	0.0267	0.0132	0.0131
Sorting	Very poor		
	3.896	2.622	2.414
Skewness	Near symmetrical		
	0.995	0.029	0.005
Kurtosis	Platykurtic		
	0.210	0.388	0.760

Component Percentages				
Gravel	Sand	Silt	Clay	Silt + Clay
0.00	20.76	50.67	28.57	79.24

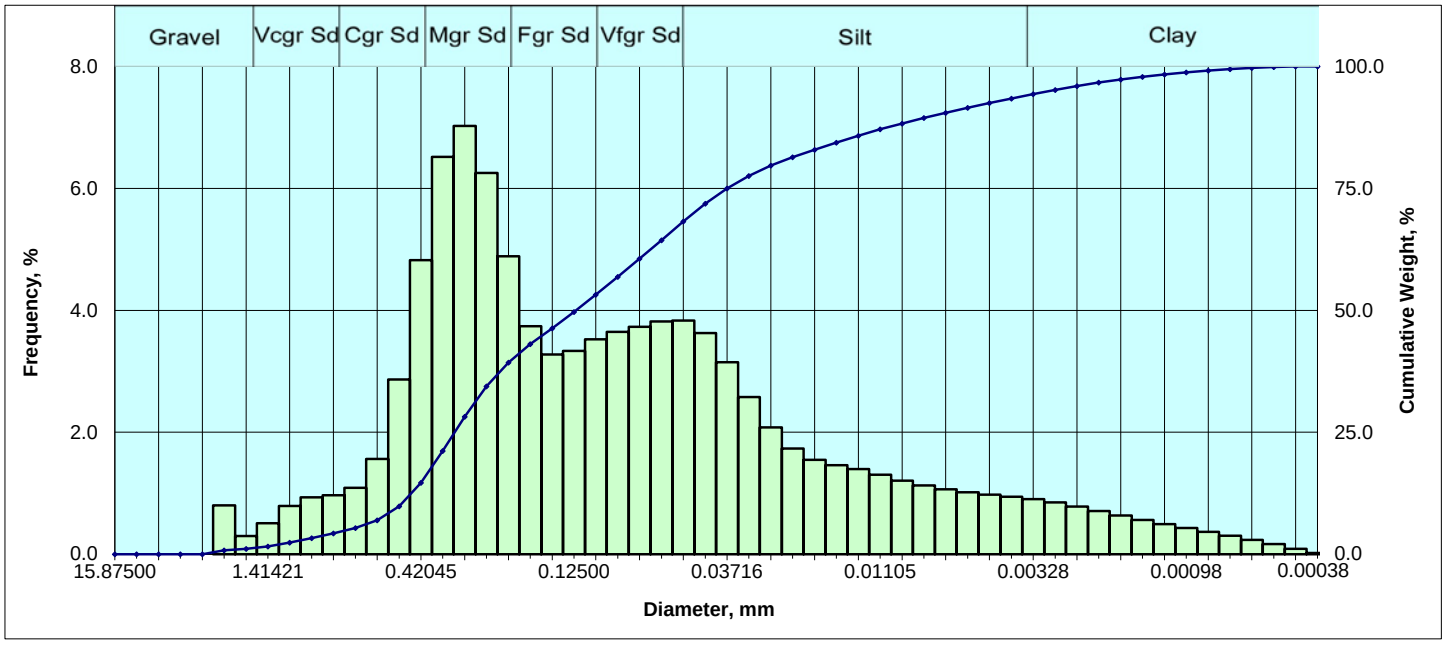
Percentile [Weight, %]	Particle Diameter		
	[in.]	[mm]	[phi]
5	0.0060	0.1530	2.7081
10	0.0045	0.1131	3.1449
16	0.0032	0.0811	3.6240
25	0.0020	0.0502	4.3170
40	0.0009	0.0226	5.4673
50	0.0005	0.0129	6.2721
70	0.0002	0.0042	7.8941
75	0.0001	0.0033	8.2409
84	0.0001	0.0021	8.8683
90	0.0001	0.0015	9.3875
95	0.0000	0.0010	9.9880

**All Grain Sizes Classed Using Wentworth Scale

Company: Ramboll US Corporation
Project Name: Calumet(CMR)

CL File No.: 1903777
Sample ID: CMR-SB102-9.0-10.0

Sieve and Laser Particle Size Analysis



	Particle Size Distribution					
	Diameter				Weight %	
	[US Mesh]	[in.]	[mm]	[ϕ]	[Incl.]	[Cum.]
Gravel	5/8 in.	0.625000	15.87500	-4.00	0.000	0.00
	3/8 in.	0.375000	9.50000	-3.25	0.000	0.00
	4	0.187008	4.75000	-2.25	0.000	0.00
	6	0.131890	3.35000	-1.75	0.000	0.00
	8	0.092913	2.36000	-1.25	0.000	0.00
	10	0.078740	2.00000	-1.00	0.801	0.80
V Crse Sand	12	0.066212	1.68179	-0.75	0.301	1.10
	14	0.055678	1.41421	-0.50	0.507	1.61
	16	0.046819	1.18921	-0.25	0.792	2.40
	18	0.039370	1.00000	0.00	0.934	3.34
Coarse Sand	20	0.033106	0.84090	0.25	0.967	4.30
	25	0.027839	0.70711	0.50	1.089	5.39
	30	0.023410	0.59460	0.75	1.565	6.96
	35	0.019685	0.50000	1.00	2.865	9.82
Medium Sand	40	0.016553	0.42045	1.25	4.822	14.64
	45	0.013919	0.35355	1.50	6.519	21.16
	50	0.011705	0.29730	1.75	7.025	28.19
	60	0.009843	0.25000	2.00	6.255	34.44
Fine Sand	70	0.008277	0.21022	2.25	4.885	39.33
	80	0.006960	0.17678	2.50	3.740	43.07
	100	0.005852	0.14865	2.75	3.274	46.34
	120	0.004921	0.12500	3.00	3.337	49.68
V. Fine Sand	140	0.004138	0.10511	3.25	3.526	53.20
	170	0.003480	0.08839	3.50	3.647	56.85
	200	0.002926	0.07433	3.75	3.729	60.58
	230	0.002461	0.06250	4.00	3.819	64.40
Silt	270	0.002069	0.05256	4.25	3.831	68.23
	325	0.001740	0.04419	4.50	3.626	71.86
	400	0.001463	0.03716	4.75	3.151	75.01
	450	0.001230	0.03125	5.00	2.580	77.59
	500	0.001035	0.02628	5.25	2.080	79.67
	635	0.000870	0.02210	5.50	1.735	81.40
		0.000732	0.01858	5.75	1.546	82.95
		0.000615	0.01562	6.00	1.459	84.41
		0.000517	0.01314	6.25	1.397	85.80
		0.000435	0.01105	6.50	1.306	87.11
		0.000366	0.00929	6.75	1.208	88.32
		0.000308	0.00781	7.00	1.126	89.45
		0.000259	0.00657	7.25	1.064	90.51
		0.000217	0.00552	7.50	1.016	91.52
		0.000183	0.00465	7.75	0.977	92.50
		0.000154	0.00391	8.00	0.944	93.45
Clay		0.000129	0.00328	8.25	0.902	94.35
		0.000109	0.00276	8.50	0.849	95.20
		0.000091	0.00232	8.75	0.783	95.98
		0.000077	0.00195	9.00	0.711	96.69
		0.000065	0.00164	9.25	0.635	97.33
		0.000054	0.00138	9.50	0.563	97.89
		0.000046	0.00116	9.75	0.496	98.38
		0.000038	0.00098	10.00	0.431	98.82
		0.000032	0.00082	10.25	0.369	99.18
		0.000027	0.00069	10.50	0.305	99.49
		0.000023	0.00058	10.75	0.237	99.73
		0.000019	0.00049	11.00	0.165	99.89
		0.000016	0.00041	11.25	0.088	99.98
		0.000015	0.00038	11.50	0.021	100.00

Sorting Statistics (Folk)			
Parameter	Trask	Inman	Folk
Median	Very fine sand sized		
(in)	0.0048	0.0048	0.0048
(mm)	0.1232	0.1232	0.1232
Mean	Very fine sand sized		
(in)	0.0071	0.0032	0.0037
(mm)	0.1800	0.0818	0.0937
Sorting	Very poor		
	2.947	2.314	2.374
Skewness	Strongly fine skewed		
	0.889	0.605	0.302
Kurtosis	Mesokurtic		
	0.292	0.736	1.056

Component Percentages				
Gravel	Sand	Silt	Clay	Silt + Clay
0.80	63.60	29.05	6.55	35.60

Percentile [Weight, %]	Particle Diameter		
	[in.]	[mm]	[phi]
5	0.0297	0.7552	0.4051
10	0.0196	0.4971	1.0085
16	0.0160	0.4065	1.2986
25	0.0127	0.3228	1.6312
40	0.0080	0.2042	2.2919
50	0.0048	0.1232	3.0211
70	0.0019	0.0485	4.3666
75	0.0015	0.0372	4.7494
84	0.0006	0.0164	5.9258
90	0.0003	0.0072	7.1250
95	0.0001	0.0029	8.4382

**All Grain Sizes Classed Using Wentworth Scale

Core Laboratories LP 3437 Lando Dr. Bakersfield, CA 93308

SHEALY

Chain of Custody Record

~~SHEALY ENVIRONMENTAL SERVICES, INC.~~
~~106 Vantage Point Drive • West Columbia, SC 29172~~
~~Telephone No. 803-791-9700 Fax No. 803-791-9111~~
www.shealylab.com

Number 097736

Client: Ramboll	Report to Contact: David Hollauf	Telephone No. / E-mail: 312-288-3800	Quote No.
Address: 333 W Wacker Dr. Ste #2700	Sampler's Signature: X	Analysis (Attach list if more space is needed)	Page 1 of 1
City: Chicago / State: IL / Zip Code: 60606	Printed Name: Kit Carson		Laboratory Lot Number
Project Name: Calumet (CMR)			
Project No.	P.O. No.		Remarks / Cooler I.D.

Sample ID / Description (Containers for each sample may be combined on one line.)	Date	Time	G=Grab C=Composite	Matrix: Aqueous	Solid	Non-Aqueous	No of Containers by Preservative Type: Unpres.	H_2SO_4	HNO_3	HCl	NaOH	5035 Kit	Porosity	Soil Bulk Density	Grain Size	Water Content / Percent Saturation
• CMR-~~MW~~SB102-9.0-10-191018-ST	10.18.19	16:15	G		X								X	X	X	X
• CMR-AS2b-~~5.0~~7.5-191018-ST	10.18.19	14:45	G		X								X	X	X	X
• CMR-AS3-6.0-7.0-191018-ST	10.18.19	17:30	G		X								X	X	X	X

Samples arrived on ice @ 66.0°F

KC 10/22/19

KC 10/22/19

Turn Around Time Required (Prior lab approval required for expedited TAT.)	Sample Disposal	Possible Hazard Identification	QC Requirements (Specify)
X Standard ☐ Rush (Specify)	☐ Return to Client X Disposal by Lab	☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison ☐ Unknown	

	Date	Time		Date	Time
1. Relinquished by	10.22.19	1700	1. Received by	10/23/19	10:30am
2. Relinquished by	Date	Time	2. Received by	Date	Time
3. Relinquished by	Date	Time	3. Received by	Date	Time
4. Relinquished by	Date	Time	4. Laboratory received by	Date	Time

Note: All samples are retained for four weeks from receipt unless other arrangements are made.

LAB USE ONLY
Received on ice (Circle) Yes No Ice Pack

Receipt Temp._____ °C

DISTRIBUTION: WHITE & YELLOW-Return to laboratory with Sample(s); PINK-Field/Client Copy

Document Number: F-AD-133 Effective Date: 08-01-2014

APPENDIX C
Soil and Groundwater Analytical Laboratory Reports

10515 Research Drive
Knoxville, TN 37932
Phone: (865) 573-8188
Fax: (865) 573-8133

Client: Paul Lindquist
Ramboll
175 North Corporate Drive
Suite 160
Brookfield, WI 53045

Phone:

Fax:

Identifier: 078QJ **Date Rec:** 10/19/2019 **Report Date:** 10/29/2019

Client Project #: 1690014124-002 **Client Project Name:** Calumet (CMR)

Purchase Order #:

Analysis Requested: Plate Count

Reviewed By:

MICROBIAL INSIGHTS, INC.

10515 Research Dr., Knoxville, TN 37932
Tel. (865) 573-8188 Fax. (865) 573-8133

CULTURE REPORT

Client: **Ramboll**
Project: Calumet (CMR)

MI Project Number: **078QJ**
Date Received: 10/19/2019

Sample Information

Client Sample ID:	**CMR-SB102-11-12-191018**	**CMR-SB103-11-12-191018**	**CMR-MW103-191022**
Sample Date:	10/18/2019	10/18/2019	10/22/2019
Analyst/Reviewer:	CB	CB	CB
Units:	cfu/g	cfu/g	cfu/mL

Bacterial Group

Aerobic Culturable Heterotrophs	**5.05E+02**	**3.05E+02**	**2.55E+05**
95% LL	*3.97E+02*	*2.95E+02*	*2.45E+05*
95% UL	*6.13E+02*	*3.15E+02*	*2.65E+05*

Legend:
NA = Not Analyzed NS = Not Sampled LL = 95% confidence lower limit UL = 95% confidence upper limit NG = no growth

SHEALY ENVIRONMENTAL SERVICES, INC.

Report of Analysis

Ramboll US Corporation
333 West Wacker Drive
Suite 2700
Chicago, IL 60606
Attention: David Heidlauf

Project Name: Calumet (CMR)

Project Number: 1690014124-002

Lot Number:**UJ19025**

Date Completed:10/29/2019

10/31/2019 3:55 PM
Approved and released by:
Project Manager: Kelly M. Nance

The electronic signature above is the equivalent of a handwritten signature.

Shealy Environmental Services, Inc.
106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.shealylab.com

Case Narrative
Ramboll US Corporation
Lot Number: UJ19025

This Report of Analysis contains the analytical result(s) for the sample(s) listed on the Sample Summary following this Case Narrative. The sample receiving date is documented in the header information associated with each sample.

All results listed in this report relate only to the samples that are contained within this report.

Sample receipt, sample analysis, and data review have been performed in accordance with the most current approved NELAC standards, the Shealy Environmental Services, Inc. ("Shealy") Quality Assurance Management Plan (QAMP), standard operating procedures (SOPs), and Shealy policies. Any exceptions to the NELAC standards, the QAMP, SOPs or policies are qualified on the results page or discussed below.

Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W" qualifier

If you have any questions regarding this report please contact the Shealy Project Manager listed on the cover page.

Sample Summary
Ramboll US Corporation
Lot Number: UJ19025

Sample Number	Sample ID	Matrix	Date Sampled	Date Received
001	CMR-SB102-11-12-191018	Solid	10/18/2019 1230	10/19/2019
002	CMR-SB103-11-12-191018	Solid	10/18/2019 1140	10/19/2019

(2 samples)

Detection Summary
Ramboll US Corporation
Lot Number: UJ19025

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	CMR-SB102-11-12-191018	Solid	Nitrate-Nitrite - N (soluble)	353.2	1.3		mg/kg	5
001	CMR-SB102-11-12-191018	Solid	Phosphorus	365.1	450		mg/kg	5
002	CMR-SB103-11-12-191018	Solid	Nitrate-Nitrite - N (soluble)	353.2	2.4		mg/kg	6
002	CMR-SB103-11-12-191018	Solid	Phosphorus	365.1	410		mg/kg	6

(4 detections)

Inorganic non-metals

Client: **Ramboll US Corporation** Laboratory ID: **UJ19025-001**

Description: **CMR-SB102-11-12-191018** Matrix: **Solid**

Date Sampled: **10/18/2019 1230** % Solids: **86.1** **10/20/2019 2035**

Date Received: **10/19/2019**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		(Nitrate-Nitr) 353.2	1	10/24/2019 2347	AMR		33258
1		(Phosphorus) 365.1	10	10/24/2019 1157	DMA	10/23/2019 1429	32936

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	Units	Run
Nitrate-Nitrite - N (soluble)		**353.2**	**1.3**		**0.23**	**mg/kg**	**1**
Phosphorus	**7723-14-0**	**365.1**	**450**		**58**	**mg/kg**	**1**

LOQ = Limit of Quantitation
ND = Not detected at or above the LOQ
H = Out of holding time
B = Detected in the method blank
N = Recovery is out of criteria
W = Reported on wet weight basis
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%

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Inorganic non-metals

Client: **Ramboll US Corporation** Laboratory ID: **UJ19025-002**

Description: **CMR-SB103-11-12-191018** Matrix: **Solid**

Date Sampled: **10/18/2019 1140** % Solids: **86.3** **10/20/2019 2035**

Date Received: **10/19/2019**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		(Nitrate-Nitr) 353.2	1	10/24/2019 2348	AMR		33258
1		(Phosphorus) 365.1	10	10/24/2019 1157	DMA	10/23/2019 1429	32936

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	Units	Run
Nitrate-Nitrite - N (soluble)		**353.2**	**2.4**		**0.23**	**mg/kg**	**1**
Phosphorus	**7723-14-0**	**365.1**	**410**		**58**	**mg/kg**	**1**

LOQ = Limit of Quantitation
ND = Not detected at or above the LOQ
H = Out of holding time
B = Detected in the method blank
N = Recovery is out of criteria
W = Reported on wet weight basis
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%

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QC Summary

Inorganic non-metals - MB

Sample ID: UQ32936-001
Batch: 32936
Analytical Method: 365.1
Matrix: Solid
Prep Method:
Prep Date: 10/23/2019 1429

Parameter	Result	Q	Dil	LOQ	Units	Analysis Date
Phosphorus	ND		1	5.0	mg/kg	10/24/2019 0943

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ
N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Inorganic non-metals - LCS

Sample ID: UQ32936-002
Batch: 32936
Analytical Method: 365.1
Matrix: Solid
Prep Method:
Prep Date: 10/23/2019 1429

Parameter	Spike Amount (mg/kg)	Result (mg/kg)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Phosphorus	25	24		1	97	90-110	10/24/2019 0943

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ
N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Inorganic non-metals - MB

Sample ID: UQ33258-001
Batch: 33258
Analytical Method: 353.2
Matrix: Solid

Parameter	Result	Q	Dil	LOQ	Units	Analysis Date
Nitrate-Nitrite - N (soluble)	ND		1	0.20	mg/kg	10/24/2019 2332

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ
N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Inorganic non-metals - LCS

Sample ID: UQ33258-002 **Matrix:** Solid

Batch: 33258

Analytical Method: 353.2

Parameter	Spike Amount (mg/kg)	Result (mg/kg)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Nitrate-Nitrite - N (soluble)	0.80	0.83		1	103	90-110	10/24/2019 2333

LOQ = Limit of Quantitation

DL = Detection Limit

LOD = Limit of Detection

P = The RPD between two GC columns exceeds 40%

J = Estimated result < LOQ and ≥ DL

ND = Not detected at or above the LOQ

N = Recovery is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Chain of Custody
and
Miscellaneous Documents

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Chain of Custody Record

Number 099864

Client: Ramboll	Report to Contact: David Haddad / Scott Turmann	Telephone No. / E-mail: (312) 288-3800	Quote No.
Address: 333 W Wacker Dr Ste#2700	Sampler's Signature: X	Analysis (Attach list if more space is needed)	Page 1 of 1
City: Chicago	State: IL	Zip Code: 60606	Printed Name: George "Kit" Larson
Project Name: Calumet (CMR)			
Project No.: 1689014129-002	P.O. No.		

