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November 6, 2020

Ms. Denise Kirkpatrick
Solid and Hazardous Waste Specialist
Montana Department of Environmental Quality
Permitting and Compliance Division
Air and Waste Management Bureau
P.O. Box 200901
Helena, MT 59620-0901

RE: AOC-16 Interim Measure Final (100%) Design Report

Submitted via Montana File Transfer Service with Hard Copy to follow

Dear Ms. Kirkpatrick,

Please find attached Calumet Montana Refining LLC's (CMR) AOC-16 Interim Measure Final (100%) Design Report for your files. The report provides the basis of design including a discussion of the Pre-Design Investigation (PDI), a description of the Dual-Phase Extraction (DPE) system design, a description of the Passive Treatment Trench (PTT) design, permits, Interim Measures construction and implementation, waste management, and a description of the Operation, Maintenance, and Monitoring (OM&M) plan. The report appendices include design drawings, PDI data results, PTT design calculations, technical specifications, the draft OM&M plan, and the draft Health and Safety Plan.

We will be proceeding with upfront work such as access coordination, permitting, bidding, contracting, and equipment procurement activities this upcoming fall, winter, and spring to allow formal construction to begin the summer of 2021 as laid forth in our project schedule included in the Report.

CALUMET
Montana Refining, LLC

Please let me know if you have any questions.

Regards,

Joe Dauner
Environmental Manager

cc: Jesse Newland, USEPA
Mark Cheesman, CMR

AOC-16 INTERIM MEASURE FINAL (100%) DESIGN REPORT

CALUMET MONTANA REFINING, LLC
GREAT FALLS, MONTANA

November 2020

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Appendix E: Draft Operation, Maintenance and Monitoring Plans
Appendix F: Health and Safety Plan

ACRONYMNS AND ABBREVIATIONS

%RE	percent reference emitter
ACFM	actual cubic feet per minute
AOC-16	Area of Concern-16
API	American Petroleum Institute
ARM	Administrative Rules of Montana
AS	air sparging
BOD	biochemical oxygen demand
BTEX	benzene, toluene, ethylbenzene, xylenes
CAC	colloidal activated carbon
cm/s	centimeters per second
CMR	Calumet Montana Refining, LLC
cm^2	square centimeters
cm/s	centimeters per second
COCs	constituents of concern
COD	chemical oxygen demand
CSM	conceptual site model
CY	cubic yards
DEQ-7 HHS	Montana Department of Environmental Quality-7 Human Health Standards
DNRC	Department of Natural Resources and Conservation
DPE	dual-phase extraction
EPH	extractable petroleum hydrocarbon
ft-bgs	feet below ground surface
ft-msl	feet above mean sea level
ft/day	feet per day
ft^2/day	square feet per day
GOAB	gang operated air break
gpd	gallons per day
gpm	gallons per minute
HAPs	hazardous air pollutants
HASP	Health and Safety Plan
HSA	hollow stem auger
IDW	investigation derived waste
IM	Interim Measures
in-Hg	inches of mercury
kV	kilovolt
lbs/year	pounds per year
LEL	lower explosive limit

LIF	laser-induced florescence
LNAPL	light non-aqueous phase liquid
µg/L	microgram per liter
µg/m^3	microgram per cubic meter
MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
MRC	Montana Refining Company
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
OM&M	operations, monitoring, and maintenance
Order	Corrective Action Order on Consent
PID	photoionization detector
PDI	pre-design investigation
PLC	programmable logic controller
PRT	primary recovery trench
PTT	passive treatment trench
PVC	polyvinyl chloride
RBSL	Risk-Based Screening Levels
RCRA	Resource Conservation Recovery Act
Ramboll	Ramboll US Consulting, Inc.
ROI	radius of influence
ROW	right-of-way
SCFM	standard cubic feet per minute
SDS	safety data sheets
SRCO	Self-Recuperative Catalytic Oxidizer
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
TCLP	toxicity characteristic leaching procedure
US DOT	United States Department of Transportation
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UVOST®	ultra-violet optical screening tool
VFD	variable frequency drive
VLS	vapor/liquid separator
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons
WWTP	wastewater treatment plant

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:	November 4, 2020

CERTIFICATION

I certify that this work has been completed under my direction and supervision and that I am a Licensed Professional Engineer with expertise in soil and groundwater remediation and corrective measures.

Scott Tarmann, PE
Project Engineer 11/4/2020

MONTANA
SCOTT W. TARMANN
No. 61906 PE
LICENSED PROFESSIONAL ENGINEER

State of Montana Professional Engineer License No. 61906

EXECUTIVE SUMMARY

Ramboll US Consulting, Inc. (Ramboll), on behalf of Calumet Montana Refining, LLC (CMR), has prepared this Area of Concern-16 (AOC-16) Interim Measure (IM) Final (100%) Design Report (the "Design Report") for the Calumet Great Falls Montana Refining facility located at 1900 10th Street NE, Great Falls, Montana. This Design Report has been prepared in accordance with the Corrective Action Order on Consent issued to Montana Refining Company, Inc. by the Montana Department of Environmental Quality (MDEQ) to govern the performance of Resource Conservation Recovery Act corrective action activities at the site and with MDEQ's January 28, 2020 AOC-16 Interim Measures letter (MDEQ, 2020b). This Design Report provides the design for the installation and implementation for two IM corrective actions in different areas within AOC-16 to be implemented to address petroleum releases including:

- dual-phase extraction (DPE) remediation system in the Truck Rack Area; and
- light non-aqueous phase liquid (LNAPL) recovery trench and passive treatment trench (PTT) in the North River Road Area.

Historical investigation information along with results of a pilot test was incorporated into an initial conceptual site model. A pre-design investigation (PDI) was conducted to address remaining data gaps and provide additional information to complete the remedial design of the DPE system and the PTT. PDI activities included discharge piping reconnaissance, soil boring installation, temporary and permanent monitoring well installation, geotechnical evaluation, groundwater sampling, and waste characterization sampling.

In the Truck Rack Area, a DPE system is proposed in order to recover free-phase LNAPL mass present in the area south of the Truck Rack and to reduce LNAPL within the vadose and saturated zone soil matrix to stabilize the dissolved phase plume. The DPE system consists of eight DPE wells screened across the shallow water bearing zone. Vapors and liquids will be extracted through a single drop tube installed in each DPE well. Two rotary claw vacuum blowers installed in parallel will extract the vapor and liquid. Each well will be connected via conveyance piping to the vacuum blowers housed at the treatment enclosure for extraction and treatment on site. A vapor/liquid separator and liquid transfer pump will be located prior to the vacuum pumps to separate vapor from fluids and convey the vapor to a self-recuperating catalytic thermal oxidizer unit for air treatment. Liquids will be pumped via underground conveyance piping to the CMR wastewater treatment plant.

In the North River Road Area, a LNAPL recovery trench and PTT are proposed in order to mitigate dissolved phase groundwater impacts migrating from the Truck Rack Area towards the Missouri River. The IM will consist of two parallel trenches separated by approximately 4 feet of native material. Both trenches will be installed perpendicular to the groundwater flow path. The upgradient LNAPL recovery trench will be 5-feet wide by 10-feet deep by 50-feet long and backfilled with coarse sand intended to recover LNAPL prior to the PTT to limit LNAPL from entering the PTT and overrunning the sorption capacity of the activated carbon in the PTT. During trench backfilling activities, 11 LNAPL recovery wells will be installed into the coarse sand to facilitate LNAPL collection and monitoring. The downgradient PTT will be 5-feet wide by 12.5-feet deep and 110-feet long. The PTT will be installed to the top of the aquitard unit/the top of the moderately to strongly cemented very fine sand. The PTT will be backfilled with colloidal activated carbon plus terminal electron acceptors (Regenesis® product PetroFix™) incorporated into coarse sand. Hydrocarbons and benzene, toluene, ethylbenzene and xylenes will partition from the dissolved phase by adsorption to the activated carbon particles. The

contaminants will be anaerobically biodegraded through chemical oxidation stimulated by the bio-stimulating electron acceptors.

For the DPE system, the primary performance monitoring metric will be contaminant mass recovery over time. Cumulative vapor flow rates will be continuously monitored, and influent vapor sampling will be periodically conducted in order to estimate mass removal rates. The combination of vapor flow rates and vapor volatile organic compounds concentrations will be used to calculate the mass of contaminants removed from the subsurface over time. When mass recovery rates from individual wells or the combined system reach diminishing returns (a.k.a. asymptotic levels), operational modifications will be considered. The individual DPE wells with low recovery rates should be turned off and the wells with the highest VOC recovery rates should be continuously operated. Pulsing of the system in which individual or groups of DPE wells are shut off will also be considered. Once the DPE system approaches asymptotic levels with full time operations, a request will be submitted to MDEQ describing modifications to discontinue extracting from individual or groups of DPE wells and/or to operate the system in a pulsed manner. Subsequently, once the DPE system approaches asymptotic levels with modified / pulsed system operations, a request will be submitted to MDEQ to place the DPE system in standby mode.

The primary goal of the PTT is to mitigate the dissolved phase groundwater impacts from migrating from the Truck Rack to the Missouri River. The primary performance monitoring metric for the PTT will be the reduction is dissolved phase petroleum contaminants of concern (COCs) from the upgradient side of the PTT to the downgradient side of the PTT. For the first year following PTT installation, quarterly sampling for COCs will be conducted at one upgradient well, one monitoring well to be installed during construction within the PTT, and a downgradient compliance well. The PTT well and the compliance well will also be sampled semi-annually for additional parameters to assess the biodegradation dynamics of the COCs. After collection and analysis of the first year PTT performance data, a recommendation will be submitted to MDEQ as to the frequency of subsequent PTT groundwater monitoring. The PTT groundwater monitoring program will be discontinued once the groundwater on the upgradient side of the PTT meets the MDEQ-7 Human Health Standards for groundwater.

1. INTRODUCTION

Ramboll US Consulting, Inc. (Ramboll), on behalf of Calumet Montana Refining, LLC (CMR), has prepared this Area of Concern-16 (AOC-16) Interim Measure (IM) Final (100%) Design Report (the "Design Report") for the Calumet Great Falls Montana Refining facility located at 1900 10th Street NE, Great Falls, Montana (Figure 1). This Design Report has been prepared in accordance with the Corrective Action Order on Consent[1] (the "Order") issued to the Montana Refining Company, Inc., by the Montana Department of Environmental Quality (MDEQ) to govern the performance of Resource Conservation Recovery Act (RCRA) corrective action activities at the site and the MDEQ's January 28, 2020 AOC-16 Interim Measures letter (MDEQ, 2020b).

1.1 Purpose and Scope of Report

This Design Report presents the Final (100%) Design for IMs to be implemented to address petroleum releases at AOC-16 which may pose an imminent threat to human health and/or the environment.

1.2 Site 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 (Figure 1). 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 approximately 7.6-acre parcel to the east of the active refinery and is owned by CMR (Figure 2). The Public Land Survey System 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. A CMR two-floored office building is in the east portion and an access road, set down area and vegetation area is in the southern portion of AOC-16. 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 the roadway right-of-way (ROW), 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.

In June 2019, CMR submitted the *AOC-16 Interim Measures Evaluation (IM) Report* (CMR, 2019c) to the MDEQ. This document contained a comprehensive collection of historical information including historic releases 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 (Figure 2). According to PRT construction drawings dated May 3, 1995, a 4-inch diameter perforated pipe is installed the entire length of the trench and accessible via two 4-foot diameter vertical steel culverts. The vertical culverts are secured at the surface with lockable steel covers.

[1] Corrective Action Order on Consent MHWCAO-12-01 in the Matter of Montana Refining Company, Inc., 1900 10th Street NE Great Falls, Montana, issued by the MDEQ, September 27, 2012.

Two areas, separated by a parcel not owned by CMR, have been identified as areas requiring IM corrective actions. The two AOC-16 IM corrective action areas are identified on Figure 2 and include:

- **Truck Rack Area** - the source area IM corrective action focuses on the portion of the CMR property immediately south of the Truck Rack. This area includes the PRT and native materials[2] north of the PRT. For the purposes of this document, the focus is on the PRT.
- **North River Road Area** - the dissolved phase IM corrective action includes the property immediately north of North River Road near the monitoring wells MW-41S, MW-41D, MW-59S, MW-59D, and MW-105. Monitoring wells MW-40, MW-41, MW-50, MW-51, MW-52, MW-58, and AS-3 were abandoned in June 2020 as part of the pre-design investigation activities.

1.3 Background

Following detection of petroleum related vapors in an offsite residential property along 11th Street NE, the MDEQ issued an IM letter on October 11, 2016, directing CMR to address imminent threats to human health and/or the environment stemming from petroleum release near CMR's Loading Rack (MDEQ, 2016). Following immediate action, the MDEQ requested an IM work plan on December 20, 2016 to "investigate groundwater, soil, and subsurface contamination" and "assess mobility and recoverability LNAPL." Following IM investigation activities in 2017 and 2018, and subsequent communications with MDEQ, the MDEQ issued a letter directing CMR to evaluate remedies to address dissolved phase impacts related to AOC-16 on January 31, 2019 (MDEQ, 2019).

As identified in the *AOC-16 Interim Measures Evaluation Report* (CMR, 2019c), the selected IM remedies were biosparging and air sparge (AS)/soil-vapor extraction (SVE) technologies. The MDEQ approved the selected IM remedy technologies shortly after document submission. As part of the selected remediation technology applicability, a pilot test was completed to collect additional site characterization data necessary to prepare the IM remedial system designs. Pilot tests were completed as documented in *AOC-16 Pilot Study Evaluation Report* (CMR, 2020a). The *AOC 16 Pilot Study Evaluation Report* concluded that a combination or individual biosparging, AS, or SVE technologies would not be practicable for the AOC-16 area. An alternative IM remedy approach was recommended consisting of dual-phase extraction (DPE) in the existing PRT in the Truck Rack Area and product recovery and a passive treatment trench (PTT) just north of North River Road. The MDEQ approved the alternative IM corrective action approach on January 28, 2020 (MDEQ, 2020b). This document presents the Final Design (100%) for the IM remedies for AOC-16.

1.4 Report Organization

As described in the sections that follow, this report provides the design for the installation and implementation of a DPE remediation system in the Truck Rack Area and a LNAPL recovery trench and PTT in the North River Road Area to address the petroleum-impacted media in the AOC-16 area. In addition to this introductory section, this Design Report is divided into the following sections:

- Section 2 – Basis of Design
- Section 3 – Dual-Phase Extraction System Design
- Section 4 – Passive Treatment Trench Design
- Section 5 - Permits

[2] Non-engineered unconsolidated matrix consisting of either fill and/or native geologically deposited sediments of the fifth member of the lower Cretaceous Kootenai Formation.

- Section 6 – IM Construction and Implementation
- Section 7 – Waste Management
- Section 8 – Operations, Maintenance, and Monitoring
- Section 9 – Schedule
- Section 10 – References

These sections are discussed in detail below. The appendices provide the Design Drawings (Appendix A), Pre-Design Investigation (PDI) Results (Appendix B), the PTT Design Calculations (Appendix C), Technical Specifications (Appendix D), Operation, Maintenance, and Monitoring (OM&M) Plans (Appendix E), and the Health and Safety Plan (HASP) (Appendix F).

2. BASIS OF DESIGN

This section presents the basis of design for the selected IM remedies.

2.1 AOC-16 IM Goals and Objectives

Corrective action remedial goals were developed as part of the *AOC-16 Interim Measures Evaluation Report* (CMR, 2019c) to protect human health and the environment. The AOC-16 IM goals specific to each treatment area include:

- Truck Rack Area (DPE in PRT)
  - Recover free phase LNAPL mass present in the area south of the Truck Rack to stabilize the LNAPL plume.
  - Reduce LNAPL within the vadose and saturated zone soil matrix to stabilize the dissolved phase plume.
- North River Road Area (LNAPL Recovery Trench and PTT)
  - Mitigate dissolved phase groundwater impacts migrating from the Truck Rack Area towards the Missouri River.

2.2 AOC-16 Conceptual Site Model

A conceptual site model (CSM) was developed to understand the site setting and nature and extent of contamination. The CSM is summarized below.

2.2.1 Physical Characteristics

Topography

The AOC-16 area is located just north of the Missouri River and grades steeply toward the river to the south. Surface elevation ranges from 3,372 feet above mean sea level (ft-msl) at MW-54, located in the north portion of AOC-16, to 3,337 ft-msl at MW-62, located on North River Road, to 3,311 ft-msl at sandpoint well MW-43, located on the Missouri Riverbank. Surface cover primarily consists of vegetation, bare soil, and gravel with intermittent paved asphalt areas and roadways. There are a few generally flat, plateaued areas between Smelter Avenue NE, located along the northern boundary of AOC-16 and the Missouri River. The pre-construction site topography is shown on Drawing C1 in Appendix A.

Geology

The near surface geologic deposits at the CMR site are comprised of the fifth member of the lower Cretaceous Kootenai Formation. These consist of siliciclastic muddy fluvial and fluviolacustrine deposits consisting predominantly of interbedded mudstones, siltstone, and thin lenses and beds of well cemented very fine to fine cross-bedded sandstone. The lower part of the fifth member of the Kootenai Formation consists a dark-gray shale.

Prior to 2019, a combination of Hollow Stem Auger (HSA) and direct push drilling methods were used to drill and install in the upper most soil boring and shallow monitoring wells at the site. Refusal at the base of the HSA or direct push boreholes were logged as the top of competent bedrock. Sonic drilling methods employed in 2019 and 2020 have been able to provide clearer subsurface geologic data and have documented the presence of red-weathered and weakly laminated mudstone deposits underlying the well consolidated sandstone bed previously referenced as the top of competent bedrock. At two deep soil borings (MW-41D and AS-3), a gray siltstone or shale with trace mottling was present beneath the red-weathered mudstone. The bottom of this unit was not reached during the AOC-16 IM Design field activities.

Hydrogeology

The CSM includes two distinct water-bearing units extend across the CMR refinery which overlie the regional aquifer (CMR, 2020b). The site's hydro-stratigraphic units are as follows:

- A "shallow" uppermost perched water-bearing unit is present within fill and/or poorly lithified mudstone/siltstone deposits that contains various amounts of fine sand. In the proposed PPT area, a thin bed of gray well consolidated sandstone approximately 2 to 3 feet thick separates the fill material and red-weathered mudstone/siltstone.
- Directly underlining this horizon is a dry dusky red unit composed primarily of well lithified siltstone and thin beds of moderately to well cemented sandstone strata. This unit acts an aquitard separating the "shallow" perched unit and the "deep" semi-confined unit. This unit is continuous across the site except for a few locations where it has been removed by excavation or erosional processes.
- A "deep" semi-confined water-bearing unit continues below the dusky red unit within alternating layers of hard massive siltstone and/or well laminated shale often with fine to very fine sand lenses or layers.

Average 2017 and 2018 fluid levels across the shallow groundwater monitoring network for AOC-16, excluding the river points MW-42 through MW-45, generally fluctuate between an average high, at upgradient well RFI-8, of 3,351 ft-msl to 3,327 ft-msl, at downgradient well MW-62, located on North River Road. Monitoring wells MW-22 and MW-64 are screened within the shallow perched zone in the Truck Rack Area. The groundwater elevation in these two wells ranged between 3340.4 ,and 3,343.6 ft-msl between December 2013 and March 2020. This corresponds to a saturated thickness ranging between 4.7 and 8.0 feet. Water levels at Monitoring wells MW-50, MW-51, and MW-52 represent groundwater conditions within the shallow perched zone in the North River Road Area. The groundwater elevation in these three wells ranged between 3,332.6 and 3,336.8 ft-msl between December 2013 and March 2020. This corresponds to a saturated thickness ranging between 4.6 and 8.7 feet.

Groundwater flow in the shallow water-bearing unit is south towards the Missouri River, located directly downgradient of the site. As documented in the *2019 Annual Groundwater Sampling*

Summary Report (CMR, 2020b), horizontal hydraulic gradients were calculated for two shallow well pairs in the AOC-16 Area over the course of four quarterly monitoring events in 2019. The horizontal hydraulic gradients in the shallow water-bearing unit were consistent over the course of the year ranging from 0.036 to 0.042 feet/feet.

2.2.2 Nature and Extent of Contamination

The current understanding of potential threats to human health and the environment related to AOC-16 are:

LNAPL

- Three laser-induced florescence (LIF) ultra-violet optical screening tool (UVOST®) investigations were completed between October 2016 and November 2018 (CMR, 2019a). In a LIF UVOST Investigation, the intensity of the fluorescent response at each measurement point within a boring is compared to a calibrated reference emitter and is recorded as a percent reference emitter (%RE). The %RE can be used to aid in identification of LNAPL and to determine the relative quantity of the compound present. A review of the data concluded:
  - The maximum %RE was identified in the center portion of AOC-16 (Figure 3). The LNAPL distribution funnels south, potentially following lithological material with higher permeability.
  - The eastern portion of LNAPL observations in AOC-16 were more diesel in nature, based on LIF UVOST® waveform analysis and soil samples collected to correlate waveform interpretation, and resting on the water table (Trihydro/CMR, 2017).
  - The western portion of LNAPL observations were predominantly gasoline, based on LIF UVOST® waveform analysis and soil samples collected to correlate waveform interpretation, and submerged below the water table (Trihydro/CMR, 2017).
- Soil samples collected from 15 locations in April 2017 throughout the 18.5% RE AOC-16 area identified LNAPL pore saturation between 0.35 and 23%. Based on the lithology, several LNAPL profiles were identified as being potentially mobile and although others were not mobile (residual), they will continue to act as a source of dissolved phase hydrocarbon impacts (Trihydro/CMR, 2017).
- In recent years, LNAPL was observed in four monitoring wells (MW-53, MW-56, MW-63, and MW-64) in the Truck Rack Area and periodically in one monitoring well (MW-41) adjacent to the North River Road Area (Figure 3). In addition, LNAPL was observed in RFI-8 in the past and LNAPL was observed in SVE well SVE-2B adjacent to the PRT during the 2019 AS/SVE Pilot Testing activities.
- LNAPL transmissivity testing was conducted in monitoring well MW-53 in October of 2017. The test, following American Petroleum Institute (API) transmissivity test methods, utilizing two models indicated an LNAPL transmissivity ranging between 0.32 and 0.41 square feet per day (ft^2/day), indicating that the LNAPL is likely marginally recoverable under current conditions (CMR, 2018).
- Historical LNAPL recovery was conducted from the early 1990s into the early 2000s using submersible pumps and belt-skimming technology. The pumping and skimming were discontinued in the early 2000s due to a decrease in LNAPL recovery.
- Active LNAPL recovery involving the use of a skimmer pump is ongoing at MW-53. In 2019, approximately 1,825 gallons of LNAPL was recovered from MW-53 (CMR, 2020b). Passive LNAPL

recovery is taking place at locations MW-63 and MW-64, with the use of hydrocarbon-absorbent socks.