Sample ID / Description (Containers for each sample may be combined on one line.)	Date	Time	Grab/Comp	Matrix: Aqueous	Matrix: Solid	Matrix: Non-Aqueous	No. of Containers by Preservative Type: Unpres.	HNO3	H2SO4	NaOH	ZnAc/NaOH	Other	Nitrogen	Phosphorus
CMR-SB102-11-12-191018	10.18.19	12:30	G				X						X	X
CMR-SB103-11-12-191018	↓	11:40	G				X						X	X

UJ19025
KMN2

KC 10/18/19

Turn Around Time Required (Prior lab approval required for expedited TAT.): [X] Standard [ ] Rush (Specify)

Sample Disposal: [ ] Return to Client [ ] Disposal by Lab

Possible Hazard Identification: [ ] Non-Hazard [ ] Flammable [ ] Skin Irritant [ ] Poison [ ] Unknown

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished by	10-18-19	1620	1. Received by		
2. Relinquished by			2. Received by		
3. Relinquished by			3. Received by		
4. Relinquished by: Fed Ex	10/19/19	0915	4. Laboratory received by: L Hite	10/19/19	0915

Note: All samples are retained for four weeks from receipt unless other arrangements are made.

LAB USE ONLY
Received on Ice (Circle) (Yes) No Ice Pack Receipt Temp. 4.8 °C

DISTRIBUTION: WHITE & YELLOW-Return to laboratory with Sample(s); PINK-Field/Client Copy

Document Number: F-AD-133 Effective Date: 06-01-2014

SHEALY ENVIRONMENTAL SERVICES, INC.

Shealy Environmental Services, Inc.
Document Number: ME0018C-14

Page 1 of 1
Effective Date: 8/2/2018

Sample Receipt Checklist (SRC)

Client: RAMBOLL Cooler Inspected by/date: LKH / 10-19-2019 Lot #: UJ19025

Means of receipt: ☐ SESI ☐ Client ☐ UPS ☑ FedEx ☐ Other: _____

☑ Yes	☐ No		1. Were custody seals present on the cooler?
☑ Yes	☐ No	☐ NA	2. If custody seals were present, were they intact and unbroken?

pH Strip ID: NA Chlorine Strip ID: NA Tested by: NA

Original temperature upon receipt / Derived (Corrected) temperature upon receipt %Solid Snap-Cup ID: 19-1616

4.8 /4.8 °C NA /NA °C NA /NA °C NA /NA °C

Method: ☑ Temperature Blank ☐ Against Bottles IR Gun ID: 5 IR Gun Correction Factor: 0 °C

Method of coolant: ☑ Wet Ice ☐ Ice Packs ☐ Dry Ice ☐ None

☐ Yes	☐ No	☑ NA	3. If temperature of any cooler exceeded 6.0°C, was Project Manager Notified? PM was Notified by: phone / email / face-to-face (circle one).
☑ Yes	☐ No	☐ NA	4. Is the commercial courier's packing slip attached to this form?
☑ Yes	☐ No		5. Were proper custody procedures (relinquished/received) followed?
☑ Yes	☐ No		6. Were sample IDs listed on the COC?
☑ Yes	☐ No		7. Were sample IDs listed on all sample containers?
☑ Yes	☐ No		8. Was collection date & time listed on the COC?
☑ Yes	☐ No		9. Was collection date & time listed on all sample containers?
☑ Yes	☐ No		10. Did all container label information (ID, date, time) agree with the COC?
☑ Yes	☐ No		11. Were tests to be performed listed on the COC?
☑ Yes	☐ No		12. Did all samples arrive in the proper containers for each test and/or in good condition (unbroken, lids on, etc.)?
☑ Yes	☐ No		13. Was adequate sample volume available?
☑ Yes	☐ No		14. Were all samples received within ½ the holding time or 48 hours, whichever comes first?
☐ Yes	☑ No		15. Were any samples containers missing/excess (circle one) samples Not listed on COC?
☐ Yes	☐ No	☑ NA	16. For VOA and RSK-175 samples, were bubbles present >"pea-size" (¼"or 6mm in diameter) in any of the VOA vials?
☐ Yes	☐ No	☑ NA	17. Were all DRO/metals/nutrient samples received at a pH of < 2?
☐ Yes	☐ No	☑ NA	18. Were all cyanide samples received at a pH > 12 and sulfide samples received at a pH > 9?
☐ Yes	☐ No	☑ NA	19. Were all applicable NH_3/TKN/cyanide/phenol/625 (< 0.5mg/L) samples free of residual chlorine?
☐ Yes	☐ No	☑ NA	20. Were client remarks/requests (i.e. requested dilutions, MS/MSD designations, etc…) correctly transcribed from the COC into the comment section in LIMS?
☑ Yes	☐ No		21. Was the quote number listed on the container label? If yes, Quote # 22433

Sample Preservation (Must be completed for any sample(s) incorrectly preserved or with headspace.)

Sample(s) NA were received incorrectly preserved and were adjusted accordingly in sample receiving with NA mL of circle one: H2SO4, HNO3, HCl, NaOH using SR # NA.
Time of preservation NA. If more than one preservative is needed, please note in the comments below.

Sample(s) NA were received with bubbles >6 mm in diameter.

Samples(s) NA were received with TRC > 0.5 mg/L (If #19 is ***no***) and were adjusted accordingly in sample receiving with sodium thiosulfate ($Na_2S_2O_3$) with Shealy ID: NA.

SR barcode labels applied by: LKH Date: 10-19-2019

Comments:

SHEALY ENVIRONMENTAL SERVICES, INC.

Report of Analysis

Ramboll US Corporation
333 West Wacker Drive
Suite 2700
Chicago, IL 60606
Attention: David Heidlauf

Project Name: Calumet (CMR)

Project Number: 1690014124-002

Lot Number:**UJ23054**

Date Completed:11/01/2019
Revision Date: 11/08/2019

11/08/2019 1:46 PM
Approved and released by:
Project Manager: Kelly M. Nance

The electronic signature above is the equivalent of a handwritten signature.

Shealy Environmental Services, Inc.
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Case Narrative
Ramboll US Corporation
Lot Number: UJ23054

This Report of Analysis contains the analytical result(s) for the sample(s) listed on the Sample Summary following this Case Narrative. The sample receiving date is documented in the header information associated with each sample.

All results listed in this report relate only to the samples that are contained within this report.

Sample receipt, sample analysis, and data review have been performed in accordance with the most current approved NELAC standards, the Shealy Environmental Services, Inc. ("Shealy") Quality Assurance Management Plan (QAMP), standard operating procedures (SOPs), and Shealy policies. Any exceptions to the NELAC standards, the QAMP, SOPs or policies are qualified on the results page or discussed below.

If you have any questions regarding this report please contact the Shealy Project Manager listed on the cover page.

This report supersedes and replaces any prior reports issued under this lot number. The details of the applicable revisions are detailed below.

Report Revision
The sample ID was changed to "CMR-MW103-191022" at theclient's request.

Sample Summary
Ramboll US Corporation
Lot Number: UJ23054

Sample Number	Sample ID	Matrix	Date Sampled	Date Received
001	CMR-MW103-191022	Aqueous	10/22/2019 1435	10/23/2019

(1 sample)

Detection Summary

Ramboll US Corporation

Lot Number: UJ23054

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	CMR-MW103-191022	Aqueous	Phosphorus	365.1	0.15		mg/L	5

(1 detection)

Inorganic non-metals

Client: Ramboll US Corporation
Laboratory ID: UJ23054-001
Description: CMR-MW103-191022
Matrix: Aqueous
Date Sampled: 10/22/2019 1435
Date Received: 10/23/2019

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		(Nitrate-Nitr) 353.2	1	10/25/2019 2216	AMR		33422
2		(Phosphorus) 365.1	1	10/31/2019 1735	MSG		34137

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	Units	Run
Nitrate-Nitrite - N		353.2	ND		0.020	mg/L	1
Phosphorus	7723-14-0	365.1	0.15		0.050	mg/L	2

LOQ = Limit of Quantitation
ND = Not detected at or above the LOQ
H = Out of holding time
B = Detected in the method blank
N = Recovery is out of criteria
W = Reported on wet weight basis
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%

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QC Summary

Inorganic non-metals - MB

Sample ID: UQ33422-001
Batch: 33422
Analytical Method: 353.2

Matrix: Aqueous

Parameter	Result	Q	Dil	LOQ	Units	Analysis Date
Nitrate-Nitrite - N	ND		1	0.020	mg/L	10/25/2019 2201

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection

P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ

N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Inorganic non-metals - LCS

Sample ID: UQ33422-002
Batch: 33422
Analytical Method: 353.2

Matrix: Aqueous

Parameter	Spike Amount (mg/L)	Result (mg/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Nitrate-Nitrite - N	0.80	0.77		1	96	90-110	10/25/2019 2202

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection

P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ

N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Inorganic non-metals - MB

Sample ID: UQ34137-001
Batch: 34137
Analytical Method: 365.1

Matrix: Aqueous

Parameter	Result	Q	Dil	LOQ	Units	Analysis Date
Phosphorus	ND		1	0.050	mg/L	10/31/2019 1718

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection

P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ

N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Inorganic non-metals - LCS

Sample ID: UQ34137-002
Batch: 34137
Analytical Method: 365.1

Matrix: Aqueous

Parameter	Spike Amount (mg/L)	Result (mg/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Phosphorus	1.0	1.0		1	102	90-110	10/31/2019 1721

LOQ = Limit of Quantitation
DL = Detection Limit
LOD = Limit of Detection

P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
ND = Not detected at or above the LOQ

N = Recovery is out of criteria
+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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Chain of Custody

and

Miscellaneous Documents

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Telephone No. 803-791-9700 Fax No. 803-791-9111
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SHEALY Chain of Custody Record

Number 099863

Client: Ramboll	Report to Contact: David Heidlauf	Telephone No. / E-mail: 312-288-3800	Quote No.: 27433
Address: 333 W Wacker Dr Ste #2700	Sampler's Signature: X	Analysis (Attach list if more space is needed)	Page ____ of ____
City: Chicago / State: IL / Zip Code: 60606	Printed Name: Pat Carson		
Project Name: Calumet (CMR)			
Project No.	P.O. No.		

Sample ID / Description (Containers for each sample may be combined on one line.)	Date	Time	# of Containers	Matrix: Aqueous	Matrix: Solid	Matrix: Non-Aqueous	No. of Containers by Preservative Type: Unpres.	HNO3	H2SO4	HCl	NaOH	ZnAc/NaOH	Nitrogen	Phosphorous	Remarks / Cooler I.D.
CMR-MW102-191022	10-22-19	1435	G	X				X					X	X	

UJ23054
KMN2

KC 10/22/19
KC 10/22/19

Turn Around Time Required (Prior lab approval required for expedited TAT.)	Sample Disposal	Possible Hazard Identification	QC Requirements (Specify)
☐ Standard ☐ Rush (Specify)	☐ Return to Client ☐ Disposal by Lab	☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison ☐ Unknown	

	Date	Time		Date	Time
1. Relinquished by	10-22-19	1700	1. Received by		
2. Relinquished by			2. Received by		
3. Relinquished by			3. Received by		
4. Relinquished by: Fed Ex	10/23/19	1027	4. Laboratory received by: L Hite	10/23/19	1027

Note: All samples are retained for four weeks from receipt unless other arrangements are made.

LAB USE ONLY
Received on Ice (Circle) (Yes) No Ice Pack
Receipt Temp. 3.6 °C

DISTRIBUTION: WHITE & YELLOW-Return to laboratory with Sample(s); PINK-Field/Client Copy

Document Number: F-AD-133 Effective Date: 08-01-2014

SHEALY ENVIRONMENTAL SERVICES, INC.

Shealy Environmental Services, Inc.
Document Number: ME0018C-14

Effective Date: 8/2/2018

Sample Receipt Checklist (SRC)

Client: RAMBOLL Cooler Inspected by/date: LKH / 10-23-2019 Lot #: UJ23054

Means of receipt: ☐ SESI ☐ Client ☐ UPS ☑ FedEx ☐ Other: _____

☑ Yes	☐ No		1. Were custody seals present on the cooler?
☑ Yes	☐ No	☐ NA	2. If custody seals were present, were they intact and unbroken?

pH Strip ID: 19-1760 Chlorine Strip ID: 19-1867 Tested by: LKH

Original temperature upon receipt / Derived (Corrected) temperature upon receipt %Solid Snap-Cup ID: NA

3.6 / 3.6 °C NA / NA °C NA / NA °C NA / NA °C

Method: ☑ Temperature Blank ☐ Against Bottles IR Gun ID: 5 IR Gun Correction Factor: 0 °C

Method of coolant: ☑ Wet Ice ☐ Ice Packs ☐ Dry Ice ☐ None

☐ Yes	☐ No	☑ NA	3. If temperature of any cooler exceeded 6.0°C, was Project Manager Notified? PM was Notified by: phone / email / face-to-face (circle one).
☑ Yes	☐ No	☐ NA	4. Is the commercial courier's packing slip attached to this form?
☑ Yes	☐ No		5. Were proper custody procedures (relinquished/received) followed?
☑ Yes	☐ No		6. Were sample IDs listed on the COC?
☑ Yes	☐ No		7. Were sample IDs listed on all sample containers?
☑ Yes	☐ No		8. Was collection date & time listed on the COC?
☑ Yes	☐ No		9. Was collection date & time listed on all sample containers?
☑ Yes	☐ No		10. Did all container label information (ID, date, time) agree with the COC?
☑ Yes	☐ No		11. Were tests to be performed listed on the COC?
☑ Yes	☐ No		12. Did all samples arrive in the proper containers for each test and/or in good condition (unbroken, lids on, etc.)? _____
☑ Yes	☐ No		13. Was adequate sample volume available?
☑ Yes	☐ No		14. Were all samples received within ½ the holding time or 48 hours, whichever comes first?
☐ Yes	☑ No		15. Were any samples containers missing/excess (circle one) samples Not listed on COC?
☐ Yes	☐ No	☑ NA	16. For VOA and RSK-175 samples, were bubbles present >"pea-size" (¼"or 6mm in diameter) in any of the VOA vials?
☑ Yes	☐ No	☐ NA	17. Were all DRO/metals/nutrient samples received at a pH of < 2?
☐ Yes	☐ No	☑ NA	18. Were all cyanide samples received at a pH > 12 and sulfide samples received at a pH > 9?
☑ Yes	☐ No	☐ NA	19. Were all applicable NH_3/TKN/cyanide/phenol/625 (< 0.5mg/L) samples free of residual chlorine?
☐ Yes	☐ No	☑ NA	20. Were client remarks/requests (i.e. requested dilutions, MS/MSD designations, etc…) correctly transcribed from the COC into the comment section in LIMS?
☑ Yes	☐ No		21. Was the quote number listed on the container label? If yes, Quote # 22433

Sample Preservation (Must be completed for any sample(s) incorrectly preserved or with headspace.)

Sample(s) NA were received incorrectly preserved and were adjusted accordingly in sample receiving with NA mL of circle one: H2SO4, HNO3, HCl, NaOH using SR # NA.
Time of preservation NA. If more than one preservative is needed, please note in the comments below.

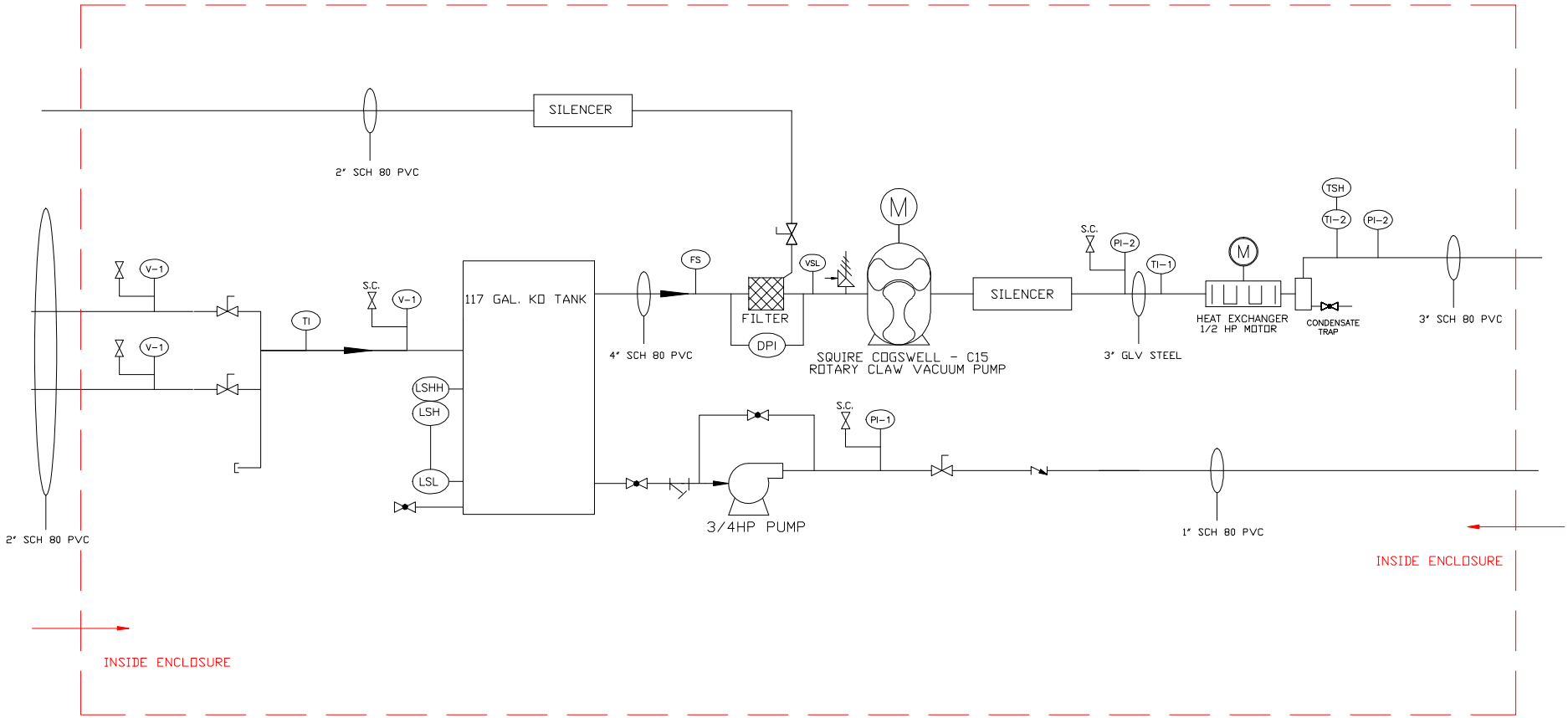
Sample(s) NA were received with bubbles >6 mm in diameter.

Samples(s) NA were received with TRC > 0.5 mg/L (If #19 is ***no***) and were adjusted accordingly in sample receiving with sodium thiosulfate ($Na_2S_2O_3$) with Shealy ID: NA.

SR barcode labels applied by: LKH Date: 10-23-2019

Comments:

APPENDIX D
AS/SVE Equipment Process and Instrumentation Diagram



RELIEF VALVE
GATE VALVE
S.C. SAMPLE CONNECTION/PORT
CHECK VALVE
BALL VALVE
BUTTERFLY VALVE

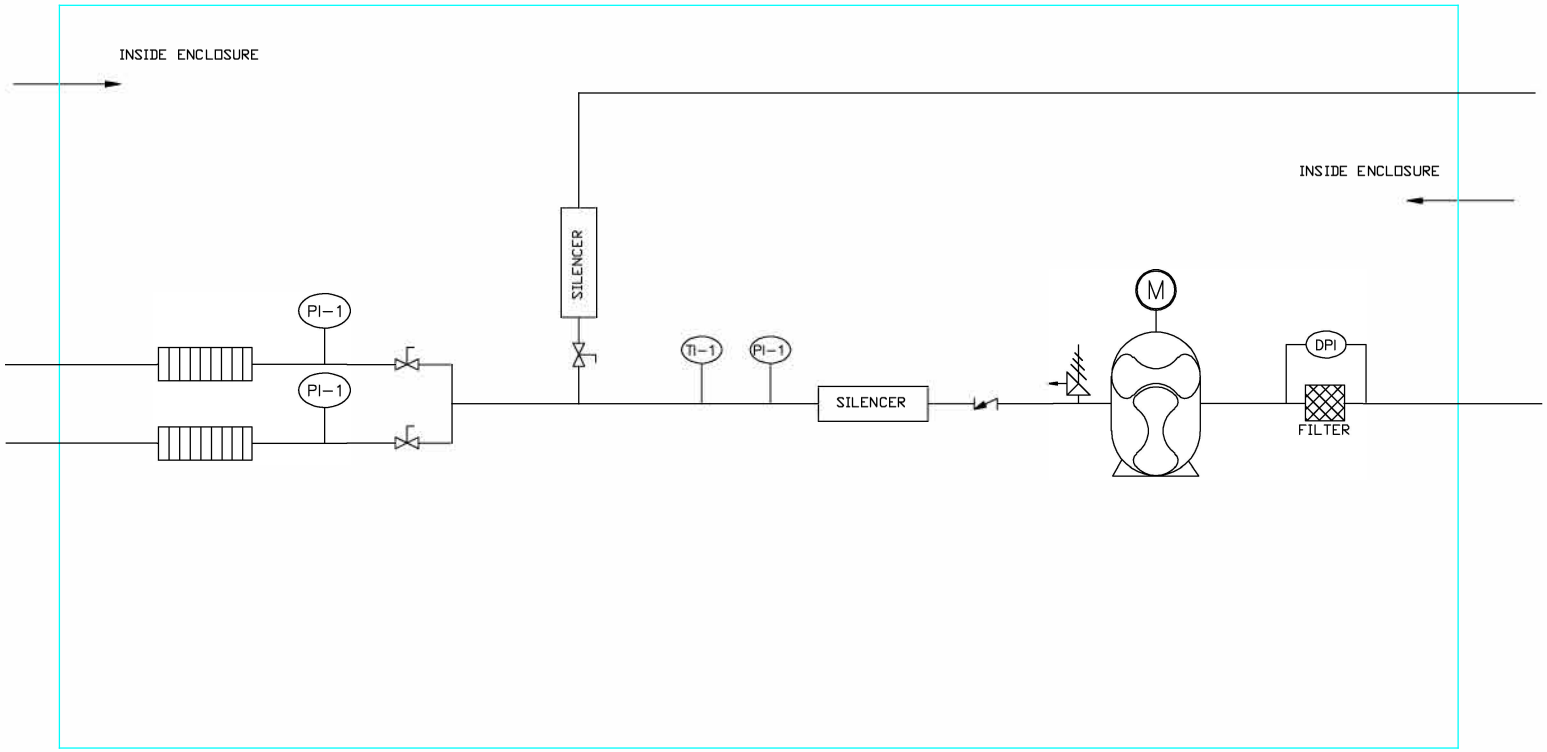
(V-1) VACUUM INDICATOR 0-30" HG
(DPI) DIFFERENTIAL PRESSURE INDICATOR
(TI) TEMPERATURE INDICATOR 0-250°
(TI-1) TEMPERATURE INDICATOR 50-450°
(TI-2) TEMPERATURE INDICATOR 32-160°
(PI-1) PRESSURE INDICATOR 0-30 PSI
(PI-2) PRESSURE INDICATOR 0-100" WC

(FS) PITOT TUBE FLOW SENSOR
(LSHH) LEVEL SWITCH HIGH-HIGH
(LSH) LEVEL SWITCH HIGH
(LSL) LEVEL SWITCH LOW
(VSL) VACUUM SWITCH LOW

SVE P&ID

RAMBOLL

4/10/18	SIZE	FSCM NO.	DWG NO. Q14811	REV
	SCALE NONE		SHEET 1 OF 1	



PI PRESSURE INDICATOR 0-60 PSI

TI-1 TEMPERATURE INDICATOR 50-400

RELIEF VALVE

BALL VALVE

GATE VALVE

CHECK VALVE

DWYER VFC-121 FLOWMETERS

5/14/18	SIZE	FSCM NO.	DWG NO. Q14811	REV
	SCALE NONE		SHEET 1 OF 1	

SPARGE P&ID

RAMBOLL

APPENDIX E
MDEQ Air Quality Bureau *De Minimis* Notification Letter and Approval

August 30, 2019

Mr. Shawn Juers
Montana Department of Environmental Quality
Air Quality Bureau Permitting Services Engineer
1520 E. Sixth Avenue P.O. Box 200901
Helena, MT 59620-0901

Re: De Minimis Notification for Soil Vapor Sampling
Calumet Montana Refining Great Falls Refinery

Mr. Juers:

Calumet Montana Refining, LLC (Calumet) owns and operates the Great Falls Refinery, located at 1900 10th Street Northeast in Great Falls, Montana. Calumet has contracted with Ramboll US Corporation (Ramboll) to conduct soil vapor sampling at three pilot test locations within the refinery to gather necessary information for upcoming soil remediation activities. Montana Department of Environmental Quality (MDEQ) recommended Calumet calculate potential emissions from the sampling event for comparison with the Montana air permit exclusion for de minimis changes (ARM 17.8.745).

Calumet determined potential volatile organic compound (VOC) emissions from the sampling event meet the de minimis change criteria, further described below, and this letter serves as required notification to MDEQ.

Sampling Event Description

On June 10, 2019 the AOC-16 Interim Measure Evaluation Report (Ramboll, 2019) (the "Report") was submitted to the MDEQ. The Report proposed field scale pilot tests for the selected interim measures technologies of biosparging, air sparging (AS), and soil vapor extraction (SVE). These technologies are briefly described below. The locations of the proposed pilot testing areas (south of AOC-16, area near MW-64, and north of North River Road, area near MW-41) are included as Attachment 1.

- AS/SVE systems involve the injection of air (AS) below the water table in an effort to drive the mass transfer of dissolved- and sorbed-phase contaminant mass into the flowing air stream. The injected air travels upward, through channels created in the saturated soil matrix, carrying the VOCs removed from the groundwater into the vadose zone soil. In the unsaturated zone, an SVE system extracts the impacted air and discharges vapor to the atmosphere.

The objectives of the pilot tests are to gather necessary information to design an interim measure remedial technology to stabilize and reduce hydrocarbon related groundwater concentrations to below applicable standards and prevent migration of the dissolved

phase groundwater downgradient in the areas immediately south of AOC-16 and immediately north of North River Road in the right-of-way (ROW). Additionally, the pilot tests will allow quantification of the extractable vapor-phase petroleum VOCs. This quantification of extractable vapor will be used for the design of the interim measure and potential treatment requirements. A follow on air permit is expected late 2018, early 2019 for a summer 2020 startup of a full system.

Potential Emissions

Over a total of three days, air samples will be collected from three different pilot test locations. Potential VOC emissions from the sampling event are based on the maximum concentrations of known VOCs in the soil vapor near the sampling locations, the maximum SVE extraction rate (325 cubic feet per minute), and continuous operation for the three-day sampling period. Based on these conservative emission calculations, potential VOC emissions from the pilot test equal 1.03 tons. Detailed emission calculations are included as Attachment 2.

Regulatory Review

Calumet reviewed federal and Montana environmental regulations to determine air quality regulations that may apply to the sampling activities addressed by this notification.

New Source Performance Standards

New Source Performance Standards (NSPS) are nationally uniform standards applied to specific categories of stationary sources that are constructed, modified, or reconstructed after the standard was proposed. NSPS are found in Title 40, Part 60 of the Code of Federal Regulations (CFR). NSPS usually represent a minimum level of control that is required on a new source.

There are no NSPS that are applicable to planned air sampling activities.

National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61)

The regulations contained in 40 CFR part 61 establish emission standards, work practices, or both for certain source categories of hazardous air pollutant (HAP) emissions. 40 CFR part 61 represents the federal regulatory mechanism used to regulate HAPs under the CAA before the CAA was amended November 15, 1990. The emission standards under 40 CFR part 61 represent risk-based standards that are intended to provide an ample margin of safety to protect public health.

There are no applicable NESHAPs, under Part 61, for the planned air sampling activities.

National Emission Standards for Hazardous Air Pollutants (40 CFR Part 63)

The regulations contained in 40 CFR part 63 establish emission standards for certain source categories of HAP emissions. This part represents the federal regulatory mechanism used to regulate HAPs under the CAA after the CAA was amended November 15, 1990.

A key component of regulatory applicability under 40 CFR part 63 is the distinction between a "major source" and an "area source" of HAPs. In short, a major source is a stationary source that emits or has the potential to emit considering controls, in the aggregate, 10 tpy or more of any HAP or 25 tpy or more of any combination of HAPs. An area source means "any stationary source of HAPs that is not a major source as defined in this part."

The Great Falls Refinery is a "major source" under 40 CFR part 63. As a result, the refinery is potentially subject to 40 CFR part 63 emission standards that are applicable to major sources of HAPs.

The only potentially applicable NESHAP for the sampling activities is Subpart GGGGG (Site Remediation). However, sampling is not subject to any requirements under this NESHAP because monitoring and measuring of contamination using wells or by sampling is not considered site remediation.[1]

ARM, Title 17 – Environmental Quality, Chapter 8 – Air Quality Regulations

The regulations contained in ARM, Title 17 – Environmental Quality, Chapter 8 address, among other things, air quality permitting applicability and procedures for new and existing stationary sources of regulated air pollutants, emission standards and limitations for new and existing stationary sources of regulated air pollutants, control technology requirements for new and existing stationary sources of regulated air pollutants, and ambient air standards in Montana.

New Source Review

New Source Review (NSR) is a pre-construction permitting program applicable to certain stationary sources. The primary purpose of NSR is to support the attainment and maintenance of specific ambient air quality standards across the country. The Great Falls Refinery is located in Cascade County, which is designated under the Clean Air Act (CAA) as attainment/unclassified for all criteria pollutants; therefore, the potential emissions from proposed sampling event are compared to applicable Prevention of Significant Deterioration (PSD) permitting thresholds (ARM 17.8, Subchapter 8).

Potential VOC emissions from the sampling event (1.03 tons) are less than the PSD significant emission rate of 40 tons per year, and PSD review is not required for this project.

Exclusion for De Minimis Changes

ARM 17.8.745 identifies the criteria for de minimis changes that do not require a Montana air quality permit (MAQP), as well as the criteria for de minimis changes that require the owner or operator to provide notice to the MDEQ.

[1] Definition of "Site Remediation" in 40 CFR 63.7957.

An MAQP is not required under ARM 17.8.743 for a de minimis change that meets the following criteria.

ARM 17.8.745(1)(a). Construction or changed conditions of operation at a facility for which a Montana air quality permit has been issued that do not increase the facility's potential to emit by more than five tons per year of any pollutant except:

The refinery's potential to emit will not increase by more than 5 tpy for any pollutant as a result of the air sampling activities. The calculated potential VOC emissions from the three-day pilot test equal 1.03 tons.

ARM 17.8.745(1)(a)(i). Any construction or changed conditions of operation at a facility that would violate any condition in the facility's existing Montana air quality permit or any applicable rule contained in this chapter is prohibited, except as allowed in ARM 17.8.745(2);

Calumet does not propose any construction or changed conditions of operation at the refinery that would violate any condition in the refinery's existing MAQP or any applicable rule contained in ARM, Title 17 – Environmental Quality, Chapter 8 – Air Quality.

ARM 17.8.745(1)(a)(ii). Any construction or changed conditions of operation at a facility that would qualify as a major modification of a major stationary source under subchapters 8 (PSD), 9 (NNSR), or 10 (new major stationary source or major modification causing or contributing to a violation of a national ambient air quality standard) of this chapter;

The planned sampling event will not be a “major modification” under subchapters 8, 9, or 10 of ARM, Title 17 – Environmental Quality, Chapter 8 – Air Quality.

ARM 17.8.745(1)(a)(iii). Any construction or changed conditions of operation at a facility that would affect the plume rise or dispersion characteristics of the emissions in a manner that would cause or contribute to a violation of an ambient air quality standard or an ambient air increment, as defined in ARM 17.8.804;

Calumet does not anticipate any measurable impact from the sampling event with respect to any ambient air quality standard or ambient air increment.

ARM 17.8.745(1)(a)(iv). Any construction or improvement project with a potential to emit more than five tons per year may not be artificially split into smaller projects to avoid permitting under this subchapter; and

Calumet is conducting this temporary sampling to gather necessary information to design an interim measure remedial technology to stabilize and reduce hydrocarbon related groundwater concentrations.

ARM 17.8.745(1)(a)(v). Emission reductions obtained through offsetting within a facility are not included when determining the potential emission increase from construction or changed conditions of operation, unless such reductions are made federally enforceable.

The planned sampling does not include any offsetting associated with emission reductions at the refinery.

ARM 17.8.745(1)(b). The owner or operator of any facility making a de minimis change pursuant to ARM 17.8.745(1)(a) shall notify the department if the change would include addition of a new emissions unit, a change in control equipment, stack height, stack diameter, stack flow, stack gas temperature, source location, or fuel specifications, or would result in an increase in source capacity above its permitted operation.

The planned sampling will temporarily release emissions to the atmosphere over a three-day period. At MDEQ's request, Calumet is submitting this de minimis change notification.

The following is a summary of the information included with the de minimis change notification.

ARM 17.8.745(1)(d). If notice is required under ARM 17.8.745(1)(b), the owner or operator shall submit the following information to the department in writing at least ten days prior to startup or use of the proposed de minimis change or as soon as reasonably practicable in the event of an unanticipated circumstance causing the de minimis change:

This de minimis change notification is being submitted to MDEQ prior to the sampling event that is currently planned for September 2019.

ARM 17.8.745(1)(d)(i). A description of the proposed de minimis change requiring notice, including the anticipated date of the change;

The proposed de minimis change is described earlier in this notification document.

ARM 17.8.745(1)(d)(ii). Sufficient information to calculate the potential emissions resulting from the proposed de minimis change;

The potential to emit calculations are included as Attachment 2 for MDEQ review.

ARM 17.8.745(1)(d)(iii). If applicable, an explanation of the unanticipated circumstance causing the change.

No explanation is required because no unanticipated circumstance is involved with the planned sampling.

Summary

Calumet prepared this de minimis notification after consulting with MDEQ staff and applicable requirements in ARM Title 17, Chapter 8, Subchapter 7, Air Quality. The planned sampling event will gather necessary information for upcoming soil remediation activities.