Soil

- Seventeen soil samples collected in April 2017 within the LIF UVOST® 18.5% RE footprint reported select extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons (VPH) above the MDEQ Risk-Based Screening Levels (RBSLs).

Groundwater

- Groundwater exceedances above applicable standards were observed in shallow monitoring wells throughout the Truck Rack Area and further downgradient along North River Road (Figure 4).
- Exceedances of the MDEQ-7 Human Health Standards (DEQ-7 HHS) for groundwater in the fourth quarter of 2019 included volatile organic compounds (VOCs) (benzene, ethylbenzene, naphthalene, and toluene), semi-volatile organic compounds (SVOCs) (2,4-dimethylphenol and naphthalene), and metals (arsenic and barium). Ethylbenzene and toluene exceedances were limited to well MW-64 located north of the PRT and well MW-88 located northwest of the PRT (CMR, 2020b).
- Exceedances of the MDEQ Tier 1 Groundwater Risk Based Screening Levels (Tier 1 RBSLs) in the fourth quarter of 2019 included VOCs (benzene, ethylbenzene, naphthalene, and toluene), SVOCs (naphthalene and 2-methylnapthalene), and VPH (CMR, 2020b).
- Benzene exceedances, used as an indicator of potential dissolved phase impacts in groundwater, ranging between 19 and 6,900 micrograms per liter (µg/L) were reported in eight monitoring wells in AOC-16 during the fourth quarter of 2019 (CMR, 2020b). This is consistent with historical groundwater data collected from the area.
- Benzene concentrations were below the DEQ-7 HHS at MW-41 from April 2010 to March 2015 with one exception (March 2013). Concentrations rose significantly during subsequent sampling events in July 2016 (4,990 µg/L), November 2016 (4,960 µg/L), and October 2017 (3,700 µg/L). In 2019, benzene was detected in May 2019 (2,600 µg/L) and October 2019 (1,200 µg/L). Benzene appears to be decreasing in concentration since July 2016 (CMR, 2020b). Monitoring MW-41 was cross-screened across the shallow perched and semi-confined hydro-stratigraphic units and was replaced with MW-41S and MW-41D to separately monitor the shallow perched and deep semi-confined units as part of the June 2020 PDI (further discussed in Section 2.4).
- Elevated dissolved phase concentrations appear to have a similar distribution to the 2016-2018 LIF UVOST® LNAPL footprint (Figure 4).

Further refinement of the vertical and horizontal extent of groundwater contamination in the North River Road Area and the proposed PTT was completed as part of a June 2020 PDI which is further discussed in Section 2.4.

2.2.3 Soil Physical Properties

Three geotechnical samples were collected at the approximate water table elevation as part of the SVE/AS Pilot Test (CMR, 2020a). One sample was collected from the native material north of the PRT in the Truck Rack Area (boring AS-3), one sample was collected near the PRT in the Truck Rack Area (boring AS-2B), and one sample was collected in the native material in the North River Road Area (boring MW-102). Samples were analyzed for moisture content, dry bulk density, total porosity, total organic carbon, fractional organic carbon, effective permeability to water, and hydraulic conductivity.

The grain size descriptions of each sample were:

- Truck Rack Area - PRT: Fine-Grained Sand (0% gravel, 81.5% sand, 13.9% silt, and 4.5% clay)
- Truck Rack Area - Native Material: Very Fine-Grained Sand (0.8% gravel, 63.6% sand, 29.0% silt, 6.5% clay)
- North River Road Area: Silt (0% gravel, 20.8% sand, 50.7% silt, and 28.6% clay)

2.2.4 Soil Permeability

Slug testing was historically completed at well MW-25 (previously located southwest of AOC-16). Based on slug testing results, the hydraulic conductivity at MW-25 was 0.15 feet per day (ft/day); (5×10^{-5} centimeters per second [cm/s]) (Montana Refining Company [MRC], 2002).

The three geotechnical samples described in Section 2.2.3 were analyzed for hydraulic conductivity via permeameter test as part of the SVE/AS Pilot Test. The permeameter tests are typically representative of the hydraulic conductivity along the vertical axis of the soil sample. The estimated vertical hydraulic conductivity for each area was:

- Truck Rack Area - PRT: 5 x 10-6 cm/s;
- Truck Rack Area - Native Material: 1 x 10-6 cm/s; and
- North River Road Area: <1 x 10-9 cm/s.

Horizontal hydraulic conductivity was estimated based on known representative values from literature. Based on this analysis, silty sands to fine sand have a hydraulic conductivity between 1×10^{-5} and 1×10^{-3} cm/s and silts, sandy silts and clayey sands have a hydraulic conductivity between 1×10^{-6} to 1×10^{-4} cm/s.

Hydraulic conductivity can also be estimated from empirical formulas used to relate grain size distribution to conductivity. Based on the grain size distribution measured during the pilot test using the Kozeny-Carmen estimate of conductivity, the estimated hydraulic conductivity for each area was:

- Truck Rack Area - PRT: 1 x 10-4 cm/s; and
- Truck Rack Area - Native Material: 2 x 10-5 cm/s.

The alternative methods for estimating hydraulic conductivity are tabled below.

Table A: Hydraulic Conductivity Summary

Method	Estimated Hydraulic Conductivity [cm/s]	Interpreted Representative Lithology
Early 2000s Slug Test, MW-25	5×10^{-5}	Native perched zone.
2019 Pilot Permeameter Test Representing Vertical Conductivity (cm/s) - MW-22 PRT	5×10^{-6}	Native perched zone; permeameter test represents vertical conductivity. In general, vertical conductivity is lower than horizontal conductivity; higher conductivity area.

Method	Estimated Hydraulic Conductivity [cm/s]	Interpreted Representative Lithology
2019 Pilot Permeameter Test Representing Vertical Conductivity (cm/s) - MW-64 Native Material	1×10^{-6}	Native perched zone; permeameter test represents vertical conductivity. In general, vertical conductivity is lower than horizontal conductivity; lower conductivity area.
2019 Pilot Permeameter Test in Native Material North of River Road	$<1 \times 10^{-9}$	Clayey or silty seam. Based on extremely low conductivity, this value is not likely to represent general conductivity and is not carried through.
Literature Value Based on Lithology Description - Silty sands, fine sands	1×10^{-5} to 1×10^{-3}	Sandy, conductive zones of native perched zone.
Literature Value Based on Lithology Description - silt, sandy silts, clayey sands	1×10^{-6} to 1×10^{-4}	Lower conductivity, silty zones of native perched zones.
Kozeny-Carmen Empirical Estimate of Conductivity Based on Grain-size analysis analyzed During 2019 Pilot Test - MW-22 PRT	1×10^{-4}	Native perched zone; higher conductivity area.
Kozeny-Carmen Empirical Estimate of Conductivity Based on Grain-size analysis analyzed During 2019 Pilot Test - MW-64 Native Material	2×10^{-5}	Native perched zone; lower conductivity area.

The geometric mean of these estimated hydraulic conductivity values is 9×10^{-6} cm/s.

Intrinsic permeability is a measure of the ability of soil to transmit any fluid and can be converted from hydraulic conductivity by:

$$k = K\left(\frac{\mu}{\rho g}\right)$$

where:
k = intrinsic permeability
K = hydraulic conductivity
μ = water dynamic viscosity
ρ = water density
g = acceleration due to gravity

Based on the hydraulic conductivity presented above, the intrinsic permeability ranges between $<1 \times 10^{-14}$ cm^2 in the North River Road Area to 1×10^{-9} cm^2 for the most conductive areas in the PRT.

AS pilot testing and SVE pilot testing was conducted as part of the 2019 SVE/AS Pilot Test (CMR, 2020a) which provide a qualitative understanding of the pneumatic conductivity in each area. Further details of the pilot testing procedures and results are discussed in Section 2.3. The pilot test results indicated that the Truck Rack Area - PRT had the highest pneumatic conductivity followed by the Truck Rack Area – Native Materials. In the North River Road Area, the AS/SVE pilot tests were not successful and minimal subsurface airflow was observed indicating low pneumatic conductivity.

2.3 AOC-16 AS/SVE Pilot Testing Results

In 2019, an AS/SVE pilot test was conducted to verify remediation technology applicability and collect additional site characterization data necessary to prepare IM remedial system designs as documented in the *AOC-16 Pilot Study Evaluation Report* (CMR, 2020a*)*. The following activities were conducted:

- Step-rate AS tests were conducted in the three different areas (the Truck Rack Area – PRT, the Truck Rack Area – Native Material, and the North River Road Area) area by applying incremental pressure levels to an injection point. The surrounding subsurface pressure was measured at adjacent monitoring wells.
- Step-rate SVE tests were conducted in each area by applying incremental vacuum levels to an extraction point. The surrounding vacuum was measured at adjacent monitoring wells.
- A constant rate SVE test was conducted in the Truck Rack Area – Native Material by applying a constant vacuum and measuring the corresponding vacuum at adjacent monitoring wells to estimate the effective vacuum radius of influence (ROI).
- Microbial and nutrient soil and groundwater samples were collected from the Truck Rack Area – Native Material.
- Geotechnical samples were collected from each area. Results were presented in Section 2.2.3 and Section 2.2.4.
- Vapor samples were collected during the Truck Rack Area – PRT step-rate test and the Truck Rack Area - Native Material SVE constant-rate test to estimate VOC vapor mass removal rates.

In the Truck Rack Area – PRT and Truck Rack Area – Native Material, air sparging was not successful due to insufficient volume of water to effectively sparge within the saturated soils or water column. In these two areas, the step-rate SVE test was generally successful with increased flow rate from increased applied vacuum and indication of vacuum in nearby subsurface. In the Truck Rack Area – PRT, the constant rate SVE test could not be completed because of the presence of LNAPL. In the Truck Rack Area – Native Material, the constant rate test estimated a vacuum ROI of approximately 24 feet.

AS and SVE testing performed within the backfill materials (e.g., trenched or fill material) within the PRT 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 LNAPL present within the PRT. This was evident when approximately 15 gallons of LNAPL was collected during the SVE step-rate test during one-hour of operation.

In the North River Road Area, the AS/SVE pilot tests were not successful and minimal evidence of subsurface airflow was recorded. This indicates a relatively low pneumatic conductivity and that AS/SVE technology would not be effective in achieving the goal of the interim measure.

In the Truck Rack Area – Native Material, hydrocarbon-degrading bacteria were 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) was present to effectively oxygenate and distribute air within the saturated soils to effectively implement the biosparging technology.

The approximate vapor removal during the step-rate tests in the Truck Rack Area – PRT and Truck Rack Area – Native Materials are summarized in the *AOC-16 Pilot Study Evaluation Report* (CMR, 2020a). The total VOC concentration recorded in the vapor sample in the Truck Rack Area - PRT was approximately 7,700,000 micrograms per cubic meter (μg/m^3). The predominant constituents included n-hexane (53% by mass), cyclo-hexane (38% by mass), and benzene (6% by mass). Based on air emissions requirement, treatment will be required prior to discharge. Based on the measured composition during the pilot test, the lower explosive limit (LEL) of the mixture is 1.2% by volume and the measured concentrations indicate 19% of the LEL in the vapor stream.