Closing

Please feel free to call me at 406-454-9887 if you have any questions about this de minimis change notification.

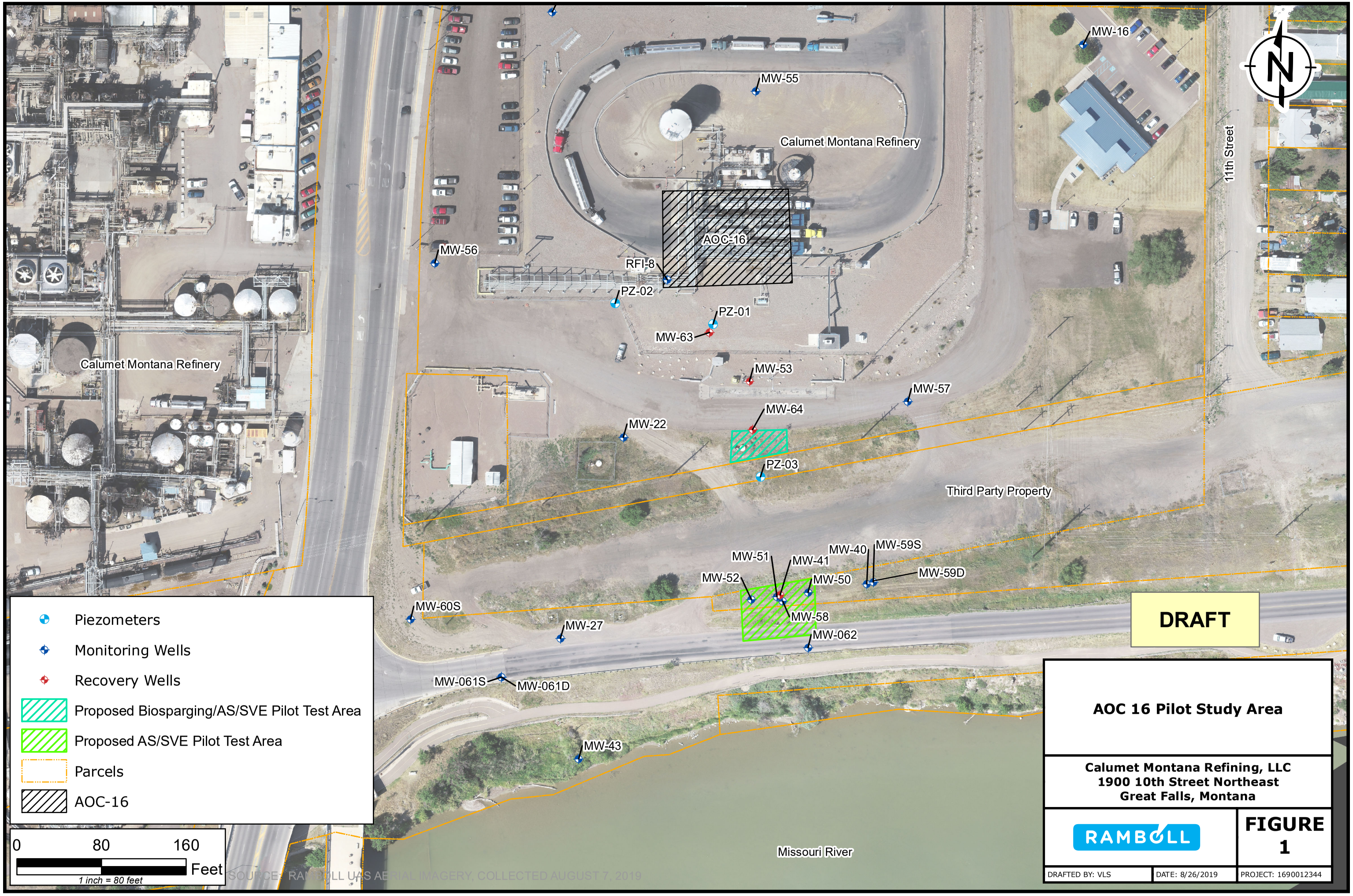
Sincerely,

Joe Dauner
Environmental Manager

ENCLOSURE

Attachment 1

Pilot Test Study Area


MW-16
MW-55
Calumet Montana Refinery
11th Street
AOC-16
MW-56
RFI-8
PZ-02
PZ-01
MW-63
Calumet Montana Refinery
MW-53
MW-57
MW-64
MW-22
PZ-03
Third Party Property
MW-51
MW-40
MW-59S
MW-41
MW-52
MW-50
MW-59D
MW-58
MW-60S
MW-27
MW-062
MW-061S
MW-061D
MW-43
Missouri River
Piezometers
Monitoring Wells
Recovery Wells
Proposed Biosparging/AS/SVE Pilot Test Area
Proposed AS/SVE Pilot Test Area
Parcels
AOC-16
0
80
160
Feet
1 inch = 80 feet
SOURCE: RAMBOLL UAS AERIAL IMAGERY, COLLECTED AUGUST 7, 2019
DRAFT
AOC 16 Pilot Study Area
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana
RAMBOLL
FIGURE 1
DRAFTED BY: VLS
DATE: 8/26/2019
PROJECT: 1690012344
K:\GIS\PROJECT\2018\CALUMET\DOCS\AOC16 2019\Fig1_PilotStudyArea.mxd

Attachment 2

Potential to Emit Calculations

Estimated Emission Rate Calculation
Biosparging/Air Sparge/SVE Remediation System
CMR - Great Falls, Montana

Individual VOC Components	Maximum Measured Vapor Concentration [1] (milligrams per cubic meter)	Maximum SVE Flow Rate [2] (SCFM)	Estimated Maximum Hourly Emissions [3] (pounds per hour)	Estimated Daily Emissions (tons per 24-hours)
Benzene	79	325	0.10	0.0012
C5-C8, Aliphatic	22,000	325	26.78	0.32
C9-C12, Aliphatic	22	325	0.03	0.00032
Cyclohexane	180	325	0.22	0.0026
Heptane	160	325	0.19	0.0023
Hexane	970	325	1.18	0.014
m,p-Xylene	18	325	0.02	0.00026
Octane	16	325	0.02	0.00023
Tetrachloroethene	0.18	325	0.00	0.0000026
Toluene	62	325	0.08	0.0009
Total VOC	--	--	**28.62**	**0.34**

Total VOC for Test Period (3 Days) [4] = 1.03 tons

Notes:
SVP = Soil Vapor Point
VOC = Volatile Organic Compound
SVE = Soil Vapor Extraction
SCFM = Standard Cubic Feet per Minute

1 - Maximum measured soil vapor concentration data from SVP-04 VOC (near monitoring well 41).
2 - Maximum vapor extraction rate from pilot test equipment.
3 - Hourly emissions based on maximum VOC concentration and maximum SVE extraction flow rate.
4 - Total emissions during testing based on hourly emissions, 24-hours per day, and 3 days for testing.

8/30/2019

Joe Dauner
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, MT 59404

Sent via Electronic Mail to: joseph.dauner@calumetspecialty.com

RE: Montana Air Quality Permit (MAQP) *de minimis* Permitting Exclusion Concurrence
Soil Vapor Sampling Pilot Study

Dear Mr. Dauner:

The Montana Department of Environmental Quality – Air Quality Bureau (DEQ-AQB) received from Calumet Montana Refining, LLC (Calumet) a de minimis notification regarding volatile organic compound emissions to occur as part of soil vapor sampling at three pilot test locations within the refinery. The purpose of this letter is to provide DEQ-AQB's written concurrence regarding applicability of the permitting exclusion provided by the Administrative Rules of Montana (ARM) 17.8.745 to this pilot study project.

Based on review of the project, DEQ-AQB finds that operation of this pilot project would not violate any condition in the current MAQP, would not be considered a major modification of a major stationary source, would not be expected to cause or contribute to a violation of an ambient air quality standard or increment, and would not have the potential to emit more than five tons per year. As such, this project qualifies for the permitting exclusion provided by ARM 17.8.745. Under the circumstances of needing to commence operation of a pilot study to appropriately design a soil vapor extraction system, DEQ-AQB accepts Calumet's letter received August 30, 2019 as satisfying, in full, the notification requirements of ARM 17.8.745(1)(b) and (d). DEQ–AQB confirms that the 10-day waiting period is waived to accommodate the start of the pilot testing as soon as practical.

Should you have any comments, questions, or concerns, feel free to contact me at sjuers@mt.gov or via phone at 406.444.2049.

Sincerely,

Shawn Juers
Air Quality Engineer

ec: Denise Kirkpatrick, Hazardous Waste Specialist, MT DEQ

APPENDIX F
Soil Vapor Analytical Laboratory Report

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

November 06, 2019

Paul Lindquist
Ramboll

,

RE: Project: 1690014124-002 CMR
Pace Project No.: 10497512

Dear Paul Lindquist:
Enclosed are the analytical results for sample(s) received by the laboratory on October 30, 2019. The results relate only to the samples included in this report. Results reported herein conform to the most current, applicable TNI/NELAC standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Carolynne Trout

Carolynne Trout
carolynne.trout@pacelabs.com
1(612)607-6351
Project Manager

Enclosures

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

CERTIFICATIONS

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Minnesota Certification IDs

1700 Elm Street SE, Minneapolis, MN 55414-2485
A2LA Certification #: 2926.01
Alabama Certification #: 40770
Alaska Contaminated Sites Certification #: 17-009
Alaska DW Certification #: MN00064
Arizona Certification #: AZ0014
Arkansas DW Certification #: MN00064
Arkansas WW Certification #: 88-0680
California Certification #: 2929
CNMI Saipan Certification #: MP0003
Colorado Certification #: MN00064
Connecticut Certification #: PH-0256
EPA Region 8+Wyoming DW Certification #: via MN 027-053-137
Florida Certification #: E87605
Georgia Certification #: 959
Guam EPA Certification #: MN00064
Hawaii Certification #: MN00064
Idaho Certification #: MN00064
Illinois Certification #: 200011
Indiana Certification #: C-MN-01
Iowa Certification #: 368
Kansas Certification #: E-10167
Kentucky DW Certification #: 90062
Kentucky WW Certification #: 90062
Louisiana DEQ Certification #: 03086
Louisiana DW Certification #: MN00064
Maine Certification #: MN00064
Maryland Certification #: 322
Massachusetts Certification #: M-MN064
Michigan Certification #: 9909
Minnesota Certification #: 027-053-137
Minnesota Dept of Ag Certifcation #: via MN 027-053-137
Minnesota Petrofund Certification #: 1240
Mississippi Certification #: MN00064
Missouri Certification #: 10100
Montana Certification #: CERT0092
Nebraska Certification #: NE-OS-18-06
Nevada Certification #: MN00064
New Hampshire Certification #: 2081
New Jersey Certification #: MN002
New York Certification #: 11647
North Carolina DW Certification #: 27700
North Carolina WW Certification #: 530
North Dakota Certification #: R-036
Ohio DW Certification #: 41244
Ohio VAP Certification #: CL101
Oklahoma Certification #: 9507
Oregon Primary Certification #: MN300001
Oregon Secondary Certification #: MN200001
Pennsylvania Certification #: 68-00563
Puerto Rico Certification #: MN00064
South Carolina Certification #:74003001
Tennessee Certification #: TN02818
Texas Certification #: T104704192
Utah Certification #: MN00064
Vermont Certification #: VT-027053137
Virginia Certification #: 460163
Washington Certification #: C486
West Virginia DEP Certification #: 382
West Virginia DW Certification #: 9952 C
Wisconsin Certification #: 999407970
Wyoming UST Certification #: via A2LA 2926.01

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

SAMPLE SUMMARY

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Lab ID	Sample ID	Matrix	Date Collected	Date Received
10497512001	**SVE-1 20191024**	Air	10/24/19 14:35	10/30/19 10:30
10497512002	**SVE-2B 20191023**	Air	10/23/19 14:30	10/30/19 10:30
10497512003	**UNUSED CAN #3256**	Air		10/30/19 10:30
10497512004	**UNUSED CAN #2085**	Air		10/30/19 10:30
10497512005	**UNUSED CAN #3282**	Air		10/30/19 10:30
10497512006	**UNUSED CAN #3123**	Air		10/30/19 10:30
10497512007	**UNUSED CAN #2515**	Air		10/30/19 10:30
10497512008	**UNUSED CAN #0905**	Air		10/30/19 10:30
10497512009	**UNUSED CAN #0996**	Air		10/30/19 10:30

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

SAMPLE ANALYTE COUNT

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Lab ID	Sample ID	Method	Analysts	Analytes Reported
10497512001	**SVE-1 20191024**	TO-15	MJL	61
10497512002	**SVE-2B 20191023**	TO-15	MJL	61

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

PROJECT NARRATIVE

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Method: **TO-15**
Description: TO15 MSV AIR
Client: Ramboll Environ- WI AIR
Date: November 06, 2019

General Information:
2 samples were analyzed for TO-15. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

QC Batch: 642772

CH: The continuing calibration for this compound is outside of Pace Analytical acceptance limits. The results may be biased high.

- LCS (Lab ID: 3461265)
  - Hexachloro-1,3-butadiene

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

QC Batch: 642772

L3: Analyte recovery in the laboratory control sample (LCS) exceeded QC limits. Analyte presence below reporting limits in associated samples.

- LCS (Lab ID: 3461265)
  - Hexachloro-1,3-butadiene

Additional Comments:

Analyte Comments:

QC Batch: 642772

E: Analyte concentration exceeded the calibration range. The reported result is estimated.

- SVE-2B 20191023 (Lab ID: 10497512002)
  - Cyclohexane
  - n-Hexane

This data package has been reviewed for quality and completeness and is approved for release.

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

ANALYTICAL RESULTS

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Sample: SVE-1 20191024 **Lab ID: 10497512001** Collected: 10/24/19 14:35 Received: 10/30/19 10:30 Matrix: Air

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
TO15 MSV AIR	Analytical Method: TO-15							
Acetone	ND	ug/m3	25900	10752		11/04/19 19:48	67-64-1	
Benzene	**46100**	ug/m3	3490	10752		11/04/19 19:48	71-43-2	
Benzyl chloride	ND	ug/m3	28300	10752		11/04/19 19:48	100-44-7	
Bromodichloromethane	ND	ug/m3	14600	10752		11/04/19 19:48	75-27-4	
Bromoform	ND	ug/m3	56400	10752		11/04/19 19:48	75-25-2	
Bromomethane	ND	ug/m3	8480	10752		11/04/19 19:48	74-83-9	
1,3-Butadiene	ND	ug/m3	4840	10752		11/04/19 19:48	106-99-0	
2-Butanone (MEK)	ND	ug/m3	32300	10752		11/04/19 19:48	78-93-3	
Carbon disulfide	ND	ug/m3	6810	10752		11/04/19 19:48	75-15-0	
Carbon tetrachloride	ND	ug/m3	13800	10752		11/04/19 19:48	56-23-5	
Chlorobenzene	ND	ug/m3	10100	10752		11/04/19 19:48	108-90-7	
Chloroethane	ND	ug/m3	5760	10752		11/04/19 19:48	75-00-3	
Chloroform	ND	ug/m3	5330	10752		11/04/19 19:48	67-66-3	
Chloromethane	ND	ug/m3	4520	10752		11/04/19 19:48	74-87-3	
Cyclohexane	**285000**	ug/m3	18800	10752		11/04/19 19:48	110-82-7	
Dibromochloromethane	ND	ug/m3	18600	10752		11/04/19 19:48	124-48-1	
1,2-Dibromoethane (EDB)	ND	ug/m3	8400	10752		11/04/19 19:48	106-93-4	
1,2-Dichlorobenzene	ND	ug/m3	13100	10752		11/04/19 19:48	95-50-1	
1,3-Dichlorobenzene	ND	ug/m3	13100	10752		11/04/19 19:48	541-73-1	
1,4-Dichlorobenzene	ND	ug/m3	32900	10752		11/04/19 19:48	106-46-7	
Dichlorodifluoromethane	ND	ug/m3	10900	10752		11/04/19 19:48	75-71-8	
1,1-Dichloroethane	ND	ug/m3	8850	10752		11/04/19 19:48	75-34-3	
1,2-Dichloroethane	ND	ug/m3	4420	10752		11/04/19 19:48	107-06-2	
1,1-Dichloroethene	ND	ug/m3	8670	10752		11/04/19 19:48	75-35-4	
cis-1,2-Dichloroethene	ND	ug/m3	8670	10752		11/04/19 19:48	156-59-2	
trans-1,2-Dichloroethene	ND	ug/m3	8670	10752		11/04/19 19:48	156-60-5	
1,2-Dichloropropane	ND	ug/m3	10100	10752		11/04/19 19:48	78-87-5	
cis-1,3-Dichloropropene	ND	ug/m3	9920	10752		11/04/19 19:48	10061-01-5	
trans-1,3-Dichloropropene	ND	ug/m3	9920	10752		11/04/19 19:48	10061-02-6	
Dichlorotetrafluoroethane	ND	ug/m3	15300	10752		11/04/19 19:48	76-14-2	
Ethanol	ND	ug/m3	20600	10752		11/04/19 19:48	64-17-5	
Ethyl acetate	ND	ug/m3	7880	10752		11/04/19 19:48	141-78-6	
Ethylbenzene	ND	ug/m3	9490	10752		11/04/19 19:48	100-41-4	
4-Ethyltoluene	ND	ug/m3	26900	10752		11/04/19 19:48	622-96-8	
n-Heptane	**18000**	ug/m3	8960	10752		11/04/19 19:48	142-82-5	
Hexachloro-1,3-butadiene	ND	ug/m3	58300	10752		11/04/19 19:48	87-68-3	
n-Hexane	**434000**	ug/m3	7700	10752		11/04/19 19:48	110-54-3	
2-Hexanone	ND	ug/m3	44700	10752		11/04/19 19:48	591-78-6	
Methylene Chloride	ND	ug/m3	38000	10752		11/04/19 19:48	75-09-2	
4-Methyl-2-pentanone (MIBK)	ND	ug/m3	44700	10752		11/04/19 19:48	108-10-1	
Methyl-tert-butyl ether	ND	ug/m3	39400	10752		11/04/19 19:48	1634-04-4	
Naphthalene	ND	ug/m3	28600	10752		11/04/19 19:48	91-20-3	
2-Propanol	ND	ug/m3	26900	10752		11/04/19 19:48	67-63-0	
Propylene	ND	ug/m3	3760	10752		11/04/19 19:48	115-07-1	
Styrene	ND	ug/m3	9310	10752		11/04/19 19:48	100-42-5	
1,1,2,2-Tetrachloroethane	ND	ug/m3	7500	10752		11/04/19 19:48	79-34-5	
Tetrachloroethene	ND	ug/m3	7410	10752		11/04/19 19:48	127-18-4	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

ANALYTICAL RESULTS

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Sample: SVE-1 20191024 **Lab ID: 10497512001** Collected: 10/24/19 14:35 Received: 10/30/19 10:30 Matrix: Air

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
TO15 MSV AIR	Analytical Method: TO-15							
Tetrahydrofuran	ND	ug/m3	6450	10752		11/04/19 19:48	109-99-9	
Toluene	**10900**	ug/m3	8240	10752		11/04/19 19:48	108-88-3	
1,2,4-Trichlorobenzene	ND	ug/m3	81100	10752		11/04/19 19:48	120-82-1	
1,1,1-Trichloroethane	ND	ug/m3	11900	10752		11/04/19 19:48	71-55-6	
1,1,2-Trichloroethane	ND	ug/m3	5970	10752		11/04/19 19:48	79-00-5	
Trichloroethene	ND	ug/m3	5870	10752		11/04/19 19:48	79-01-6	
Trichlorofluoromethane	ND	ug/m3	12300	10752		11/04/19 19:48	75-69-4	
1,1,2-Trichlorotrifluoroethane	ND	ug/m3	16800	10752		11/04/19 19:48	76-13-1	
1,2,4-Trimethylbenzene	ND	ug/m3	10700	10752		11/04/19 19:48	95-63-6	
1,3,5-Trimethylbenzene	ND	ug/m3	10700	10752		11/04/19 19:48	108-67-8	
Vinyl acetate	ND	ug/m3	7700	10752		11/04/19 19:48	108-05-4	
Vinyl chloride	ND	ug/m3	2800	10752		11/04/19 19:48	75-01-4	
m&p-Xylene	ND	ug/m3	19000	10752		11/04/19 19:48	179601-23-1	
o-Xylene	ND	ug/m3	9490	10752		11/04/19 19:48	95-47-6	

Sample: SVE-2B 20191023 **Lab ID: 10497512002** Collected: 10/23/19 14:30 Received: 10/30/19 10:30 Matrix: Air

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
TO15 MSV AIR	Analytical Method: TO-15							
Acetone	ND	ug/m3	27000	11210		11/04/19 20:15	67-64-1	
Benzene	**481000**	ug/m3	3640	11210		11/04/19 20:15	71-43-2	
Benzyl chloride	ND	ug/m3	29500	11210		11/04/19 20:15	100-44-7	
Bromodichloromethane	ND	ug/m3	15200	11210		11/04/19 20:15	75-27-4	
Bromoform	ND	ug/m3	58900	11210		11/04/19 20:15	75-25-2	
Bromomethane	ND	ug/m3	8850	11210		11/04/19 20:15	74-83-9	
1,3-Butadiene	ND	ug/m3	5050	11210		11/04/19 20:15	106-99-0	
2-Butanone (MEK)	ND	ug/m3	33600	11210		11/04/19 20:15	78-93-3	
Carbon disulfide	ND	ug/m3	7100	11210		11/04/19 20:15	75-15-0	
Carbon tetrachloride	ND	ug/m3	14400	11210		11/04/19 20:15	56-23-5	
Chlorobenzene	ND	ug/m3	10500	11210		11/04/19 20:15	108-90-7	
Chloroethane	ND	ug/m3	6010	11210		11/04/19 20:15	75-00-3	
Chloroform	ND	ug/m3	5560	11210		11/04/19 20:15	67-66-3	
Chloromethane	ND	ug/m3	4710	11210		11/04/19 20:15	74-87-3	
Cyclohexane	**2920000**	ug/m3	19600	11210		11/04/19 20:15	110-82-7	E
Dibromochloromethane	ND	ug/m3	19400	11210		11/04/19 20:15	124-48-1	
1,2-Dibromoethane (EDB)	ND	ug/m3	8760	11210		11/04/19 20:15	106-93-4	
1,2-Dichlorobenzene	ND	ug/m3	13700	11210		11/04/19 20:15	95-50-1	
1,3-Dichlorobenzene	ND	ug/m3	13700	11210		11/04/19 20:15	541-73-1	
1,4-Dichlorobenzene	ND	ug/m3	34300	11210		11/04/19 20:15	106-46-7	
Dichlorodifluoromethane	ND	ug/m3	11300	11210		11/04/19 20:15	75-71-8	
1,1-Dichloroethane	ND	ug/m3	9230	11210		11/04/19 20:15	75-34-3	
1,2-Dichloroethane	ND	ug/m3	4610	11210		11/04/19 20:15	107-06-2	
1,1-Dichloroethene	ND	ug/m3	9040	11210		11/04/19 20:15	75-35-4	
cis-1,2-Dichloroethene	ND	ug/m3	9040	11210		11/04/19 20:15	156-59-2	
trans-1,2-Dichloroethene	ND	ug/m3	9040	11210		11/04/19 20:15	156-60-5	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, LLC
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ANALYTICAL RESULTS

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Sample: SVE-2B 20191023 **Lab ID: 10497512002** Collected: 10/23/19 14:30 Received: 10/30/19 10:30 Matrix: Air

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
TO15 MSV AIR	Analytical Method: TO-15							
1,2-Dichloropropane	ND	ug/m3	10500	11210		11/04/19 20:15	78-87-5	
cis-1,3-Dichloropropene	ND	ug/m3	10300	11210		11/04/19 20:15	10061-01-5	
trans-1,3-Dichloropropene	ND	ug/m3	10300	11210		11/04/19 20:15	10061-02-6	
Dichlorotetrafluoroethane	ND	ug/m3	15900	11210		11/04/19 20:15	76-14-2	
Ethanol	ND	ug/m3	21500	11210		11/04/19 20:15	64-17-5	
Ethyl acetate	ND	ug/m3	8220	11210		11/04/19 20:15	141-78-6	
Ethylbenzene	ND	ug/m3	9900	11210		11/04/19 20:15	100-41-4	
4-Ethyltoluene	ND	ug/m3	28000	11210		11/04/19 20:15	622-96-8	
n-Heptane	**195000**	ug/m3	9340	11210		11/04/19 20:15	142-82-5	
Hexachloro-1,3-butadiene	ND	ug/m3	60800	11210		11/04/19 20:15	87-68-3	
n-Hexane	**4120000**	ug/m3	8030	11210		11/04/19 20:15	110-54-3	E
2-Hexanone	ND	ug/m3	46600	11210		11/04/19 20:15	591-78-6	
Methylene Chloride	ND	ug/m3	39600	11210		11/04/19 20:15	75-09-2	
4-Methyl-2-pentanone (MIBK)	ND	ug/m3	46600	11210		11/04/19 20:15	108-10-1	
Methyl-tert-butyl ether	ND	ug/m3	41000	11210		11/04/19 20:15	1634-04-4	
Naphthalene	ND	ug/m3	29800	11210		11/04/19 20:15	91-20-3	
2-Propanol	ND	ug/m3	28000	11210		11/04/19 20:15	67-63-0	
Propylene	ND	ug/m3	3920	11210		11/04/19 20:15	115-07-1	
Styrene	ND	ug/m3	9710	11210		11/04/19 20:15	100-42-5	
1,1,2,2-Tetrachloroethane	ND	ug/m3	7830	11210		11/04/19 20:15	79-34-5	
Tetrachloroethene	ND	ug/m3	7730	11210		11/04/19 20:15	127-18-4	
Tetrahydrofuran	ND	ug/m3	6730	11210		11/04/19 20:15	109-99-9	
Toluene	**23400**	ug/m3	8590	11210		11/04/19 20:15	108-88-3	
1,2,4-Trichlorobenzene	ND	ug/m3	84500	11210		11/04/19 20:15	120-82-1	
1,1,1-Trichloroethane	ND	ug/m3	12400	11210		11/04/19 20:15	71-55-6	
1,1,2-Trichloroethane	ND	ug/m3	6220	11210		11/04/19 20:15	79-00-5	
Trichloroethene	ND	ug/m3	6120	11210		11/04/19 20:15	79-01-6	
Trichlorofluoromethane	ND	ug/m3	12800	11210		11/04/19 20:15	75-69-4	
1,1,2-Trichlorotrifluoroethane	ND	ug/m3	17500	11210		11/04/19 20:15	76-13-1	
1,2,4-Trimethylbenzene	ND	ug/m3	11200	11210		11/04/19 20:15	95-63-6	
1,3,5-Trimethylbenzene	ND	ug/m3	11200	11210		11/04/19 20:15	108-67-8	
Vinyl acetate	ND	ug/m3	8030	11210		11/04/19 20:15	108-05-4	
Vinyl chloride	ND	ug/m3	2920	11210		11/04/19 20:15	75-01-4	
m&p-Xylene	ND	ug/m3	19800	11210		11/04/19 20:15	179601-23-1	
o-Xylene	ND	ug/m3	9900	11210		11/04/19 20:15	95-47-6	

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QUALITY CONTROL DATA

Project: 1690014124-002 CMR
Pace Project No.: 10497512

QC Batch: 642772 Analysis Method: TO-15
QC Batch Method: TO-15 Analysis Description: TO15 MSV AIR Low Level
Associated Lab Samples: 10497512001, 10497512002

METHOD BLANK: 3461264 Matrix: Air
Associated Lab Samples: 10497512001, 10497512002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
1,1,1-Trichloroethane	ug/m3	ND	0.56	11/04/19 09:09	
1,1,2,2-Tetrachloroethane	ug/m3	ND	0.35	11/04/19 09:09	
1,1,2-Trichloroethane	ug/m3	ND	0.28	11/04/19 09:09	
1,1,2-Trichlorotrifluoroethane	ug/m3	ND	0.78	11/04/19 09:09	
1,1-Dichloroethane	ug/m3	ND	0.41	11/04/19 09:09	
1,1-Dichloroethene	ug/m3	ND	0.40	11/04/19 09:09	
1,2,4-Trichlorobenzene	ug/m3	ND	3.8	11/04/19 09:09	
1,2,4-Trimethylbenzene	ug/m3	ND	0.50	11/04/19 09:09	
1,2-Dibromoethane (EDB)	ug/m3	ND	0.39	11/04/19 09:09	
1,2-Dichlorobenzene	ug/m3	ND	0.61	11/04/19 09:09	
1,2-Dichloroethane	ug/m3	ND	0.21	11/04/19 09:09	
1,2-Dichloropropane	ug/m3	ND	0.47	11/04/19 09:09	
1,3,5-Trimethylbenzene	ug/m3	ND	0.50	11/04/19 09:09	
1,3-Butadiene	ug/m3	ND	0.22	11/04/19 09:09	
1,3-Dichlorobenzene	ug/m3	ND	0.61	11/04/19 09:09	
1,4-Dichlorobenzene	ug/m3	ND	1.5	11/04/19 09:09	
2-Butanone (MEK)	ug/m3	ND	1.5	11/04/19 09:09	
2-Hexanone	ug/m3	ND	2.1	11/04/19 09:09	
2-Propanol	ug/m3	ND	1.2	11/04/19 09:09	
4-Ethyltoluene	ug/m3	ND	1.2	11/04/19 09:09	
4-Methyl-2-pentanone (MIBK)	ug/m3	ND	2.1	11/04/19 09:09	
Acetone	ug/m3	ND	1.2	11/04/19 09:09	
Benzene	ug/m3	ND	0.16	11/04/19 09:09	
Benzyl chloride	ug/m3	ND	1.3	11/04/19 09:09	
Bromodichloromethane	ug/m3	ND	0.68	11/04/19 09:09	
Bromoform	ug/m3	ND	2.6	11/04/19 09:09	
Bromomethane	ug/m3	ND	0.39	11/04/19 09:09	
Carbon disulfide	ug/m3	ND	0.32	11/04/19 09:09	
Carbon tetrachloride	ug/m3	ND	0.64	11/04/19 09:09	
Chlorobenzene	ug/m3	ND	0.47	11/04/19 09:09	
Chloroethane	ug/m3	ND	0.27	11/04/19 09:09	
Chloroform	ug/m3	ND	0.25	11/04/19 09:09	
Chloromethane	ug/m3	ND	0.21	11/04/19 09:09	
cis-1,2-Dichloroethene	ug/m3	ND	0.40	11/04/19 09:09	
cis-1,3-Dichloropropene	ug/m3	ND	0.46	11/04/19 09:09	
Cyclohexane	ug/m3	ND	0.88	11/04/19 09:09	
Dibromochloromethane	ug/m3	ND	0.86	11/04/19 09:09	
Dichlorodifluoromethane	ug/m3	ND	0.50	11/04/19 09:09	
Dichlorotetrafluoroethane	ug/m3	ND	0.71	11/04/19 09:09	
Ethanol	ug/m3	ND	0.96	11/04/19 09:09	
Ethyl acetate	ug/m3	ND	0.37	11/04/19 09:09	

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REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, LLC
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QUALITY CONTROL DATA

Project: 1690014124-002 CMR
Pace Project No.: 10497512

METHOD BLANK: 3461264 Matrix: Air
Associated Lab Samples: 10497512001, 10497512002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Ethylbenzene	ug/m3	ND	0.44	11/04/19 09:09	
Hexachloro-1,3-butadiene	ug/m3	ND	2.7	11/04/19 09:09	
m&p-Xylene	ug/m3	ND	0.88	11/04/19 09:09	
Methyl-tert-butyl ether	ug/m3	ND	1.8	11/04/19 09:09	
Methylene Chloride	ug/m3	ND	1.8	11/04/19 09:09	
n-Heptane	ug/m3	ND	0.42	11/04/19 09:09	
n-Hexane	ug/m3	ND	0.36	11/04/19 09:09	
Naphthalene	ug/m3	ND	1.3	11/04/19 09:09	
o-Xylene	ug/m3	ND	0.44	11/04/19 09:09	
Propylene	ug/m3	ND	0.18	11/04/19 09:09	
Styrene	ug/m3	ND	0.43	11/04/19 09:09	
Tetrachloroethene	ug/m3	ND	0.34	11/04/19 09:09	
Tetrahydrofuran	ug/m3	ND	0.30	11/04/19 09:09	
Toluene	ug/m3	ND	0.38	11/04/19 09:09	
trans-1,2-Dichloroethene	ug/m3	ND	0.40	11/04/19 09:09	
trans-1,3-Dichloropropene	ug/m3	ND	0.46	11/04/19 09:09	
Trichloroethene	ug/m3	ND	0.27	11/04/19 09:09	
Trichlorofluoromethane	ug/m3	ND	0.57	11/04/19 09:09	
Vinyl acetate	ug/m3	ND	0.36	11/04/19 09:09	
Vinyl chloride	ug/m3	ND	0.13	11/04/19 09:09	

LABORATORY CONTROL SAMPLE: 3461265

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
1,1,1-Trichloroethane	ug/m3	55.5	60.9	110	70-130	
1,1,2,2-Tetrachloroethane	ug/m3	69.8	70.3	101	70-132	
1,1,2-Trichloroethane	ug/m3	55.5	60.3	109	70-130	
1,1,2-Trichlorotrifluoroethane	ug/m3	77.9	91.0	117	70-130	
1,1-Dichloroethane	ug/m3	41.1	41.5	101	70-130	
1,1-Dichloroethene	ug/m3	40.3	46.2	115	70-130	
1,2,4-Trichlorobenzene	ug/m3	75.4	87.9	116	56-130	
1,2,4-Trimethylbenzene	ug/m3	50	57.5	115	70-134	
1,2-Dibromoethane (EDB)	ug/m3	78.1	87.2	112	70-130	
1,2-Dichlorobenzene	ug/m3	61.1	72.5	119	70-132	
1,2-Dichloroethane	ug/m3	41.1	44.4	108	70-130	
1,2-Dichloropropane	ug/m3	47	49.2	105	70-130	
1,3,5-Trimethylbenzene	ug/m3	50	58.4	117	70-132	
1,3-Butadiene	ug/m3	22.5	27.1	121	65-130	
1,3-Dichlorobenzene	ug/m3	61.1	73.2	120	70-137	
1,4-Dichlorobenzene	ug/m3	61.1	73.0	120	70-134	
2-Butanone (MEK)	ug/m3	30	32.2	107	70-130	
2-Hexanone	ug/m3	41.6	38.9	93	70-135	
2-Propanol	ug/m3	125	135	108	68-130	
4-Ethyltoluene	ug/m3	50	57.0	114	70-138	

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: 1690014124-002 CMR
Pace Project No.: 10497512

LABORATORY CONTROL SAMPLE: 3461265

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
4-Methyl-2-pentanone (MIBK)	ug/m3	41.6	40.1	96	70-131	
Acetone	ug/m3	121	129	107	67-130	
Benzene	ug/m3	32.5	33.0	102	70-130	
Benzyl chloride	ug/m3	52.6	52.6	100	70-130	
Bromodichloromethane	ug/m3	68.1	72.2	106	70-130	
Bromoform	ug/m3	105	122	116	70-132	
Bromomethane	ug/m3	39.5	47.7	121	69-130	
Carbon disulfide	ug/m3	31.6	35.3	112	56-137	
Carbon tetrachloride	ug/m3	64	68.5	107	66-131	
Chlorobenzene	ug/m3	46.8	52.1	111	70-130	
Chloroethane	ug/m3	26.8	33.2	124	70-130	
Chloroform	ug/m3	49.6	50.8	102	70-130	
Chloromethane	ug/m3	21	23.2	111	66-130	
cis-1,2-Dichloroethene	ug/m3	40.3	45.9	114	70-130	
cis-1,3-Dichloropropene	ug/m3	46.1	48.8	106	70-133	
Cyclohexane	ug/m3	35	36.3	104	68-132	
Dibromochloromethane	ug/m3	86.6	101	117	70-130	
Dichlorodifluoromethane	ug/m3	50.3	52.7	105	70-130	
Dichlorotetrafluoroethane	ug/m3	71	79.3	112	70-130	
Ethanol	ug/m3	95.8	103	108	68-133	
Ethyl acetate	ug/m3	36.6	35.9	98	69-130	
Ethylbenzene	ug/m3	44.1	48.5	110	67-131	
Hexachloro-1,3-butadiene	ug/m3	108	150	138	66-137	CH,L3
m&p-Xylene	ug/m3	88.3	99.2	112	70-132	
Methyl-tert-butyl ether	ug/m3	36.6	43.4	118	70-130	
Methylene Chloride	ug/m3	177	173	98	65-130	
n-Heptane	ug/m3	41.7	42.3	102	65-130	
n-Hexane	ug/m3	35.8	34.1	95	66-130	
Naphthalene	ug/m3	53.3	49.6	93	56-130	
o-Xylene	ug/m3	44.1	49.9	113	70-130	
Propylene	ug/m3	17.5	17.3	99	67-130	
Styrene	ug/m3	43.3	48.5	112	69-136	
Tetrachloroethene	ug/m3	68.9	87.0	126	70-130	
Tetrahydrofuran	ug/m3	30	30.7	102	68-131	
Toluene	ug/m3	38.3	41.6	109	70-130	
trans-1,2-Dichloroethene	ug/m3	40.3	46.0	114	70-130	
trans-1,3-Dichloropropene	ug/m3	46.1	48.0	104	70-134	
Trichloroethene	ug/m3	54.6	66.5	122	70-130	
Trichlorofluoromethane	ug/m3	57.1	65.0	114	65-130	
Vinyl acetate	ug/m3	35.8	39.6	111	61-133	
Vinyl chloride	ug/m3	26	31.7	122	70-130	

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REPORT OF LABORATORY ANALYSIS

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QUALIFIERS

Project: 1690014124-002 CMR
Pace Project No.: 10497512

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

TNTC - Too Numerous To Count

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit - The lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

ANALYTE QUALIFIERS

CH	The continuing calibration for this compound is outside of Pace Analytical acceptance limits. The results may be biased high.
E	Analyte concentration exceeded the calibration range. The reported result is estimated.
L3	Analyte recovery in the laboratory control sample (LCS) exceeded QC limits. Analyte presence below reporting limits in associated samples.