2.4 Pre-Design Investigation

In June 2020, PDI was conducted to address remaining data gaps and provide additional information to complete the remedial design of the DPE System and the PTT. The following subsections present the objectives, describe the PDI activities and discuss the results of the PDI activities by remedial area. The investigation locations associated with the PDI are shown on Figure 5.

2.4.1 Truck Rack Area

In the Truck Rack Area, the PDI goals included:

- Determine the suitability of existing discharge piping for use in the DPE system.
- Characterize soil grain size and permeability within the saturated zone in order to confirm anticipated liquid and vapor flow rates and specify DPE well screen design.

2.4.1.1 Discharge Pipe Reconnaissance and Video Inspection

Approximately 150 feet of piping associated with the former PRT runs from the vertical culvert at the western end of the PRT (adjacent to the proposed DPE system enclosure) to a second vertical culvert located at the Truck Rack (Figure 5). At the Truck Rack, the PRT piping ties into a gravity sewer running from the Truck Rack oil-water separator to the Refinery wastewater treatment plant (WWTP).

Pipe reconnaissance and a video inspection was attempted in order to determine the suitability of the existing PRT piping for use as liquid transfer piping from the DPE system to the Refinery WWTP. The vertical culvert on the west side of the PRT and the vertical culvert at the Truck Rack were opened and the existing PRT piping was determined to be 1-inch diameter carbon steel pipe. Due to the small diameter, the video inspection could not be completed. Additionally, based on friction loss calculations, 1-inch diameter piping is insufficient to convey the anticipated maximum flow rate of 30 gallons per minute (gpm) from the DPE to the refinery gravity sewer. Due to the unknown condition of the transfer piping and the anticipated friction losses, it is recommended that new 1.5-inch diameter transfer piping be installed between the DPE system and the gravity sewer.

The gravity sewer could not be viewed or accessed at the Truck Rack vertical culvert so video inspection was not completed; however, it is understood that the gravity sewer is actively used to convey wastewater from the Truck Rack oil-water separator to the WWTP. Based on this understanding, the gravity sewer is considered adequate to convey liquids from the DPE to the WWTP.

2.4.1.2 Geotechnical Evaluation

During the pilot test within the DPE, geotechnical samples were collected from the unsaturated zone. To confirm anticipated permeability and liquid and vapor flow rates within the saturated zone and determine appropriate screen and filter pack design, two geotechnical borings (SB-200 and SB-201 as shown on Figure 5) were advanced within the PRT using a sonic drill rig to 10 ft-bgs. The soil borings

were continuously logged, and field screened with a photoionization detector (PID). In both borings, the coarsest material encountered was sand from 6 to 7 ft-bgs; therefore, one sample was collected from each boring (SB-200 and SB-201) at this interval and submitted to Core Laboratories LP of Bakersfield, California, for grain size analysis in accordance with ASTM Method D422/D4464AM. Boring logs and the geotechnical laboratory report are provided in Appendix B.

The grain size descriptions of each sample were:

- SB-200: Very Fine-Grained Sand (0.8% gravel, 62.2% sand, 30.0% silt, and 7.0% clay); and
- SB-201: Very Fine-Grained Sand (0% gravel, 65.4% sand, 28.0% silt, and 6.6% clay).

Based on this grain size distribution and the empirical Kozeny-Carmen estimate of conductivity, the estimated hydraulic conductivity for each boring is 10^{-5} cm/s. These hydraulic conductivity results are generally consistent with previous estimates of hydraulic conductivity via other methods as discussed in Section 2.2.4.

2.4.2 North River Road Area

In the North River Road Area, the PDI goals included:

- Refine the vertical and horizontal extent of groundwater contamination in order to define the vertical and horizontal limits of the PTT.
- Install compliance well MW-105 downgradient of the PTT in the shallow, perched hydro-stratigraphic unit.
- Conduct geotechnical testing in order to determine safe construction techniques for trench installation.
- Determine the chemical oxygen demand (COD) and biochemical oxygen demand (BOD) of groundwater intersecting the PTT to conduct reactive barrier dosing calculations.
- Abandon monitoring wells within or adjacent to the proposed PTT footprint in preparation for construction of the PTT.

2.4.2.1 Boring and Monitoring Well Installation

Monitoring well MW-41 was designated as a cross-connected monitoring well between the shallow perched and deep semi-confined hydro-stratigraphic units. In order to limit vertical contaminant migration as recommended in the *2019 Annual Groundwater Sampling Summary Report* (CMR, 2020b), cross-screened monitoring well MW-41 was abandoned. In order to understand the vertical extent of groundwater impacts, replacement monitoring wells MW-41S and MW-41D were installed in the shallow perched hydro-stratigraphic unit and deep semi-confined hydro-stratigraphic unit, respectively. Monitoring well MW-41S was installed to 14 ft-bgs and MW-41D was installed to 35 ft-bgs using a sonic drill rig. The wells were constructed of 2-inch diameter, schedule 40 polyvinyl chloride (PVC) with 10-foot 0.010-inch slotted screen.

To define the horizontal limits of the PTT and refine the understanding of lithology, soil borings were advanced and temporary monitoring wells were installed at the anticipated eastern and western boundary of the PTT based on interpolation of groundwater concentrations between existing monitoring wells. Boring SB-202 was advanced to the west (Figure 5) to 20 ft-bgs. Temporary monitoring well TW-202S was screened at this location from 7 to 12 ft-bgs in the fine silty sand unit. Temporary monitoring well TW-202D was screened from 12 to 17 ft-bgs in the strongly cemented very

fine sand unit. Boring SB-203 was advanced to the east (Figure 5) to 20 ft-bgs. Temporary monitoring well TW-203S was screened at this location from 8 to 13 ft-bgs in the fine silty sand unit. The temporary wells were constructed of 1-inch diameter, schedule 40 PVC with a 5-ft 0.010-inch slotted screen.

In the *AOC-16 Interim Measures Evaluation Report* (CMR, 2019c), monitoring well MW-62 located south of River Road was identified as the point of compliance well. However, upon further review of the site lithology, it was determined that MW-62 was screened across both the shallow perched and deep semi-confined hydro-stratigraphic units. As part of the PDI, alternative compliance well MW-105 was installed north of River Road (Figure 5). The well was advanced to 10 ft-bgs and screened in the shallow, perched hydro-stratigraphic unit from 5 to 10 ft-bgs. The well was constructed of 2-inch diameter, schedule 40 PVC with a 5-ft 0.010-inch slotted screen. Boring logs and well log reports are provided in Appendix B.

Based on the newly installed borings and a review of historical borings in the area, an updated understanding of the geology in the vicinity of the PTT is provided in Table 1 and presented in cross-section on Drawing C11 in Appendix A.

Based on this analysis, the hydrocarbon impacts were observed in the shallow, perched hydro-stratigraphic unit. Permanent wells MW-41S and MW-105 and temporary wells TW-202S and TW-203S were installed within this unit. Temporary well TW-202D was installed within the moderately to strongly cemented very fine sand layer. Permanent MW-41D was installed within the deep gray silt layer.

2.4.2.2 Well Development and Groundwater Sampling

Permanent monitoring well MW-41S was developed following installation to remove sediment that may have accumulated during drilling. Well development was surged and purged using a peristaltic pump.

Prior to abandonment, air sparge location AS-3 was sampled using a peristaltic pump. The groundwater sample was submitted to Energy Laboratories of Billings, Montana, for analysis of COD and BOD. This analysis was conducted in order to understand the presence of potential non-target compounds that could modify required PTT amendment dosing. The laboratory analytical report is provided in Appendix B. COD was 79 mg/L and BOD was less than 24 mg/L. These results do not indicate the presence of non-target compounds and do not require modifications to the dosing requirements.

Temporary monitoring wells TW-202S, TW-202D, and TW-203S were sampled using a peristaltic pump. Permanent well MW-41S and existing well MW-59S were sampled using low-flow sampling techniques.

Groundwater samples were submitted for analysis to Pace Analytical Services, Inc. (Pace) in West Columbia, South Carolina, for VOCs, SVOCs, Montana VPH, Montana EPH, and modified Skinner-List metals (including mercury). Metals were field filtered with a 0.45-micron filter.

The analytical results from the PDI groundwater sampling event are summarized in Table B-1 in Appendix B and the laboratory analytical report is provided in Appendix B. Analytical results are displayed on Figure 4. Results were compared to the DEQ-7 HHS and the MDEQ Tier 1 RBSLs. Benzene concentrations exceeded the DEQ-7 HHS and Tier 1 RBSLs at shallow perched wells MW-41S, TW-202S, MW-203S, and MW-105 with the highest benzene concentration observed at MW-41S.

Bis(2-ethylhexyle)phthalate, C5-C8 aliphatics, C9-C12 aliphatics, and C9-C10 Aromatics also exceeded the DEQ-7 HHS or Tier 1 RBSLs at MW-41S and C5-C8 aliphatics and C9-C10 aromatics exceeded the Tier 1 RBSLs at TW-202S.

2.4.2.3 Geotechnical Evaluation

During the installation of MW-41S, three Shelby tube samples were collected for geotechnical analysis to determine the constructability of the trenches. One sample was collected from the upper silty sand unit (4 to 5 ft-bgs) and two samples were collected from the very fine sand with silt unit (9 to 10 ft-bgs and 11 to 12 ft-bgs). A Shelby tube could not be advanced into the sandstone unit (7 to 8 ft-bgs) due to the hardness of the material. The Shelby tubes were submitted to Core Laboratories LP of Bakersfield, California for the following analyses:

- Atterberg Limits (ASTM D4318),
- Bulk Density (ASTM D2937),
- Specific Gravity (ASTM D854/D5550), and
- Moisture Content (ASTM D2216).

The geotechnical laboratory report is provided in Appendix B. Results indicate non-cohesive soils that will likely require the use of excavation sidewall support/shoring while trenching at deeper depths within the upper soil unit.

2.4.2.4 Monitoring Well Abandonment

Monitoring wells MW-40, MW-41, MW-50, MW-51, MW-52, MW-58, and pilot test wells SVE-3, and AS-3, located in the proposed PTT footprint, were abandoned by a licensed well driller in preparation for construction of the PTT. Well abandonment forms are provided in Appendix B.

2.4.2.5 Waste Characterization

During the PDI, three waste characterization samples were collected by Ramboll and analyzed by Energy Laboratories. Sample S-527 was collected from SB-202 where the heaviest petroleum visual impacts were observed. This sample was analyzed for VOCs using toxicity characteristic leaching procedure method (TCLP) 1311 zero headspace extraction to obtain an accurate measurement of maximum potential VOC concentrations in an undisturbed sample. Sample S-528, a composite sample collected from SB-202 and SB-203, was analyzed for total concentrations and TCLP concentrations of relevant RCRA hazardous waste characteristics (VOCs, SVOCs, RCRA eight metals plus nickel, reactive cyanide, reactive sulfide, and pH). Sample S-529, a composite sample representative of waste soil that will be generated during the construction of the AOC-16 remediation system as a whole, was analyzed for TCLP concentrations of relevant RCRA hazardous waste characteristics (VOCs, SVOCs, RCRA eight metals plus nickel, reactive cyanide, reactive sulfide, and pH).

The analytical laboratory reports are provided in Appendix B. The three sets of analytical results support a non-hazardous waste designation.