Pace Analytical Services, LLC
1700 Elm Street - Suite 200
Minneapolis, MN 55414
(612)607-1700

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 1690014124-002 CMR
Pace Project No.: 10497512

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
10497512001	**SVE-1 20191024**	TO-15	642772		
10497512002	**SVE-2B 20191023**	TO-15	642772		

Pace Analytical®
www.pacelabs.com

AIR: CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

45962

Page: 1 of 1

Section A Required Client Information:

Company: RAMBOLL
Address: 175 N. CORPORATE DR STE 160
Email To: plindquist@ramboll.com
Phone: Fax:
Requested Due Date/TAT: STANDARD

Section B Required Project Information:

Report To: PAUL LINDQUIST
Copy To:
Purchase Order No.: ~~1690014652~~
Project Name: ~~MT~~ CMR
Project Number: 1690014124-002

Section C Invoice Information:

Attention:
Company Name: RAMBOLL
Address:
Pace Quote Reference:
Pace Project Manager/Sales Rep.
Pace Profile #: 40492

Program: ☐ UST ☐ Superfund ☐ Emissions ☐ Clean Air Act ☐ Voluntary Clean Up ☐ Dry Clean ☐ RCRA ☐ Other

Location of Sampling by State: MT

Reporting Units: ug/m³ X mg/m³ X PPBV PPMV X Other

Report Level: II. III. IV. Other

Section D Required Client Information

AIR SAMPLE ID
Sample IDs MUST BE UNIQUE

Valid Media Codes

MEDIA	CODE
Tedlar Bag	TB
1 Liter Summa Can	1LC
6 Liter Summa Can	6LC
Low Volume Puff	LVP
High Volume Puff	HVP
Other	PM10

Method: PM10 | 3C - Fixed Gas (%) | TO-3 BTEX | TO-3M (Methane) | TO-14 | TO-15 Full List VOCs | TO-15 Short List BTEX | TO-15 Short List Chlorinated | TO-15 Short List (other)

ITEM #	Section D Required Client Information: AIR SAMPLE ID	MEDIA CODE	PID Reading (Client only)	COLLECTED COMPOSITE START DATE	COMPOSITE START TIME	COMPOSITE - END/GRAB DATE	COMPOSITE - END/GRAB TIME	Canister Pressure (Initial Field - in Hg)	Canister Pressure (Final Field - in Hg)	Summa Can Number	Flow Control Number	TO-14	TO-15 Full List VOCs	TO-15 Short List BTEX	Pace Lab ID
1	SVE-1 20191024	1LC		10/24	1425	10/24	1435	27.5	5	2546	~~1977~~ 1282		X		001
2	SVE-2B 20191023	1LC		10/23	1420	10/23	1430	25.5	5	2200	~~1978~~ 1304		X		002
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

WO#: 10497512

10497512

Comments:

SAMPLES COLLECTED FROM FREE PRODUCT AREA. POTENTIALLY PETROLEUM IMPACTED.

ORIGINAL

RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME
Paul L — RAMBOLL	10/25	1147	FEDEX	10/25	1147
			PACE	10/28/19	1030

SAMPLE CONDITIONS

Temp in °C	Received on Ice Y/N	Custody Sealed Cooler Y/N	Samples Intact Y/N
—	Y/N	Y/N	Y/N
	Y/N	Y/N	Y/N
	Y/N	Y/N	Y/N

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: PAUL LINDQUIST

SIGNATURE of SAMPLER: Paul L — DATE Signed (MM / DD / YY): 10/25/19

1700 Elm Street SE, Suite 200, Minneapolis, MN 55414 Air Technical Phone: 612.607.6386

Pace Analytical®	Document Name: Air Sample Condition Upon Receipt	Document Revised: 14Oct2019 Page 1 of 1
	Document No.: F-MN-A-106-rev.19	Issuing Authority: Pace Minnesota Quality Office

Air Sample Condition Upon Receipt **Client Name:** CMR/RAMBOLL **Project #:** **WO#: 10497512**

PM: CT1 **Due Date: 11/06/19**

CLIENT: Ramboll-WI

Courier: ☒Fed Ex ☐UPS ☐USPS ☐Client ☐Pace ☐SpeeDee ☐Commercial **See Exception** ☐

Tracking Number: 1083 0281 5948

Custody Seal on Cooler/Box Present? ☐Yes ☒No **Seals Intact?** ☐Yes ☒No

Packing Material: ☐Bubble Wrap ☐Bubble Bags ☒Foam ☐None ☐Tin Can ☐Other:_____ **Temp Blank rec:** ☐Yes ☒No

Temp. (TO17 and TO13 samples only) (°C): X **Corrected Temp (°C):** X **Thermometer Used:** ☐G87A9170600254 ☐G87A9155100842

Temp should be above freezing to 6°C **Correction Factor:** X **Date & Initials of Person Examining Contents:** 10/30/19 CMY

Type of ice Received ☐Blue ☐Wet ☒None

		Comments:
Chain of Custody Present?	☒Yes ☐No	1.
Chain of Custody Filled Out?	☒Yes ☐No	2.
Chain of Custody Relinquished?	☒Yes ☐No	3.
Sampler Name and/or Signature on COC?	☒Yes ☐No ☐N/A	4.
Samples Arrived within Hold Time?	☒Yes ☐No	5.
Short Hold Time Analysis (<72 hr)?	☐Yes ☒No	6.
Rush Turn Around Time Requested?	☐Yes ☒No	7.
Sufficient Volume?	☒Yes ☐No	8.
Correct Containers Used?	☒Yes ☐No	9.
-Pace Containers Used?	☒Yes ☐No	
Containers Intact?	☒Yes ☐No	10.
Media: (Air Can) Airbag Filter TDT Passive		11. Individually Certified Cans Y (N) (list which samples)
Is sufficient information available to reconcile samples to the COC?	☒Yes ☐No	12.
Do cans need to be pressurized? **(DO NOT PRESSURIZE 3C or ASTM 1946!!!)**	☒Yes ☐No	13.

Gauge # ☒10AIR26 ☐10AIR34 ☐10AIR35 ☐4097

Canisters					Canisters				
Sample Number	Can ID	Flow Controller	Initial Pressure	Final Pressure	10/30/19 CMY Sample Number	Can ID	Flow Controller	Initial Pressure	Final Pressure
SVE-1	2546	1287	-6	no	~~"~~	~~09~~			
SVE-2B	2200	1304	-7	no	"	0996	1300	-29.5	
UNUSED	3256	1289	-29.5						
"	2085	1347	-30						
"	3282	1465	-29						
"	3123	1499	-30						
"	2515	1305	-29.5						
"	0905	1331	-28						

CLIENT NOTIFICATION/RESOLUTION **Field Data Required?** ☐Yes ☐No

Person Contacted: _____ Date/Time: _____

Comments/Resolution: _____

Project Manager Review: Carolyne Trust **Date:** 10/31/19

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e out of hold, incorrect preservative, out of temp, incorrect containers)

Pace Analytical Services, LLC
1700 Elm Street, Suite 200
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645

Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512001 ProjSampleNum: 10497512001 Date Collected: 10/24/19 14:35
Client Sample ID: SVE-1 20191024 Matrix: Air Date Received: 10/30/19 10:30

Air

TO-15

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
1,1,1-Trichloroethane	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	71-55-6	
1,1,2,2-Tetrachloroethane	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	79-34-5	
1,1,2-Trichloroethane	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	79-00-5	
1,1,2-Trichlorotrifluoroethane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	76-13-1	
1,1-Dichloroethane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	75-34-3	
1,1-Dichloroethene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	75-35-4	
1,2,4-Trichlorobenzene	ND	ppmv	10.8	10752	11/04/19 19:48	MJL	120-82-1	
1,2,4-Trimethylbenzene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	95-63-6	
1,2-Dibromoethane (EDB)	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	106-93-4	
1,2-Dichlorobenzene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	95-50-1	
1,2-Dichloroethane	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	107-06-2	
1,2-Dichloropropane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	78-87-5	
1,3,5-Trimethylbenzene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	108-67-8	
1,3-Butadiene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	106-99-0	
1,3-Dichlorobenzene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	541-73-1	
1,4-Dichlorobenzene	ND	ppmv	5.4	10752	11/04/19 19:48	MJL	106-46-7	
2-Butanone (MEK)	ND	ppmv	10.8	10752	11/04/19 19:48	MJL	78-93-3	
2-Hexanone	ND	ppmv	10.7	10752	11/04/19 19:48	MJL	591-78-6	
2-Propanol	ND	ppmv	10.8	10752	11/04/19 19:48	MJL	67-63-0	
4-Ethyltoluene	ND	ppmv	5.4	10752	11/04/19 19:48	MJL	622-96-8	
4-Methyl-2-pentanone (MIBK)	ND	ppmv	10.7	10752	11/04/19 19:48	MJL	108-10-1	
Acetone	ND	ppmv	10.7	10752	11/04/19 19:48	MJL	67-64-1	
Benzene	14.2	ppmv	1.1	10752	11/04/19 19:48	MJL	71-43-2	
Benzyl chloride	ND	ppmv	5.4	10752	11/04/19 19:48	MJL	100-44-7	
Bromodichloromethane	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	75-27-4	
Bromoform	ND	ppmv	5.4	10752	11/04/19 19:48	MJL	75-25-2	
Bromomethane	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	74-83-9	
Carbon disulfide	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	75-15-0	
Carbon tetrachloride	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	56-23-5	
Chlorobenzene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	108-90-7	
Chloroethane	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	75-00-3	
Chloroform	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	67-66-3	
Chloromethane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	74-87-3	
cis-1,2-Dichloroethene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	156-59-2	
cis-1,3-Dichloropropene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	10061-01-5	
Cyclohexane	81.5	ppmv	5.4	10752	11/04/19 19:48	MJL	110-82-7	
Dibromochloromethane	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	124-48-1	
Dichlorodifluoromethane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	75-71-8	

SUPPLEMENTAL REPORT
Units Conversion Request

Pace Analytical Services, LLC
1700 Elm Street, Suite 200
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645

Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512001 ProjSampleNum: 10497512001 Date Collected: 10/24/19 14:35
Client Sample ID: SVE-1 20191024 Matrix: Air Date Received: 10/30/19 10:30

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
Air								
Dichlorotetrafluoroethane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	76-14-2	
Ethanol	ND	ppmv	10.8	10752	11/04/19 19:48	MJL	64-17-5	
Ethyl acetate	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	141-78-6	
Ethylbenzene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	100-41-4	
Hexachloro-1,3-butadiene	ND	ppmv	5.4	10752	11/04/19 19:48	MJL	87-68-3	
m&p-Xylene	ND	ppmv	4.3	10752	11/04/19 19:48	MJL	179601-23-1	
Methylene Chloride	ND	ppmv	10.8	10752	11/04/19 19:48	MJL	75-09-2	
Methyl-tert-butyl ether	ND	ppmv	10.8	10752	11/04/19 19:48	MJL	1634-04-4	
Naphthalene	ND	ppmv	5.4	10752	11/04/19 19:48	MJL	91-20-3	
n-Heptane	4.3	ppmv	2.2	10752	11/04/19 19:48	MJL	142-82-5	
n-Hexane	121	ppmv	2.1	10752	11/04/19 19:48	MJL	110-54-3	
o-Xylene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	95-47-6	
Propylene	ND	ppmv	2.1	10752	11/04/19 19:48	MJL	115-07-1	
Styrene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	100-42-5	
Tetrachloroethene	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	127-18-4	
Tetrahydrofuran	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	109-99-9	
Toluene	2.8	ppmv	2.2	10752	11/04/19 19:48	MJL	108-88-3	
trans-1,2-Dichloroethene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	156-60-5	
trans-1,3-Dichloropropene	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	10061-02-6	
Trichloroethene	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	79-01-6	
Trichlorofluoromethane	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	75-69-4	
Vinyl acetate	ND	ppmv	2.2	10752	11/04/19 19:48	MJL	108-05-4	
Vinyl chloride	ND	ppmv	1.1	10752	11/04/19 19:48	MJL	75-01-4	

DISCLAIMER: These results have been converted to the units shown from the original units of measurement assuming 20 degrees Celsius and 1 atmosphere pressure. Values were not rounded according to EPA rounding rules. THC is quantitated based on the average response factors of several compounds; the nominal molecular weight of THC used for units conversion is the average of the molecular weights of the compounds used for quantitation.

SUPPLEMENTAL REPORT
Units Conversion Request

Pace Analytical Services, LLC
1700 Elm Street, Suite 200
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645
Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512002 ProjSampleNum: 10497512002 Date Collected: 10/23/19 14:30
Client Sample ID: SVE-2B 20191023 Matrix: Air Date Received: 10/30/19 10:30

Air

TO-15

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
1,1,1-Trichloroethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	71-55-6	
1,1,2,2-Tetrachloroethane	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	79-34-5	
1,1,2-Trichloroethane	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	79-00-5	
1,1,2-Trichlorotrifluoroethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	76-13-1	
1,1-Dichloroethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-34-3	
1,1-Dichloroethene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-35-4	
1,2,4-Trichlorobenzene	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	120-82-1	
1,2,4-Trimethylbenzene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	95-63-6	
1,2-Dibromoethane (EDB)	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	106-93-4	
1,2-Dichlorobenzene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	95-50-1	
1,2-Dichloroethane	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	107-06-2	
1,2-Dichloropropane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	78-87-5	
1,3,5-Trimethylbenzene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	108-67-8	
1,3-Butadiene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	106-99-0	
1,3-Dichlorobenzene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	541-73-1	
1,4-Dichlorobenzene	ND	ppmv	5.6	11210	11/04/19 20:15	MJL	106-46-7	
2-Butanone (MEK)	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	78-93-3	
2-Hexanone	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	591-78-6	
2-Propanol	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	67-63-0	
4-Ethyltoluene	ND	ppmv	5.6	11210	11/04/19 20:15	MJL	622-96-8	
4-Methyl-2-pentanone (MIBK)	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	108-10-1	
Acetone	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	67-64-1	
Benzene	148	ppmv	1.1	11210	11/04/19 20:15	MJL	71-43-2	
Benzyl chloride	ND	ppmv	5.6	11210	11/04/19 20:15	MJL	100-44-7	
Bromodichloromethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-27-4	
Bromoform	ND	ppmv	5.6	11210	11/04/19 20:15	MJL	75-25-2	
Bromomethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	74-83-9	
Carbon disulfide	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-15-0	
Carbon tetrachloride	ND	ppmv	2.3	11210	11/04/19 20:15	MJL	56-23-5	
Chlorobenzene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	108-90-7	
Chloroethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-00-3	
Chloroform	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	67-66-3	
Chloromethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	74-87-3	
cis-1,2-Dichloroethene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	156-59-2	
cis-1,3-Dichloropropene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	10061-01-5	
Cyclohexane	835	ppmv	5.6	11210	11/04/19 20:15	MJL	110-82-7	E
Dibromochloromethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	124-48-1	
Dichlorodifluoromethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-71-8	

SUPPLEMENTAL REPORT
Units Conversion Request

Pace Analytical Services, LLC
1700 Elm Street, Suite 200
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645
Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512002 ProjSampleNum: 10497512002 Date Collected: 10/23/19 14:30
Client Sample ID: SVE-2B 20191023 Matrix: Air Date Received: 10/30/19 10:30

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
Air								
Dichlorotetrafluoroethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	76-14-2	
Ethanol	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	64-17-5	
Ethyl acetate	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	141-78-6	
Ethylbenzene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	100-41-4	
Hexachloro-1,3-butadiene	ND	ppmv	5.6	11210	11/04/19 20:15	MJL	87-68-3	
m&p-Xylene	ND	ppmv	4.5	11210	11/04/19 20:15	MJL	179601-23-1	
Methylene Chloride	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	75-09-2	
Methyl-tert-butyl ether	ND	ppmv	11.2	11210	11/04/19 20:15	MJL	1634-04-4	
Naphthalene	ND	ppmv	5.6	11210	11/04/19 20:15	MJL	91-20-3	
n-Heptane	46.8	ppmv	2.2	11210	11/04/19 20:15	MJL	142-82-5	
n-Hexane	1150	ppmv	2.2	11210	11/04/19 20:15	MJL	110-54-3	E
o-Xylene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	95-47-6	
Propylene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	115-07-1	
Styrene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	100-42-5	
Tetrachloroethene	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	127-18-4	
Tetrahydrofuran	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	109-99-9	
Toluene	6.1	ppmv	2.2	11210	11/04/19 20:15	MJL	108-88-3	
trans-1,2-Dichloroethene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	156-60-5	
trans-1,3-Dichloropropene	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	10061-02-6	
Trichloroethene	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	79-01-6	
Trichlorofluoromethane	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	75-69-4	
Vinyl acetate	ND	ppmv	2.2	11210	11/04/19 20:15	MJL	108-05-4	
Vinyl chloride	ND	ppmv	1.1	11210	11/04/19 20:15	MJL	75-01-4	

DISCLAIMER: These results have been converted to the units shown from the original units of measurement assuming 20 degrees Celsius and 1 atmosphere pressure. Values were not rounded according to EPA rounding rules. THC is quantitated based on the average response factors of several compounds; the nominal molecular weight of THC used for units conversion is the average of the molecular weights of the compounds used for quantitation.