2.4.2.6 Management of IDW

Investigation derived waste (IDW) generated during the PDI included soil cuttings, purge water and wastewater from decontamination procedures, and solid waste. Soil cuttings were containerized in a 55-gallon drums and disposed of directly by CMR utilizing the waste characterization sampling described in Section 2.4.2.3. Purge water and wastewater was disposed via a sewer line that runs to

the refinery's wastewater treatment plant. Solid waste, including disposable gloves and sampling equipment, was placed in a dumpster for off-site disposal.

2.5 Dual-Phase Extraction Basis Of Design

Based on the IM Objectives, Site CSM, and AS/SVE Pilot Study results, DPE within the existing PRT was selected as the IM remedial approach in the Truck Rack Area. DPE is expected to be an effective IM remedial alternative based on the following site characteristics:

- The measured hydraulic conductivity in the PRT is estimated to range from 5 x 10^{-6} cm/s (based on the 2019 Pilot Permeameter Test from the PRT) to 1.3 x 10^{-4} cm/s (based on the Kozeny-Carmen Empirical Estimate of Conductivity determined from grain-size analysis of material collected during the 2019 Pilot test within the PRT). This value falls within the literature value optimal range of 10^{-3} to 10^{-5} cm/s (USEPA, 1999). The intrinsic permeability of the PRT is estimated between 5 x 10^{-10} cm^2 and 1 x 10^{-9} cm^2 which falls into the "effective" category per the United States Environmental Protection Agency's (USEPA) October 2017 *How to Evaluate Alternative Cleanup Technologies For Underground Storage Tank Sites* (USEPA, 2017).
- LNAPL recovery associated with conventional pump and treat remediation reached diminishing levels in the early 2000s. The LNAPL, including residual LNAPL, is present in the vadose, saturated, and capillary zones. DPE is most applicable when contamination is present in all three zones (USEPA, 1999).
- The water table is shallow and the saturated thickness is small (USEPA, 1999).
- SVE alone was not effective during the pilot test due to the presence of LNAPL.
- The product composition is primarily gasoline and diesel. Due to their relatively high volatility and high vapor pressure, these constituents fall into the USEPA's "effective" and "most effective" contaminant category for remediation via DPE (USEPA, 2017).

DPE involves the extraction of soil vapor, groundwater, and LNAPL under vacuum conditions. The applied vacuum extracts soil vapor in the vadose zone and groundwater/LNAPL is extracted by pumping below the water table. The primary design considerations include the vapor extraction ROI, water/ liquid extraction rate, LNAPL/contaminant extraction rate, air flow/vapor extraction rate and applied vacuum as described below.

2.5.1 Radius of Influence

To determine optimum well spacing and vapor treatment area of the DPE wells in the Truck Rack Area - PRT, a vapor ROI was determined utilizing the results of the constant rate SVE pilot test conducted in the Truck Rack Area - Native Material. The constant rate test in the native material concluded that the effective vapor ROI (defined as the area surrounding a vapor extraction point in which vapor flow is effectively achieved) was 24 feet.

The ROI achievable within the PRT when dewatered will likely be higher than the ROI measured in the native material under saturated conditions because the non-native PRT media has a higher intrinsic permeability than the native material where the pilot test was conducted. Additionally, pneumatic permeability in the formation will increase once the PRT is dewatered and less water is present in the soil matrix.

Based on the pilot test in native material, the conservative vapor treatment ROI in the PRT is between 20 and 30 feet.

2.5.2 Water/Liquid Extraction Rate

The estimated groundwater extraction rate from a single well was determined utilizing the Cooper Jacob modification to the Theis solution to the well equation as described in the *USACE Engineering and Design Multi-Phase Extraction Engineer Manual* (USACE, 1999) which is generally applicable to confined conditions. However, it can also be used to approximate drawdown during early pumping times under unconfined conditions. In this case, the Theis equation was used to estimate early dewatering drawdown (from storage) and an order of magnitude estimate of liquid flow rates.

The water bearing zone is relatively heterogeneous and the conductivity of the PRT is greater than that of the native materials. It is assumed that upon startup as the PRT is dewatered, the flow rates will be highest. Once the PRT is dewatered, the flow rate will be limited by the conductivity of the native material. To estimate the potential flow rates, radial distance versus drawdown was calculated for three different hydraulic conductivities (5×10^{-6} cm/s, 5×10^{-5} cm/s, 5×10^{-4} cm/s).

An achievable flow rate was determined iteratively to keep drawdown at well screen to approximately 25 feet. While the saturated thickness is only between 5 and 8 feet, the effective drawdown under vacuum can be greater than the saturated thickness because effective drawdown is equal to the actual drawdown plus the applied vacuum.

The achievable flow rate at a single well as a function of conductivity ranges between 0.03 gpm under a hydraulic conductivity of 5×10^{-6} cm/s to 1.6 gpm under a hydraulic conductivity of 5×10^{-4} cm/s.

Based on these calculations, the achievable flow rates from individual wells will be between 0.03 and 1.6 gpm during startup and on the order of 0.03 gpm at steady-state operation. Using eight extraction wells, the flow rate from the eight DPE wells is estimated to range from 0.25 to 12.8 gpm during startup and approximately 0.25 gpm during steady-state operation. The calculated start-up flow rates are in line with the SVE pilot test which recorded 20 gallons of liquid extracted over 1 hour (0.3 gpm) from a single well. Given the heterogeneity of the water bearing zone and variation in the available hydraulic conductivity data, historical pumping/flow rate data from the PRT in the early 2000s serve as an indicator of anticipated future flow rates for the DPE system design. Per the May 2004 *IM Corrective Action Report Cost Estimate, AOC #16* (MRC, 2004), the PRT ground water recovery rates ranged from 160 to 299 gallons per day (gpd) (0.1 gpm to 0.2 gpm) during normal operation. A maximum pumping rate of 1,428 gpd was noted due to a leak from a nearby fire water main.

An analysis of the expected infiltration rate during rain events was performed using the methods described in the United States Department of Agriculture (USDA) Natural Resources Conservation Service *Estimation of Direct Runoff From Storm Rainfall* (USDA, 2004). Based on this analysis, a maximum increased flow rate of 7 to 8 gpm (10,080 to 11,520 gpd) would be expected during storm events. Considering the rate of groundwater flow and the contribution of infiltrating rainwater into the PRT, the design flow rate for the DPE system will range between 0.25 and 21 gpm to account for precipitation events.

Generally, the relatively low groundwater transmissivity will limit the potential flow rates from individual wells at steady-state operation (i.e., the well will be dewatered faster than it can recharge).

2.5.3 LNAPL/Contaminant Extraction Rate

As describe d above, given the low native material conductivity and higher PRT conductivity, the liquid flow rates will be highest upon startup. After the DPE system dewaters the PRT, the total fluids

recovery will decrease (see Section 2.4.2). During steady-state operations, the system will shift to primarily vapor recovery and most of the contaminant mass will be recovered in the vapor phase.

During the pilot test in the Truck Rack Area - PRT, approximately 15 gallons of LNAPL was recovered over the course of the 60-minute step test (0.25 gpm). The pilot test was conducted in the highest %RE area of the PRT. Other wells with lower %RE UVOST results will yield lower LNAPL recovery rates. LNAPL recovery rates will also decrease over time as LNAPL saturation decreases.

LNAPL transmissivity testing was conducted in monitoring well MW-53 in October of 2017. The test, following API transmissivity test methods, utilized two models indicated an LNAPL transmissivity ranging between 0.32 and 0.41 ft^2/day, indicating that the LNAPL is likely marginally recoverable under current conditions (CMR, 2018). Transmissivity is a function of both aquifer conductivity and LNAPL saturation. MW-53 is located in native material with the highest LNAPL saturation (per UVOST testing and indicated by the presence of LNAPL in the well). The higher hydraulic conductivity of the PRT means potentially higher transmissivity within the PRT whereas the generally lower LNAPL saturation means an expected lower LNAPL transmissivity.

Vapor concentrations observed during the pilot test represent a maximum vapor recovery that will also decrease with time. VOC vapor concentrations measured during the step-rate test in the Truck Rack Area – PRT (7,700,000 ug/m^3) represent maximum observed vapor loading and are expected to decrease with time as remediation proceeds. The predominant constituents include n-hexane (53% by mass), cyclo-hexane (38% by mass), and benzene (6% by mass). Based on an anticipated flow of 200 standard cubic feet per minute (SCFM), the maximum mass loading will be 5.8 pounds (lbs) per hour. LNAPL was recovered in the well during the step-rate test. At equilibrium, the maximum vapor concentration in the presence of LNAPL is driven by Raoult's law. Assuming a relatively consistent LNAPL composition across the PRT, exposing additional LNAPL will not drive additional contaminants into the vapor phase.

2.5.4 Applied Blower Vacuum/Vapor Extraction Rate

The applied blower vacuum must be sufficient to extract both vapors and liquids from each well. Therefore, the system design is constrained by the vacuum required to remove liquids from the bottom of each well. Given that the bottom of the shallow zone is approximately 14 feet, an applied vacuum of 14 feet of water or 12.6 inches of mercury (in-Hg) is required at each wellhead to provide sufficient suction lift to extract liquid from the bottom of the well. Due to the variability and uncertainty in the subsurface permeability and required flexibility in the system design, a factor of safety of 25% was incorporated into the design necessitating an applied vacuum of 16 in-Hg at each well head. To determine the required blower vacuum, the frictional pipe losses were calculated between the well furthest from the DPE enclosure and the blower (approximately 240 feet). Between frictional losses and the required vacuum at the wellhead to extract liquids, a minimum blower vacuum of 17 in-Hg is recommended.

The vapor extraction rate is a function of the applied blower vacuum. The relationship between blower vacuum and vapor extraction rate was determined during the step-rate pilot test. During the pilot study, vapor flow rates of 24.3 SCFM and 28.3 SCFM were recorded at applied vacuums of 15 in-Hg and 17.5 in-Hg respectively. Based on this analysis, a design vapor flow rate of approximate 25 SCFM is anticipated from each extraction well or 200 SCFM combined flow from eight DPE wells. At the altitude of Great Falls, Montana (approximately 3,330 feet) under 17 in-Hg, 200 SCFM corresponds to 620 actual cubic feet per minute (ACFM) of vapor flow.

2.6 Passive Treatment Trench Basis Of Design

A PTT with contingent LNAPL recovery wells was chosen for the North of River Road Area for the following reasons:

- The primary goal in this area is to mitigate the dissolved phase groundwater impacts from migrating from the Truck Rack towards the Missouri River.
- The measured hydraulic conductivity and air permeability was low as demonstrated by the SVE/AS pilot test. The matrix is not conducive to SVE/AS or other active pumping. A hydraulic conductivity less than 1.0 ft/day is generally considered suitable for passive treatment trenches (ITRC, 2011).
- The contaminant distribution depth is less than 15 feet which is within the depth of traditional trenching/excavation methods (ITRC, 2011).
- Due to low conductivity, contaminant flux is also low so a PTT will have relatively long lifespan.
- LNAPL has periodically been observed in monitoring well MW-41. Mobile LNAPL can overrun the sorption capacity of the colloidal activated carbon (CAC) used as the reactive media. As such, a second trench outfitted with LNAPL recovery wells will be installed upgradient of the PTT to protect it from LNAPL intrusion.

The PTT consists of a trench oriented perpendicular to and centered on the axis of impacted groundwater flow that is backfilled with a media that treats the groundwater flowing through it. The primary design considerations include the groundwater flow velocity/ specific discharge, the contaminant flux, and the treatment trench chemistry as described below.

2.6.1 Groundwater Flow Velocity

The specific discharge is calculated by:

$$q = -K(i)$$

where: q = specific discharge
K = hydraulic conductivity
i = horizontal gradient

The effective velocity is calculated by:

$$v = \frac{q}{n}$$

where: v = effective velocity
q = specific discharge
n = porosity (measured to be 0.3 in the native material during the pilot test)

As described in the *2019 Annual Groundwater Sampling Summary Report*, the groundwater in the AOC-16 area is from north to south with relatively constant gradients ranging between 0.036 and 0.042 feet/feet (CMR, 2020b).

Based on the geotechnical analysis (Section 2.2.4), the hydraulic conductivity of the native media north of river road was measured to be less than 1 x 10^{-9} cm/s. However, as described in Section 2.2.4, the lithology within AOC-16 is known to be heterogenous and layered with estimates of hydraulic conductivity ranging from less than 1 x 10^{-9} cm/s to 1 x 10^{-3} cm/s. The maximum value of 1 x 10^{-3} cm/s is based on literature values of fine sands and is likely more representative of soils in the PRT area than the North of River Road Area. Because the North River Road Area has generally

demonstrated lower conductivity, the next highest conductivity estimate of 1.3 x 10^{-4} cm/s was conservatively chosen as the design hydraulic conductivity for the passive treatment trench.

Based on a gradient of 0.042 ft/ft and a hydraulic conductivity of 1.3 x 10^{-4} cm/s, the design specific discharge is 5.5 ft/yr and the design effective velocity is 18.3 ft/yr.

2.6.2 Contaminant Flux

To determine the worst-case scenario contaminant flux into the PTT, the maximum historical contaminant concentrations recorded at monitoring wells in the vicinity of the PTT including MW-52, AS-3, MW-41, MW-50, and MW-52 were utilized. The maximum contaminant concentrations historically recorded entering the PTT were:

- Benzene – 4,990 µg/L;
- Toluene – 6,960 µg/L;
- Ethylbenzene – 2,740 µg/L;
- Xylenes and Naphthalene – 21,250 µg/L; and
- Total petroleum hydrocarbons subtracting benzene, toluene, ethylbenzene, and xylenes (BTEX) – 2,410 µg/L.

Based on these maximum concentrations and a specific discharge of 5.5 ft/yr (as described in Section 2.6.1), the estimated maximum contaminant flux per unit of saturated PTT is approximately 18.6 milligrams per square foot per day.

The width of the PTT will be based upon the parcel boundary to the west and the width of the LNAPL footprint and groundwater impacts to the east as shown on Figure 3 and is further discussed in Section 4.2. The geometry of the barrier is also constrained by the presence of an active sewer line (Drawing C10 in Appendix A). The vertical extent of the PTT corresponds to the saturated, shallow perched zone.

Based on this geometry (10 feet saturated thickness by 110 feet long or a PTT face area of 1,100 square feet), the maximum contaminant flux through the PTT is approximately 16.4 pounds per year.

2.6.3 Treatment Kinetics and Chemistry

Based on the existing site data and remedial goals, Regenesis® product PetroFix™ will be utilized in the PTT. PetroFix™ is a highly concentrated water-based suspension made up of micron-scale activated carbon and bio-stimulating electron acceptors consisting of a sulfate/nitrate combination. Hydrocarbons and benzene, toluene, ethylbenzene and xylenes will partition from the dissolved phase by adsorption to the activated carbon particles. The contaminants will be anaerobically biodegraded through chemical oxidation stimulated by the bio-stimulating electron acceptors. In chemical oxidation, the substrate loses electrons and is oxidized, while the oxidants (nitrate and sulfate) gain electrons and are reduced.

2.6.4 Longevity

The remediation contractor Regenesis® has prepared a finite difference dosing model to determine the optimal dosage based on a design lifespan of 30 years. A technical memorandum describing the assumptions, dosing model, and longevity calculations is provided in Appendix C. The dosing model

suggests that the proposed quantity of PetroFix™ (14,000 pounds) will result in an effective longevity of 23 years assuming no biodegradation (adsorptive capacity only). Biodegradation through natural attenuation, aided by the PetroFix™ electron acceptors, is anticipated to increase barrier longevity to greater than 30 years total.

2.6.5 LNAPL Recovery and Removal

LNAPL has periodically been observed in monitoring well MW-41. Mobile LNAPL can overrun the sorption capacity of the activated carbon used as the reactive media. As such, an LNAPL recovery trench outfitted with 11 vertical 6-inch diameter, schedule 80, PVC LNAPL recovery wells used to facilitate LNAPL collection will be installed upgradient of the passive treatment trench to facilitate LNAPL collection, if necessary.

While measurable LNAPL has been periodically observed in MW-41, multiple lines of evidence indicate that there is not a continuous, migrating LNAPL plume upgradient of the PTT including:

- The 2017 UVOST data and 2017 soil analytical data as reported in the July 2017 Trihydro/CMR *AOC-16 Interim Measures Investigation Report, Calumet Montana Refining, LLC, Great Falls Montana* indicated %RE and total petroleum hydrocarbon concentrations less than residual saturation.
- Groundwater concentrations in the vicinity of the PTT have been decreasing over time suggesting a stable or shrinking LNAPL body.
- In 2019, only 1.4 gallons of LNAPL were recovered via passive means (adsorbent socks) at MW-41.

As such, passive recovery methods are anticipated to be sufficient to recover LNAPL. If LNAPL is present, passive absorbent materials or skimmers will be installed in the recovery well and incorporated into current OM&M activities. If the passive LNAPL absorbent material or skimmers are not sufficient to collect the LNAPL, an active pneumatic LNAPL recovery pumps or skimmers will be installed.

3. DUAL-PHASE EXTRACTION SYSTEM DESIGN

This section presents the design of the DPE system to capture and treat impacted groundwater, soils, and soil vapor in the Truck Rack Area. Design drawings showing the system components including existing site features and PRT layout, proposed DPE extraction well and transfer piping, mechanical layout and process and instrumentation diagram are provided in Appendix A. Technical performance specifications are provided in Appendix D. Components of the DPE are summarized below.

3.1 System Description

3.1.1 General

The DPE system consists of eight DPE wells screened across the shallow water bearing zone within the existing PRT. Vapors and liquids will be extracted through a single drop tube installed in each DPE well. Two rotary claw vacuum blowers installed in parallel will extract the vapor and liquid. Each well will be connected via conveyance piping to the vacuum blowers housed at the treatment enclosure for extraction and treatment on-site. A vapor/liquid separator (VLS) will be located prior to the vacuum pumps to separate vapor from fluids and convey the vapor to a self-recuperating catalytic thermal

oxidizer (SRCO) unit for air treatment. Liquids will be pumped via underground conveyance piping to the CMR WWTP. Waste streams and waste conveyance are further discussed in Section 7.

3.1.2 Configuration

The DPE wells will be located within the PRT which has a higher permeability than the native formation likely due to the disturbed soils within the PRT which allows for increased air and liquid flow. The project vapor ROI was conservatively estimated from the pilot test to be 24 feet. The layout of the DPE wells will utilize a spacing between 30 and 40 feet (corresponding to a ROI of between 15 and 20 feet per well) within the existing PRT which allows for 5 to 10 feet of overlap of ROI between wells. The wells are spaced closer in the eastern portion of the site corresponding to the area where higher residual concentrations were observed in the UVOST data. The spacing in the northwestern portion of the PRT is greater (approximately 40 feet between wells) due to surface obstructions which also corresponds to the area where UVOST data demonstrated lower residual concentrations. Drawing C5 and Drawing C6 in Appendix A shows the DPE equipment layout.

3.1.3 NFPA Hazardous Location Classification

The DPE system aims to recover LNAPL and impacted vapor. Based on the measured vapor composition during the pilot test, the LEL of the extracted vapor mixture is 1.2% by volume and the measured concentrations indicated 19% of the LEL in the vapor stream. To minimize the risk of explosion, combustible composition control will be utilized in accordance with National Fire Protection Association (NFPA) 67 *Guide on Explosion Protection for Gaseous Mixtures in Pipe Systems*, Chapter 6.1.1. The vapor concentration within the system will be maintained at or below 25% of the LEL using LEL monitors and dilution ambient air modulating control valves.

The DPE enclosure will be divided into a main equipment room and a control room (see Drawing M1 in Appendix A). The main equipment room housing the process piping, VLS, and blower will be rated Class 1, Division 2 per NFPA 70, *National Electric Code*. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations are further subdivided into two Divisions and three Zones. The DPE enclosure falls under Division 2 as defined by NFPA 70 as an area where *"volatile flammable liquids or flammable gases are handled, processed or used, but the hazardous liquids, vapors or gases will normally be confined within closed containers or closed systems from which they can escape only in the event of accidental rupture or breakdown of such containers or systems, or as a result of abnormal operation of equipment."* The control room will be separated from the main equipment room as shown on Drawing M1 in Appendix A. Due to the separation, there is no potential for volatile flammable liquids or flammable gasses in the control room and that area will be unclassified.

Given the Class 1, Division 2 classification of the main equipment room, adequate ventilation, defined as at 12 air changes per hour, will be required. The main equipment room will be outfitted with an exhaust fan and louvers to meet this condition.

3.2 Dual-Phase Extraction Wells and Drop Pipe

DPE wells will be installed using sonic drilling methods utilizing a core barrel with a 12-inch diameter override casing. DPE wells will be constructed utilizing 6-inch diameter schedule 80 PVC with a 5-foot slotted PVC wells screen at the base of the well. The well will be screened from 9 to 14 ft-bgs in order to generate a cone of depression and enhance LNAPL recovery.

The grain size distribution from borings SB-200 and SB-201 collected during the PDI (Section 2.4.1.1) was reviewed with a well-screen manufacturer. This evaluation determined that a slot size larger than 15-slot (0.015 inch) may allow for fine silts and sands to enter the well during pumping. However, the small slot size may also limit the amount of LNAPL that enters the well. The wells are anticipated to primarily recover vapor at steady-state operation which will minimize the amount of fine silts and sands that enter the well compared to continuous water extraction. In order to balance fines entering the well while maximizing LNAPL recovery, a 20-slot (0.020 inch) screen with 10-20 sand filter pack is recommended.

The filter pack will be placed from the bottom of the boreholes to 1 foot above the top of the well screens. The remaining annular space will be comprised of cement grout on the coarse sand ensuring a secure seal. All DPE wells will be protected with a 24-inch square, bolt-down, flush-mount well vault and traffic rated access cover. Well construction details are provided in Drawing C7 in Appendix A.

DPE wells will be developed after installation to remove residual materials remaining in the well after installation and to re-establish the hydraulic flow conditions of the PRT which may have been disturbed during well construction. Each well will be developed using a submersible pump and surged to purge the well until residual materials (fines) are minimized.

Each DPE well will be equipped with a pitless adapter for a 2-inch diameter galvanized steel drop pipe which will be attached to DPE PVC conveyance piping. The 2-inch diameter drop tube was sized to maintain a linear gas velocity greater than 500 meters per minute in order to entrain liquid droplets in the gas stream. The pitless adapter will be installed approximately 3 ft-bgs. The drop pipe will extend from the pitless adapter to approximately one foot from the bottom of each DPE well. The drop pipe length can be adjusted to modify the ratio of groundwater to vapor recovered by the system.