Pace Analytical Services, LLC
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ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645

Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

PARAMETER FOOTNOTES

ND Not detected at or above adjusted reporting limit

NC Not Calculable

J Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

[E] Analyte concentration exceeded the calibration range. The reported result is estimated.

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ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645

Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512001 ProjSampleNum: 10497512001 Date Collected: 10/24/19 14:35
Client Sample ID: SVE-1 20191024 Matrix: Air Date Received: 10/30/19 10:30

Air

TO-15

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
1,1,1-Trichloroethane	ND	mg/m3	11.9	10752	11/04/19 19:48	MJL	71-55-6	
1,1,2,2-Tetrachloroethane	ND	mg/m3	7.5	10752	11/04/19 19:48	MJL	79-34-5	
1,1,2-Trichloroethane	ND	mg/m3	6	10752	11/04/19 19:48	MJL	79-00-5	
1,1,2-Trichlorotrifluoroethane	ND	mg/m3	16.8	10752	11/04/19 19:48	MJL	76-13-1	
1,1-Dichloroethane	ND	mg/m3	8.8	10752	11/04/19 19:48	MJL	75-34-3	
1,1-Dichloroethene	ND	mg/m3	8.7	10752	11/04/19 19:48	MJL	75-35-4	
1,2,4-Trichlorobenzene	ND	mg/m3	81.1	10752	11/04/19 19:48	MJL	120-82-1	
1,2,4-Trimethylbenzene	ND	mg/m3	10.7	10752	11/04/19 19:48	MJL	95-63-6	
1,2-Dibromoethane (EDB)	ND	mg/m3	8.4	10752	11/04/19 19:48	MJL	106-93-4	
1,2-Dichlorobenzene	ND	mg/m3	13.1	10752	11/04/19 19:48	MJL	95-50-1	
1,2-Dichloroethane	ND	mg/m3	4.4	10752	11/04/19 19:48	MJL	107-06-2	
1,2-Dichloropropane	ND	mg/m3	10.1	10752	11/04/19 19:48	MJL	78-87-5	
1,3,5-Trimethylbenzene	ND	mg/m3	10.7	10752	11/04/19 19:48	MJL	108-67-8	
1,3-Butadiene	ND	mg/m3	4.8	10752	11/04/19 19:48	MJL	106-99-0	
1,3-Dichlorobenzene	ND	mg/m3	13.1	10752	11/04/19 19:48	MJL	541-73-1	
1,4-Dichlorobenzene	ND	mg/m3	32.9	10752	11/04/19 19:48	MJL	106-46-7	
2-Butanone (MEK)	ND	mg/m3	32.3	10752	11/04/19 19:48	MJL	78-93-3	
2-Hexanone	ND	mg/m3	44.7	10752	11/04/19 19:48	MJL	591-78-6	
2-Propanol	ND	mg/m3	26.9	10752	11/04/19 19:48	MJL	67-63-0	
4-Ethyltoluene	ND	mg/m3	26.9	10752	11/04/19 19:48	MJL	622-96-8	
4-Methyl-2-pentanone (MIBK)	ND	mg/m3	44.7	10752	11/04/19 19:48	MJL	108-10-1	
Acetone	ND	mg/m3	25.9	10752	11/04/19 19:48	MJL	67-64-1	
Benzene	46.1	mg/m3	3.5	10752	11/04/19 19:48	MJL	71-43-2	
Benzyl chloride	ND	mg/m3	28.3	10752	11/04/19 19:48	MJL	100-44-7	
Bromodichloromethane	ND	mg/m3	14.6	10752	11/04/19 19:48	MJL	75-27-4	
Bromoform	ND	mg/m3	56.4	10752	11/04/19 19:48	MJL	75-25-2	
Bromomethane	ND	mg/m3	8.5	10752	11/04/19 19:48	MJL	74-83-9	
Carbon disulfide	ND	mg/m3	6.8	10752	11/04/19 19:48	MJL	75-15-0	
Carbon tetrachloride	ND	mg/m3	13.8	10752	11/04/19 19:48	MJL	56-23-5	
Chlorobenzene	ND	mg/m3	10.1	10752	11/04/19 19:48	MJL	108-90-7	
Chloroethane	ND	mg/m3	5.8	10752	11/04/19 19:48	MJL	75-00-3	
Chloroform	ND	mg/m3	5.3	10752	11/04/19 19:48	MJL	67-66-3	
Chloromethane	ND	mg/m3	4.5	10752	11/04/19 19:48	MJL	74-87-3	
cis-1,2-Dichloroethene	ND	mg/m3	8.7	10752	11/04/19 19:48	MJL	156-59-2	
cis-1,3-Dichloropropene	ND	mg/m3	9.9	10752	11/04/19 19:48	MJL	10061-01-5	
Cyclohexane	285	mg/m3	18.8	10752	11/04/19 19:48	MJL	110-82-7	
Dibromochloromethane	ND	mg/m3	18.6	10752	11/04/19 19:48	MJL	124-48-1	
Dichlorodifluoromethane	ND	mg/m3	10.9	10752	11/04/19 19:48	MJL	75-71-8	

SUPPLEMENTAL REPORT
Units Conversion Request

Pace Analytical Services, LLC
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ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645

Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512001 ProjSampleNum: 10497512001 Date Collected: 10/24/19 14:35
Client Sample ID: SVE-1 20191024 Matrix: Air Date Received: 10/30/19 10:30

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
Air								
Dichlorotetrafluoroethane	ND	mg/m3	15.3	10752	11/04/19 19:48	MJL	76-14-2	
Ethanol	ND	mg/m3	20.6	10752	11/04/19 19:48	MJL	64-17-5	
Ethyl acetate	ND	mg/m3	7.9	10752	11/04/19 19:48	MJL	141-78-6	
Ethylbenzene	ND	mg/m3	9.5	10752	11/04/19 19:48	MJL	100-41-4	
Hexachloro-1,3-butadiene	ND	mg/m3	58.3	10752	11/04/19 19:48	MJL	87-68-3	
m&p-Xylene	ND	mg/m3	19	10752	11/04/19 19:48	MJL	179601-23-1	
Methylene Chloride	ND	mg/m3	38	10752	11/04/19 19:48	MJL	75-09-2	
Methyl-tert-butyl ether	ND	mg/m3	39.4	10752	11/04/19 19:48	MJL	1634-04-4	
Naphthalene	ND	mg/m3	28.6	10752	11/04/19 19:48	MJL	91-20-3	
n-Heptane	18	mg/m3	9	10752	11/04/19 19:48	MJL	142-82-5	
n-Hexane	434	mg/m3	7.7	10752	11/04/19 19:48	MJL	110-54-3	
o-Xylene	ND	mg/m3	9.5	10752	11/04/19 19:48	MJL	95-47-6	
Propylene	ND	mg/m3	3.8	10752	11/04/19 19:48	MJL	115-07-1	
Styrene	ND	mg/m3	9.3	10752	11/04/19 19:48	MJL	100-42-5	
Tetrachloroethene	ND	mg/m3	7.4	10752	11/04/19 19:48	MJL	127-18-4	
Tetrahydrofuran	ND	mg/m3	6.4	10752	11/04/19 19:48	MJL	109-99-9	
Toluene	10.9	mg/m3	8.2	10752	11/04/19 19:48	MJL	108-88-3	
trans-1,2-Dichloroethene	ND	mg/m3	8.7	10752	11/04/19 19:48	MJL	156-60-5	
trans-1,3-Dichloropropene	ND	mg/m3	9.9	10752	11/04/19 19:48	MJL	10061-02-6	
Trichloroethene	ND	mg/m3	5.9	10752	11/04/19 19:48	MJL	79-01-6	
Trichlorofluoromethane	ND	mg/m3	12.3	10752	11/04/19 19:48	MJL	75-69-4	
Vinyl acetate	ND	mg/m3	7.7	10752	11/04/19 19:48	MJL	108-05-4	
Vinyl chloride	ND	mg/m3	2.8	10752	11/04/19 19:48	MJL	75-01-4	

DISCLAIMER: These results have been converted to the units shown from the original units of measurement assuming 20 degrees Celsius and 1 atmosphere pressure. Values were not rounded according to EPA rounding rules. THC is quantitated based on the average response factors of several compounds; the nominal molecular weight of THC used for units conversion is the average of the molecular weights of the compounds used for quantitation.

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ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645
Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512002 ProjSampleNum: 10497512002 Date Collected: 10/23/19 14:30
Client Sample ID: SVE-2B 20191023 Matrix: Air Date Received: 10/30/19 10:30

Parameters	Results	Units	Report Limit	DF	Analyzed	CAS No.	Qualifiers
Air							
TO-15							
1,1,1-Trichloroethane	ND	mg/m3	12.4	11210	11/04/19 20:15 MJL	71-55-6	
1,1,2,2-Tetrachloroethane	ND	mg/m3	7.8	11210	11/04/19 20:15 MJL	79-34-5	
1,1,2-Trichloroethane	ND	mg/m3	6.2	11210	11/04/19 20:15 MJL	79-00-5	
1,1,2-Trichlorotrifluoroethane	ND	mg/m3	17.5	11210	11/04/19 20:15 MJL	76-13-1	
1,1-Dichloroethane	ND	mg/m3	9.2	11210	11/04/19 20:15 MJL	75-34-3	
1,1-Dichloroethene	ND	mg/m3	9	11210	11/04/19 20:15 MJL	75-35-4	
1,2,4-Trichlorobenzene	ND	mg/m3	84.5	11210	11/04/19 20:15 MJL	120-82-1	
1,2,4-Trimethylbenzene	ND	mg/m3	11.2	11210	11/04/19 20:15 MJL	95-63-6	
1,2-Dibromoethane (EDB)	ND	mg/m3	8.8	11210	11/04/19 20:15 MJL	106-93-4	
1,2-Dichlorobenzene	ND	mg/m3	13.7	11210	11/04/19 20:15 MJL	95-50-1	
1,2-Dichloroethane	ND	mg/m3	4.6	11210	11/04/19 20:15 MJL	107-06-2	
1,2-Dichloropropane	ND	mg/m3	10.5	11210	11/04/19 20:15 MJL	78-87-5	
1,3,5-Trimethylbenzene	ND	mg/m3	11.2	11210	11/04/19 20:15 MJL	108-67-8	
1,3-Butadiene	ND	mg/m3	5	11210	11/04/19 20:15 MJL	106-99-0	
1,3-Dichlorobenzene	ND	mg/m3	13.7	11210	11/04/19 20:15 MJL	541-73-1	
1,4-Dichlorobenzene	ND	mg/m3	34.3	11210	11/04/19 20:15 MJL	106-46-7	
2-Butanone (MEK)	ND	mg/m3	33.6	11210	11/04/19 20:15 MJL	78-93-3	
2-Hexanone	ND	mg/m3	46.6	11210	11/04/19 20:15 MJL	591-78-6	
2-Propanol	ND	mg/m3	28	11210	11/04/19 20:15 MJL	67-63-0	
4-Ethyltoluene	ND	mg/m3	28	11210	11/04/19 20:15 MJL	622-96-8	
4-Methyl-2-pentanone (MIBK)	ND	mg/m3	46.6	11210	11/04/19 20:15 MJL	108-10-1	
Acetone	ND	mg/m3	27	11210	11/04/19 20:15 MJL	67-64-1	
Benzene	481	mg/m3	3.6	11210	11/04/19 20:15 MJL	71-43-2	
Benzyl chloride	ND	mg/m3	29.5	11210	11/04/19 20:15 MJL	100-44-7	
Bromodichloromethane	ND	mg/m3	15.2	11210	11/04/19 20:15 MJL	75-27-4	
Bromoform	ND	mg/m3	58.9	11210	11/04/19 20:15 MJL	75-25-2	
Bromomethane	ND	mg/m3	8.8	11210	11/04/19 20:15 MJL	74-83-9	
Carbon disulfide	ND	mg/m3	7.1	11210	11/04/19 20:15 MJL	75-15-0	
Carbon tetrachloride	ND	mg/m3	14.4	11210	11/04/19 20:15 MJL	56-23-5	
Chlorobenzene	ND	mg/m3	10.5	11210	11/04/19 20:15 MJL	108-90-7	
Chloroethane	ND	mg/m3	6	11210	11/04/19 20:15 MJL	75-00-3	
Chloroform	ND	mg/m3	5.6	11210	11/04/19 20:15 MJL	67-66-3	
Chloromethane	ND	mg/m3	4.7	11210	11/04/19 20:15 MJL	74-87-3	
cis-1,2-Dichloroethene	ND	mg/m3	9	11210	11/04/19 20:15 MJL	156-59-2	
cis-1,3-Dichloropropene	ND	mg/m3	10.3	11210	11/04/19 20:15 MJL	10061-01-5	
Cyclohexane	2920	mg/m3	19.6	11210	11/04/19 20:15 MJL	110-82-7	E
Dibromochloromethane	ND	mg/m3	19.4	11210	11/04/19 20:15 MJL	124-48-1	
Dichlorodifluoromethane	ND	mg/m3	11.3	11210	11/04/19 20:15 MJL	75-71-8	

SUPPLEMENTAL REPORT
Units Conversion Request

Pace Analytical Services, LLC
1700 Elm Street, Suite 200
Minneapolis, MN 55414
Phone: 612.607.1700
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ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645
Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

Lab Sample No: 10497512002 ProjSampleNum: 10497512002 Date Collected: 10/23/19 14:30
Client Sample ID: SVE-2B 20191023 Matrix: Air Date Received: 10/30/19 10:30

Parameters	Results	Units	Report Limit	DF	Analyzed		CAS No.	Qualifiers
Air								
Dichlorotetrafluoroethane	ND	mg/m3	15.9	11210	11/04/19 20:15	MJL	76-14-2	
Ethanol	ND	mg/m3	21.5	11210	11/04/19 20:15	MJL	64-17-5	
Ethyl acetate	ND	mg/m3	8.2	11210	11/04/19 20:15	MJL	141-78-6	
Ethylbenzene	ND	mg/m3	9.9	11210	11/04/19 20:15	MJL	100-41-4	
Hexachloro-1,3-butadiene	ND	mg/m3	60.8	11210	11/04/19 20:15	MJL	87-68-3	
m&p-Xylene	ND	mg/m3	19.8	11210	11/04/19 20:15	MJL	179601-23-1	
Methylene Chloride	ND	mg/m3	39.6	11210	11/04/19 20:15	MJL	75-09-2	
Methyl-tert-butyl ether	ND	mg/m3	41	11210	11/04/19 20:15	MJL	1634-04-4	
Naphthalene	ND	mg/m3	29.8	11210	11/04/19 20:15	MJL	91-20-3	
n-Heptane	195	mg/m3	9.3	11210	11/04/19 20:15	MJL	142-82-5	
n-Hexane	4120	mg/m3	8	11210	11/04/19 20:15	MJL	110-54-3	E
o-Xylene	ND	mg/m3	9.9	11210	11/04/19 20:15	MJL	95-47-6	
Propylene	ND	mg/m3	3.9	11210	11/04/19 20:15	MJL	115-07-1	
Styrene	ND	mg/m3	9.7	11210	11/04/19 20:15	MJL	100-42-5	
Tetrachloroethene	ND	mg/m3	7.7	11210	11/04/19 20:15	MJL	127-18-4	
Tetrahydrofuran	ND	mg/m3	6.7	11210	11/04/19 20:15	MJL	109-99-9	
Toluene	23.4	mg/m3	8.6	11210	11/04/19 20:15	MJL	108-88-3	
trans-1,2-Dichloroethene	ND	mg/m3	9	11210	11/04/19 20:15	MJL	156-60-5	
trans-1,3-Dichloropropene	ND	mg/m3	10.3	11210	11/04/19 20:15	MJL	10061-02-6	
Trichloroethene	ND	mg/m3	6.1	11210	11/04/19 20:15	MJL	79-01-6	
Trichlorofluoromethane	ND	mg/m3	12.8	11210	11/04/19 20:15	MJL	75-69-4	
Vinyl acetate	ND	mg/m3	8	11210	11/04/19 20:15	MJL	108-05-4	
Vinyl chloride	ND	mg/m3	2.9	11210	11/04/19 20:15	MJL	75-01-4	

DISCLAIMER: These results have been converted to the units shown from the original units of measurement assuming 20 degrees Celsius and 1 atmosphere pressure. Values were not rounded according to EPA rounding rules. THC is quantitated based on the average response factors of several compounds; the nominal molecular weight of THC used for units conversion is the average of the molecular weights of the compounds used for quantitation.

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ANALYTICAL RESULTS

Client: Ramboll Environ- WI AIR
Phone: 414-837-3645

Lab Project Number: 10497512
Project Name: 1690014124-002 CMR

PARAMETER FOOTNOTES

ND Not detected at or above adjusted reporting limit

NC Not Calculable

J Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

[E] Analyte concentration exceeded the calibration range. The reported result is estimated.

APPENDIX G
Updated AOC-16 Interim Measure Remedial Options Cost Estimate

Appendix G
Alternative 1 - DPE Cost Analysis
MW-22 PRT AREA
CMR
Great Falls, Montana

SUMMARY OF ALTERNATIVE 1: DPE

	Units	Qty	Unit Cost	Total Cost
CAPTIAL COSTS - DPE				
DPE Well Drilling				
Private Utility Locate	ea	1	$ 2,000	$ 2,000
Mobilization/demobilization	ls	1	$ 10,000	$ 10,000
Montana well logs	ea	11	$ 100	$ 1,100
Per Diem, drill crew	ea	10	$ 800	$ 8,000
Set-up/cleanup/decon - sonic drill rig	hr	10	$ 700	$ 7,000
Drill & sample 8.25-inch	ft	165	$ 70	$ 11,550
Borehole sealing and patch	ft	165	$ 20	$ 3,300
4-inch schedule 40 PVC well construction	ft	165	$ 50	$ 8,250
12-inch flush grade completion	ea	11	$ 700	$ 7,700
Well development (1 hour per installation)	hr	11	$ 400	$ 4,400
Support Equipment (skid-steer)	day	9	$ 500	$ 4,500
Subtotal				$ 67,800
DPE Equipment and Materials				
Remediation Building (Procurement, Fabrication, and Retrofitting	ls	1	$ 48,000	$ 48,000
DPE Vacuum Pump and Components (PLC, K/O Tank)	ls	1	$ 150,000	$ 150,000
Misc Building Components (Lighting, heaters, louvers)	ls	1	$ 7,000	$ 7,000
API OWS	ls	1	$ 21,000	$ 21,000
LNAPL Tank (Double Wall)	ls	1	$ 3,000	$ 3,000
Thermal Oxidizer	ls	1	$ 335,000	$ 335,000
Shipping	ls	1	$ 40,000	$ 40,000
Conveyance piping (3-inch, HPDE)	ft	1500	$ 4	$ 6,000
Subtotal				$ 610,000
DPE Installation and Startup				
Mobilization/demobilization	ls	1	$ 20,000	$ 20,000
Trenching	BCY	300	$ 30	$ 9,000
Sand Backfill around Pipe	LCY	100	$ 68	$ 6,800
Backfill of Excavated Soil	LCY	250	$ 20	$ 5,000
Gas Line	ls	1	$ 10,000	$ 10,000
Electric Service Installation	ls	1	$ 50,000	$ 50,000
Creation of Remediation Building Pad (Includes Material)	SY	50	$ 100	$ 5,000
DPE Remedaition Building Fence	LF	150	$ 40	$ 6,000
Effluent Water Samples (SVOCs, VOCs, and Metals)	sample	4	$ 300	$ 1,200
Vapor Samples (TO-15)	sample	12	$ 400	$ 4,800
Subtotal				$ 117,800
DPE Waste Management				
55-gallon drums (soil cuttings)	ea	34	$ 125	$ 4,250
Development water			$ -	$ -
Subtotal				$ 4,250
Other Capital Costs				
Waste Water Treatment Sewer Line (Tie-in to Truck Rack)	ls	1	$ 200,000	$ 200,000
Air Treatment During 30-Day Start-Up	ls	1	$ 40,000	$ 40,000
Permitting (Air, Local, County)	ls	1	$ 60,000	$ 60,000
Surveyor	ls	1	$ 5,000	$ 5,000
Subtotal				$ 305,000
Construction Oversight				$ 104,000
TOTAL CAPITAL COSTS - DPE				**$ 1,208,850**
ANNUAL O&M COSTS - DPE				
DPE Operations, Maintenance, and Monitoring				
Ramboll OM&M Labor	hr	200	$ 70.00	$ 14,000.00
Oil and Filter Changes	each	4	$ 3,000.00	$ 12,000.00
Miscellaneous equipment rental and repair (includes material)	ls	1	$ 14,000.00	$ 14,000.00
Monthly Vapor Samples (TO-15)	sample	12	$ 400.00	$ 4,800.00
Quarterly Effluent water Samples (SVOCs, VOCs, and Metals)	sample	8	$ 300.00	$ 2,400.00
Quarterly GW Samples (SVOCs, VOCs, Metals, MNA)	sample	8	$ 500.00	$ 4,000.00
Subtotal				$ 51,200.00
DPE Annual Utilities				
Electric	kwh	400,000	$ 0.10	$ 40,000.00
Natural Gas	1000 cu ft	500	$ 6.20	$ 3,100.00
Subtotal				$ 43,100.00
Annual OM&M Total - DPE				**$ 94,300.00**

Appendix G
Alternative 1 - AS/SVE within Engineered Trench Cost Analysis
MW-22 PRT AREA
CMR
Great Falls, Montana

SUMMARY OF ALTERNATIVE 1: AS/SVE within Engineered Trench

	Units	Qty	Unit Cost	Total Cost
CAPTIAL COSTS - AS/SVE System				
AS/SVE Well Drilling				
Private Utility Locate	ea	1	$ 2,000.00	$ 2,000.00
Mobilization/demobilization	ls	1	$ 2,000.00	$ 2,000.00
Montana well logs	ea	11	$ 100.00	$ 1,100.00
Per Diem, drill crew	ea	2	$ 800.00	$ 1,600.00
Set-up/cleanup/decon - sonic drill rig	hr	2	$ 450.00	$ 900.00
Drill & sample 6.25-inch	ft	165	$ 15.00	$ 2,475.00
Borehole sealing and patch	ft	165	$ 8.00	$ 1,320.00
1-inch schedule 40 PVC well construction (AS Well)	ft	165	$ 20.00	$ 3,300.00
Well development (0.5 hour per AS installation)	hr	5.5	$ 225.00	$ 1,237.50
Support Equipment (skid-steer)	day	2	$ 500.00	$ 1,000.00
Subtotal				$ 16,932.50
AS/SVE Equipment and Materials				
Remediation Building (Procurement, Fabrication, and Retrofitting)	ls	1	$ 41,000.00	$ 41,000.00
AS/SVE Vacuum Pump and Components (PLC, K/O Tank)	ls	1	$ 120,000.00	$ 120,000.00
Misc Building Components (Lighting, heaters, louvers)	ls	1	$ 7,000.00	$ 7,000.00
Vapor Phase Granular Activated Carbon Tanks	ea	3	$ 27,000.00	$ 81,000.00
Shipping	ls	1	$ 40,000.00	$ 40,000.00
AS Conveyance piping (1-inch, HPDE)	ft	500	$ 3.00	$ 1,500.00
SVE Conveyance piping (3-inch, HPDE)	ft	300	$ 10.00	$ 3,000.00
Subtotal				$ 293,500.00
AS/SVE Installation and Startup				
Private Utility Locate	ea	1	$ 2,000.00	$ 2,000.00
Mobilization/demobilization	ls	1	$ 6,800.00	$ 6,800.00
Trenching	BCY	200	$ 50.00	$ 10,000.00
Backfill of Excavated Area	LCY	250	$ 25.00	$ 6,250.00
Electric Service Installation	ls	1	$ 20,000.00	$ 20,000.00
Creation of Remediation Building Pad (Includes Material)	SY	50	$ 50.00	$ 2,500.00
Vapor Samples (TO-15)	sample	12	$ 400.00	$ 4,800.00
Remedaition Building Fence	LF	110	$ 40.00	$ 4,400.00
Subtotal				$ 54,750.00
Waste Management				
Transportation and disposal of excavated material	ton	400	$ 70.00	$ 28,000.00
Subtotal				$ 28,000.00
Other Capital Costs				
Permitting (Air, Local, State)	ls	1	$ 32,000.00	$ 32,000.00
Surveyor	ls	1	$ 3,000.00	$ 3,000.00
Subtotal				$ 35,000.00
Construction Oversight				$ 70,000.00
TOTAL CAPITAL COSTS - AS/SVE				**$ 498,182.50**
ANNUAL O&M COSTS - AS/SVE				
AS/SVE Operations, Maintenance, and Monitoring				
Ramboll OM&M Labor	hr	208	$ 70.00	$ 14,560.00
Oil and Filter Changes	each	4	$ 1,400.00	$ 5,600.00
Miscellaneous equipment rental and repair (includes material)	ls	1	$ 1,200.00	$ 1,200.00
Vapor Phase Granular Activated Carbon Change Out	ls	1	$ 15,000.00	$ 15,000.00
Quarterly Vapor Samples (TO-15)	sample	4	$ 400.00	$ 1,600.00
Quarterly GW Samples (SVOCs, VOCs, Metals, MNA)	sample	8	$ 500.00	$ 4,000.00
Subtotal				$ 41,960.00
AS/SVE Annual Utilities				
Electric	kwh	220,000	$ 0.10	$ 22,000.00
Subtotal				$ 22,000.00
Annual OM&M Total - AS/SVE within Engineered Trench				**$ 63,960.00**

Appendix G
Alternative 2 -DPE Cost Analysis
MW-41 AREA
CMR
Great Falls, Montana

SUMMARY OF ALTERNATIVE 2: DPE

	Units	Qty	Unit Cost	Total Cost
CAPTIAL COSTS - DPE				
DPE Well Drilling				
Private Utility Locate	ea	1	$ 2,000	$ 2,000
Mobilization/demobilization	ls	1	$ 10,000	$ 10,000
Montana well logs	ea	11	$ 100	$ 1,100
Per Diem, drill crew	ea	10	$ 800	$ 8,000
Set-up/cleanup/decon - sonic drill rig	hr	10	$ 700	$ 7,000
Drill & sample 8.25-inch	ft	165	$ 70	$ 11,550
Borehole sealing and patch	ft	165	$ 20	$ 3,300
4-inch schedule 40 PVC well construction	ft	165	$ 50	$ 8,250
12-inch flush grade completion	ea	11	$ 700	$ 7,700
Well development (1 hour per installation)	hr	11	$ 400	$ 4,400
Support Equipment (skid-steer)	day	9	$ 500	$ 4,500
Subtotal				$ 67,800
DPE Equipment and Materials				
Remediation Building (Procurement, Fabrication, and Retrofitting)	ls	1	$ 48,000	$ 48,000
DPE Vacuum Pump and Components (PLC, K/O Tank)	ls	1	$ 150,000	$ 150,000
Misc Building Components (Lighting, heaters, louvers)	ls	1	$ 7,000	$ 7,000
API OWS	ls	1	$ 21,000	$ 21,000
LNAPL Tank (Double Wall)	ls	1	$ 3,000	$ 3,000
Thermal Oxidizer	ls	1	$ 335,000	$ 335,000
Shipping	ls	1	$ 40,000	$ 40,000
Conveyance piping (3-inch, HPDE)	ft	1500	$ 4	$ 6,000
Subtotal				$ 610,000
DPE Installation and Startup				
Mobilization/demobilization	ls	1	$ 20,000	$ 20,000
Trenching	BCY	300	$ 30	$ 9,000
Sand Backfill around Pipe	LCY	100	$ 68	$ 6,800
Backfill of Excavated Soil	LCY	250	$ 20	$ 5,000
Gas Line	ls	1	$ 10,000	$ 10,000
Electric Service Installation	ls	1	$ 50,000	$ 50,000
Creation of Remediation Building Pad (Includes Material)	SY	50	$ 100	$ 5,000
DPE Remedaition Building Fence	LF	150	$ 40	$ 6,000
Effluent Water Samples (SVOCs, VOCs, and Metals)	sample	4	$ 300	$ 1,200
Vapor Sample (TO-15)	sample	12	$ 400	$ 4,800
Subtotal				$ 117,800
DPE Waste Management				
55-gallon drums (soil cuttings)	ea	34	$ 125	$ 4,250
Development water			$ -	$ -
Subtotal				$ 4,250
Other Capital Costs				
Waste Water Treatment Sewer Line (Tie-in to Truck Rack)	ls	1	$ 200,000	$ 200,000
Air Treatment During 30-Day Start-Up	ls	1	$ 40,000	$ 40,000
Permitting (Air, Local, State)	ls	1	$ 60,000	$ 60,000
Surveyor	ls	1	$ 5,000	$ 5,000
Subtotal				$ 305,000
Construction Oversight				$ 104,000
TOTAL CAPITAL COSTS - DPE				**$ 1,208,850**

Appendix G
Alternative 2 -DPE Cost Analysis
MW-41 AREA
CMR
Great Falls, Montana

SUMMARY OF ALTERNATIVE 2: DPE

	Units	Qty	Unit Cost	Total Cost
ANNUAL O&M COSTS - DPE				
DPE Operations, Maintenance, and Monitoring				
OM&M Labor	hr	200	$ 70.00	$ 14,000.00
Oil and Filter Changes	each	4	$ 3,000.00	$ 12,000.00
Miscellaneous equipment rental and repair (includes material)	ls	1	$ 14,000.00	$ 14,000.00
Monthly Vapor Samples (TO-15)	sample	12	$ 400.00	$ 4,800.00
Quarterly Effluent water Samples (SVOCs, VOCs, and Metals)	sample	8	$ 300.00	$ 2,400.00
Quarterly GW Samples (SVOCs, VOCs, Metals, MNA)	sample	8	$ 500.00	$ 4,000.00
Subtotal				$ 51,200.00
DPE Annual Utilities				
Electric	kwh	400,000	$ 0.10	$ 40,000.00
Natural Gas	1000 cu ft	500	$ 6.20	$ 3,100.00
Subtotal				$ 43,100.00
Annual OM&M Total - DPE				**$ 94,300.00**

Appendix G
Alternative 2 - Product Recovery and Passive Treatment Trench Cost Analysis
MW-41 AREA
CMR
Great Falls, Montana

SUMMARY OF ALTERNATIVE 2: PRODUCT RECOVERY AND PASSIVE TREATMENT TRENCH

	Units	Qty	Unit Cost	Total Cost
CAPTIAL COSTS - PRODUCT RECOVERY AND PASSIVE TREATMENT TRENCH				
Bench Scale Testing of Remediation Products				
Private Utility Locate	ls	1	$ 2,000.00	$ 2,000.00
Mobilization/demobilization for drilling	ls	1	$ 10,000.00	$ 10,000.00
Montana well logs	ea	1	$ 100.00	$ 100.00
Per Diem, drill crew	ea	1	$ 700.00	$ 700.00
Drill & sample 8.25-inch	ft	15	$ 70.00	$ 1,050.00
Borehole sealing and patch	ft	15	$ 20.00	$ 300.00
Set-up/cleanup/decon - sonic drill rig	hr	2	$ 700.00	$ 1,400.00
Laboratory	ea	1	$ 5,000.00	$ 5,000.00
Equipment and Misc. Supplies	ea	1	$ 1,000.00	$ 1,000.00
Subtotal				$ 19,550.00
Product Recovery Equipment and Passive Treatment Materials				
PetroFix (includes transport and delivery)	lb	14000	$ 4.50	$ 63,000.00
ORC Advanced	lb	1212	$ 60.00	$ 72,720.00
Photovoltaic Powered Passive Skimmer Pump	ea	3	$ 10,000.00	$ 30,000.00
Product Recovery Tank and Telemetry	ea	1	$ 10,000.00	$ 10,000.00
Subtotal				$ 165,720.00
PRB Installation				
Mobilization/demobilization	ls	1	$ 10,000.00	$ 10,000.00
Trenching	BCY	150	$ 25.00	$ 3,750.00
Backfill of Excavated Area With Gravel and Remediation Products	LCY	200	$ 50.40	$ 10,080.00
Subtotal				$ 23,830.00
Product Recovery and Monitoring Well Drilling				
Private Utility Locate	ea	1	$ 2,000.00	$ 2,000.00
Mobilization/demobilization	ls	1	$ 10,000.00	$ 10,000.00
Montana well logs	ea	5	$ 100.00	$ 500.00
Per Diem, drill crew	ea	4	$ 800.00	$ 3,200.00
Set-up/cleanup/decon - sonic drill rig	hr	5	$ 700.00	$ 3,500.00
Drill & sample 8.25-inch	ft	75	$ 70.00	$ 5,250.00
Borehole sealing and patch	ft	75	$ 20.00	$ 1,500.00
4-inch schedule 40 PVC well construction	ft	75	$ 50.00	$ 3,750.00
12-inch flush grade completion	ea	5	$ 700.00	$ 3,500.00
Well development (1 hour per installation)	hr	5	$ 400.00	$ 2,000.00
Support Equipment (skid-steer)	day	4	$ 500.00	$ 2,000.00
Subtotal				$ 37,200.00
Waste Management				
55-gallon drums (soil cuttings)	ea	10	$ 125.00	$ 1,250.00
Excavated Material Disposal	ton	400	$ 65.00	$ 26,000.00
Subtotal				$ 27,250.00
TOTAL CAPITAL COSTS - Product Recovery and Passive Treatment Trench				**$ 273,550.00**
Annual Product Recovery Operations, Maintenance, and Monitoring				
Ramboll OM&M Labor	hr	160	$ 70.00	$ 11,200.00
Miscellaneous equipment rental and repair (includes material)	ls	1	$ 5,000.00	$ 5,000.00
Quarterly GW Samples (SVOCs, VOCs, Metals, MNA)	ea	8	$ 300.00	$ 2,400.00
Disposal of Recovered Fluid	Month	12	$ 500.00	$ 6,000.00
Subtotal				$ 24,600.00
Annual OM&M Total - Product Recovery and Passive Treatment Trench				**$ 24,600.00**