3.3 Treatment System Enclosure

The process treatment system will be housed in a pre-engineered treatment enclosure (DPE enclosure). As shown on Drawing C6 in Appendix A, the DPE enclosure will be placed west of the existing PRT on a gravel pad foundation. The DPE enclosure will be divided into a Class 1, Division 2 hazardous area rated main equipment room and an unclassified control room (see Drawing M1 in Appendix A) as described in Section 3.1.3. The DPE enclosure will include appropriate heating and thermostat to prevent freezing, appropriate ventilation in the main equipment room given the Class 1, Division 2 hazardous area rating, and appropriate lighting for proper operation of the system. The unclassified control room will include an air conditioner to prevent overheating of the controls. The DPE enclosure will include built-in secondary containment in the event of a leak along with an interlock that will shut down the DPE System in the event of liquid accumulation within the secondary containment. A layout of the DPE enclosure in provided in Drawing M1 in Appendix A.

3.4 Process Treatment System

3.4.1 Dual-Phase Extraction Conveyance Piping

The pitless adapter at each wellhead will be connected to horizontal 2-inch diameter schedule 80 PVC pipe installed in a trench. The soil vapor, groundwater and LNAPL extracted from each extraction well will be conveyed below ground in individual 2-inch diameter schedule 80 PVC pipes. Individual DPE conveyance pipe will be run in a dedicated trench which joins with a common trench accommodating all eight DPE well conveyance pipes into the DPE system enclosure. The underground piping will be heat-traced and insulated.

Within the treatment enclosure, each extraction well pipeline will be equipped with a throttling ball valve to allow for individual flow control from each well. The manual throttling valves will be used to throttle the flow rate for each individual extraction line and maintain the design flow rate per well.

Sample ports will also be located on each extraction well suction line to allow vapor or groundwater samples to be taken from the suction line of each well.

Within the treatment enclosure, the eight 2-inch suction lines will be manifolded into two 6-inch schedule 80 PVC headers. Each header will be equipped with a motor-actuated 6-inch butterfly valve used to isolate the flow of fluids from each set of wells in the event of a high-water table condition and to limit the rate of water discharge to the WWTP. After the butterfly valves, the two headers will be manifolded into a single 6-inch schedule 80 PVC header which is conveyed to the VLS.

3.4.2 Vapor/Liquid Separator Tank And Transfer Pump

The extracted fluids and vapor will be drawn through a 300-gallon VLS to remove entrained fluids. The extracted fluids will pass through a vertical, cylindrical vessel through the tangential inlet and top center outlet. A wire mesh pad in the vessel will be used to separate the LNAPL and water from the extracted soil gas.

The vapor liquid separator will be equipped with a low-level switch, a high-level switch, and a high-level shutoff switch. The low-level switch and high-level switch will be used to operate a condensate transfer pump. When the amount of liquid in the tank reaches the high-level switch, the transfer pump will be operated to transfer the recovered liquids to the Refinery's WWTP.

The extracted liquids (water and LNAPL) will be pumped via a progressive cavity pump through 1.5-inch PVC effluent piping to a 6-inch refinery gravity process sewer located 150 feet north of the treatment enclosure. The process sewer conveys the liquids to the CMR WWTP for treatment and discharge to the City of Great Falls WWTP.

3.4.3 Vacuum Blowers

The selected vacuum blowers for the DPE application are rotary-claw blowers. The required blowers for the DPE system must be capable of generating 17 in-Hg (corresponding to the required vacuum at each wellhead as described in Section 2.5.4 plus calculated frictional losses through the longest run of pipe) and a flow rate of 200 SCFM at the site elevation of 3,300 ft-amsl. Rotary claw blowers were selected because they are capable of generating sufficient vacuum, while minimizing maintenance requirements. In order to meet the flow requirements, two rotary-claw blowers will be required. The blowers will be equipped with variable frequency drives (VFD) to allow for vacuum and flow adjustments.

Inlet piping to the vacuum blowers will include soil vapor and dilution ambient air modulating control valves. Each blower will include the provision for the addition of ambient air to be fed into the vacuum header to dilute soil vapor in event of a high LEL explosive condition. The vacuum blower system controls will include automated safeguards to introduce ambient dilution air if an elevated LEL condition is detected and to shut down the vacuum blowers if an alarm LEL condition is detected.

3.4.4 Vapor Treatment System

Vapors extracted during DPE operation will be conveyed from the VLS to an electric SRCO for treatment of VOCs via destruction through thermal catalytic oxidation to innocuous components.

Treated vapors are then released to the atmosphere. Catalytic oxidizers utilize a catalyst (metal substrate) to allow oxidization to occur at lower temperatures than thermal oxidation alone. A heat exchanger is also used to preheat the incoming process air using the oxidizer exhaust stream in order to reduce energy costs.

The selected SRCO unit has a maximum air flow rate of 1000 SCFM, maximum loading of 25% LEL, and 99% destruction and removal efficiency. The SRCO unit will be equipped with an inlet air blower and an auto dilution valve to control the temperature of the catalyst bed and process inlet and outlet air temperature. The catalyst inlet operating temperature is 650ºF, catalyst outlet operating temperature is ~1160°F, with a maximum outlet high temperature setting of 1,250°F. The SRCO design heat exchange efficiency is approximately 50% and will have a minimum design destruction efficiency of 99%.

During remediation, VOC concentrations are anticipated to decrease over operation. As the VOC concentrations decrease, additional electrical power is required to bring the catalyst inlet temperatures to the set point required for adequate destruction efficiency.

As shown on Drawing C6 in Appendix A, the SRCO will be placed east of the DPE enclosure on a gravel pad foundation.

3.5 Electrical Power Requirements

A separate electrical power distribution service will be installed from the existing Northwestern Energy wooden pole mounted overhead transmission lines located south of the CMR property. The CMR truck rack area is currently connected to the single circuit 12.47 kilovolt (kV) three-phase electrical source. The electrical service for the DPE system and vapor treatment system will be separately connected to the 12.47 kV transmission line.

A new underground electrical service will be installed near the existing transmission line and connected by Northwestern Energy construction personnel to create a new primary service. The proposed service will be routed underground to an electrical transformer located adjacent to the proposed DPE system enclosure area to an electrical meter and main electrical panel. A gang operated air break (GOAB) switch and meter socket will be located on the transmission line power pole and the conductors feed a 225 kVA transformer that supplies power to an exterior-mounted secondary disconnect switch that feeds the main power panel inside the DPE enclosure.

A licensed electrician will run conductors from the main electrical panel to energize the DPE process equipment and the SRCO as shown on the electrical one-line drawings (Drawing E1 through E3 in Appendix A). All equipment will be installed, wired, and commissioned in accordance with the National Electrical Code.

3.6 Process Treatment System Controls

The DPE system will be equipped with a programmable logic controller (PLC) to monitor and record selected system operating data including vacuums, temperatures, fluid levels in the VLS, and SRCO for the DPE system equipment. The PLC will be accessible remotely through a cellular internet connection, allowing personnel to remotely access the PLC and observe the same operating information available to the field staff. If monitoring data exceeds pre-established normal operating ranges, the system operator will be notified via visual display elements on the control screen. If the system is shut down due to an alarm condition, the system operator and project personnel will receive

notifications via SMS text message to a cellular device or via electronic message. Alarms and unplanned shutdowns will lead to notification to the system operators who will respond to the alarm and communicate with the operations and/or engineering staff to determine appropriate response actions and troubleshooting activities. Further details regarding system alarms and interlocks are presented on Drawings PID-01 through PID-07 in Appendix A and in the OM&M Plan included as Appendix E.

4. PASSIVE TREATMENT TRENCH AREA DESIGN

This section presents the design of the PTT Area to intercept periodic LNAPL slugs (LNAPL recovery trench) and treat the groundwater plume (PTT) within the North River Road Area. Design drawings showing cross-sections and a plan view of the PTT Area is provided in Appendix A. Design calculations associated with the PTT provided by the remediation contractor are provided in Appendix C. Technical performance specifications are provided in Appendix D.

4.1 General Description

The North River Road Area will consist of two parallel trenches separated by approximately 4 feet of native material as shown on Drawing C10 in Appendix A. Both trenches will be installed perpendicular to the groundwater flow path.

The upgradient LNAPL recovery trench will be 5-feet wide by 10-feet deep by 50-feet long and centered along and downgradient of the elevated 2017 LIF data. The upgradient trench will be backfilled with coarse sand intended to recover LNAPL prior to the PTT to limit LNAPL from entering the PTT and overrunning the sorption capacity of the activated carbon. During trench backfilling activities, eleven vertical 6-inch diameter, Schedule 80, PVC LNAPL recovery wells will be installed into the coarse sand to facilitate LNAPL collection and monitoring. LNAPL absorbent materials will be installed in each recovery well and incorporated into current LNAPL OM&M activities for AOC-16 recovery well MW-53. If LNAPL absorbent material is not adequately collecting LNAPL in a recovery well, active pneumatic LNAPL recovery pumps will be installed. The pneumatic pumps will be driven using compressed air canisters in a similar configuration as the automated recovery system at MW-53. LNAPL absorbent materials will be containerized with existing CMR oil absorbent wastes. If necessary, extracted LNAPL will be containerized within a 250-gallon tote with appropriate secondary containment.

The downgradient PTT will be 5-feet wide by 12.5-feet deep and 110-feet long. The PTT will be installed to the top of the aquitard unit/the top of the moderately to strongly cemented very fine sand. The PTT will be backfilled with a reactive media (CAC plus terminal electron acceptors) incorporated into coarse sand (Appendix A, Drawing C12). Groundwater will flow through the PTT and hydrocarbons, benzene, toluene, ethylbenzene and xylenes will partition from the dissolved phase by adsorption to the activated carbon particles. The contaminants will be anaerobically biodegraded through chemical oxidation stimulated by the bio-stimulating electron acceptors.

At the PTT, the trench will be backfilled from 12.5 ft-bgs to 2.5 ft-bgs with a CAC material (Regenesis® product PetroFix™) mixed into a coarse sand in 1 to 2-foot lifts. The coarse sand is used to maximize the flux through the barrier by utilizing a material that is more permeable than the surrounding native formation. The liquid PetroFix™ will be mixed with the coarse sand using an excavator. The top 2.5 feet of the trench will be backfilled with clean reused native soil material excavated and stockpiled

from the initial top 2 feet of the trench alignment and compacted to match the surrounding topography.

4.2 LNAPL Recovery Trench Configuration

The proposed LNAPL Recovery Trench configuration is shown on Drawing C10 in Appendix A. The LNAPL recovery trench will be installed upgradient of the passive treatment trench to limit LNAPL from entering the PTT and overrunning the sorption capacity of the activated carbon. The highest potential for mobile LNAPL occurs along the 50-foot center of the PTT immediately downgradient of the greatest %RE LIF UVOST® response.

The geology in this area is heterogenous and previous investigations did not indicate a continuous, migrating LNAPL body. If migrating LNAPL is present, it is likely in thin, higher conductivity zones. Because the exact location of the thin, higher conductivity zones is unknown, the trench will protect the entire face of the PTT. Wells installed within the trench will be used to monitor and extract, if necessary, any LNAPL that accumulates.

Vertically, the trench will span the length of the smear zone so that the trench intersects mobile LNAPL under high and low water table conditions. The top of the smear zone corresponds to historical groundwater high elevations and is indicated by elevated PID readings, visual evidence of hydrocarbon staining, and hydrocarbon odor in boring logs. Based on a review of historical groundwater elevations and historical boring logs, the upper limit of the smear zone is encountered at approximately 2.5 ft-bgs. Based on a review of historical groundwater elevations, the lower limit of the smear zone is anticipated at approximately 8 ft-bgs. The trench will be installed an additional 2 feet below the bottom of the anticipated smear zone to assure that LNAPL is captured in the trench. The total proposed depth of the LNAPL recovery trench is 10 ft-bgs. The LNAPL recovery wells will consist of slotted 6-inch diameter slotted piping installed during trench installation. The LNAPL recovery wells will be slotted from 3 to 8 ft-bgs.

4.3 PTT Configuration

The proposed PTT configuration is shown on Drawing C10 in Appendix A. The available area for installation is constrained by property access concerns and existing utilities. CMR has an access agreement with Northwestern Energy for the 23-foot-wide parcel located between the third-party property and the North River Road ROW. CMR does not have access to the third-party property north of the Northwestern Energy parcel. A City of Great Falls sanitary sewer line runs east-west along the southern edge of the North River Road Area. A 7-foot offset from the center line of the sewer is proposed bounding the southern extent of the PTT. The City of Great Falls has a 20-foot utility easement or 10 feet on each side of the centerline of the sanitary sewer main along the length of the main. Per preliminary discussions with the City of Great Falls, encroachment into the utility easement will be allowable with appropriate liability protection in the event that the city must repair the sanitary sewer and causes damage to the PTT.

Due to the access and utility constraints, the proposed PTT will be positioned parallel to North River Road on the Northwestern Energy property. The trench will be centered at MW-41S corresponding to the location of the highest dissolved phase concentrations and the greatest %RE LIF UVOST® response (Figure 3 and Figure 4). Groundwater concentrations of constituents of concern (COCs) decrease laterally east and west from MW-41S (Figure 4). The PTT is intended to intersect the most-impacted groundwater or approximately a design concentration of 50 µg/L. Based on interpolation of the

groundwater data and the 2017 %RE LIF UVOST® response data, this region is approximately 110 feet wide centered at the MW-41 well nest as shown on Drawing C10 in Appendix A.

Impacted groundwater is anticipated to be encountered within the shallow perched zone approximately 2.5 to 8 ft-bgs. Vertically, the PTT will cover the saturated interval of the shallow perched zone. The underlying compacted sand aquitard layer was encountered during PDI activities between 12 and 13 ft-bgs defining the bottom limit of the PTT. To confirm that the PTT will intersect the entire saturated thickness under all water table conditions, the upper limit of the active PTT treatment zone will be set at the maximum groundwater elevation recorded in the North River Road Area between December 2013 and March 2020 corresponding to a groundwater elevation of 3,336.8 ft-msl or a depth of 2.5 ft-bgs. Between 0 and 2.5 ft-bgs, groundwater is not anticipated to be encountered and the backfill will not be amended with PetroFix™.

4.4 Trench Backfill Material Quantities

The specified primary backfill material for the PTT and LNAPL Recovery Trench backfill is coarse sand; however, CAC material will be incorporated into the PTT during backfill activities as described in Section 6.8.2. The LNAPL Recovery Trench is anticipated to require approximately 100 cubic yards of coarse sand material. The PTT is anticipated to require approximately 280 cubic yards of coarse sand material. The coarse sand material for both trenches will be laboratory certified clean and sourced from an CMR pre-approved off-site source as specified in Appendix D – Technical Specifications. Backfill material will be placed in the excavation using an excavator bucket.

During backfilling of the PTT and per the dosing calculations provided by Regenesis in Appendix C, 14,000 pounds of CAC material will be incorporated into the coarse sand backfill material. The 14,000 pounds of CAC material corresponds to 1,500 gallons of non-diluted liquid material.

5. PERMITS

To construct and operate the DPE System and PTT, the following permits are anticipated:

5.1 Air Discharge Permit

MDEQ regulation [Administrative Rules of Montana [ARM] 17.8.743(1)(c)] requires that a pre-construction permit is needed for a SRCO (incinerator rule as defined in 75-2-103(11) Montana Code Annotated [MCA]) combusting "waste" vapor and is subject to 75-2-215, MCA, which covers Solid or Hazardous Waste Incineration. Incinerator permitting must include a passing human health risk assessment per Administrative Rules of Montana (ARM) 17.8.770.

Federal regulations may require that National Emission Standards for Hazardous Air Pollutants (NESHAPs) be addressed with this control technology due to the site being listed as a major source of hazardous air pollutants (HAPs). Based on the current projected quantity of HAP to be remediated (greater than 2,204.6 pounds/year), activities will not be exempted from the Remediation NESHAP. A compliance plan for the NESHAP is suggested along with required initial notifications and compliance reports.

5.2 Well Construction

Montana Department of Natural Resources and Conservation (DNRC) Regulation ARM 36.21 Chapter 8 regulates construction and material requirements for monitoring wells. The wells placed during

construction in the LNAPL Recovery Trench and PTT will not meet these construction requirements and will need approval by the Board of Water Well Contractors prior to installation per ARM 36.21.802(1).

For the DPE wells, the licensed well constructor will prepare well report forms and submit them to the DNRC and file well log reports with the Montana State Bureau of Mines and Geology in accordance with ARM 36.21.801 and MCA 85-2-516.

Note that Water Use Permitting under MCA 85-2 will not be required for the DPE extraction wells. Based on correspondence with the DNRC, the DNRC's interpretation of the Water Use Statute (MCA 85-2) is that no water right is required for this type of remediation application because it does not involve a beneficial use of the water.

5.3 Sediment and Erosion Control

Per the City of Great Falls Code of Ordinances Title 17 Chapter 48 - Erosion Control During Site Development, an Erosion Control Plan is required if disturbing one or more acre, or disturbing soils with a slope greater than 12 percent, or if more than 400 cubic yards (CY) are moved or placed on a site. While the anticipated disturbance area is less than 1 acre, more than 400 CY are estimated to be moved during implementation; therefore, a City of Great Falls Erosion Control Plan will be required.

A Montana Permit for Storm Water Discharge Associated with the Construction Activity will not be required as the anticipated disturbed area during construction is less than 1 acre.

5.4 Additional Permits

A City of Great Falls Planning and Community Development Department, Building Division Building Permit application will be required for installation of the DPE System.

For installation of the PTT, the excavation itself is located outside of the North River Road ROW. However, construction activities and staging will likely occur within the ROW. As such, Montana ARM 18.7.102 requires a Montana Department of Transportation Encroachment Permit. A Cascade County Permit to Work on a County Road or ROW Permit will also be required.

As previously described, the proposed PTT extents fall within a City of Great Falls utility easement. Per preliminary discussions with the City of Great Falls, encroachment into the utility easement will be allowable with appropriate liability protection in the event that the city must repair the sanitary sewer and causes damage to the PTT.

6. INTERIM MEASURES CONSTRUCTION AND IMPLEMENTATION

6.1 General Health and Safety Requirements

Installation and operation activities have been incorporated into the site-specific HASP included in Appendix F. In addition, contractors and any personnel (including Ramboll employees) working on the Interim Measures DPE system or PTT installation will be required to complete CMR Health and Safety training and participate in daily health and safety meetings.

Overhead utilities are present in the Truck Rack Area. Designated Health and Safety personnel will complete an evaluation of overhead utility and proximity to the work areas. If work areas are

determined to be under or immediately adjacent to overhead utilities, the designed Health and Safety person, contractor, and field team will evaluate if the work can be moved to a location outside of the overhead utility. If moving the work area cannot be completed, precautions will be implemented including employing a "spotter" to visually observe work activities during movement of equipment or supplies.

6.2 Public Notification

Prior to construction, CMR will prepare an updated Truck Loading Rack Fact Sheet describing the planned IM construction and implementation activities. The updated Fact Sheet will be distributed to the Cascade County commissioners, the CMR community advisory panel, and the residential parcels located to the northeast of AOC-16. CMR will also update its environmental website for the Calumet Montana Refinery to include information on the AOC-16 IMs.

6.3 Site Access

The DPE System will be installed south of the truck rack on property owned by CMR so no access agreements will be required.

The LNAPL Recovery Trench and PTT will be installed on property owned by Northwestern Energy. An access agreement between CMR and Northwestern Energy was established on June 11, 2020, for the parcel located between the third-party property and the North River Road ROW. The scope of the access agreement includes PDI and remedial construction activities. The existing access agreement covers a 180-day duration beginning June 11, 2020. The agreement will need to be extended in order to accommodate the proposed construction schedule.

While the trenches will be located entirely on the Northwester Energy property, construction activities and staging will likely occur within the roadway ROW. As such, Montana ARM 18.7.102 requires a Montana Department of Transportation Encroachment Permit. A Cascade County permit to work on a county road or ROW Permit will also be required.

6.4 Work Area Boundaries and Site Security

The work area is divided into the Truck Rack Area and the North River Road Area.

6.4.1 Site Security

General on-site security will be provided by CMR contractor Securitas Security Services USA. Routine security patrols are completed at the facility which include the Truck Rack Area.

All contractor equipment, materials, and supplies must be located within existing fenced area located near the PRT or temporary fenced areas installed by contractor. Reactive media for the PTT will be stored in a lockable, intermodal container (i.e., CONEX box) or stored in a weather protected location within the CMR facility specified by CMR. Monitoring wells and DPE wells will be equipped with a lockable well plug or lockable vault.

The excavations will be protected overnight using engineering controls preventing workers or the public from gaining access. Engineering protections include but are not limited to steel plates, flowable fill, or fencing.

Permanent security fencing will be installed concurrently or immediately following DPE system installation which will encompass the DPE system enclosure and SRCO.

6.4.2 Truck Rack Area

The PRT is located south of the truck rack on property owned by CMR. The area is outside of the facility fence as shown on Figure 2. Work activities will not interfere with ongoing site activities (e.g., existing site traffic or processes). Work activities must be kept off the paved road, unless required. Equipment laydown areas are discussed in Section 6.6.

6.4.3 North River Road Area

The LNAPL Recovery Trench and PTT will be located north of North River Road on property owned by Northwestern Energy immediately north of the ROW as shown on Drawing C10 in Appendix A. Work must not extend off Northwestern Energy property. Due to limited area available for work activities and storage, the DPE area will utilized for equipment and material laydown. Equipment laydown areas are discussed in Section 6.6.

6.5 Mobilization and Site Controls

6.5.1 Traffic Control

Traffic control signage and traffic control plan will be required due to work activities being conducted along the North River Road ROW. A traffic control contractor will provide and install traffic signage by the initial day of work and remove after work is completed.

6.5.2 Sediment and Erosion Control

Erosion control measures will be used to limit inadvertent environmental conditions that could detrimentally affect potential off-Site environmental receptors. Best Management Practices such as a silt fence and inlet protection will be utilized during the work to prevent soil and water transport. Detailed erosion control measures are provided on Drawings C3 and C4 (Sheets 1 through 4) in Appendix A.

6.6 Utility Locating and Protection

Prior to any subsurface work, all utilities will be located by completing a Montana Utilities Underground Location Center phone call (in the North River Road Area only) and employing a private utility locator to verify utility locations. CMR and public utility maps will also be reviewed.

6.7 Materials Delivery and Storage

Regenesis will coordinate delivery and storage of the PetroFix™ material. PetroFix™ is a black, viscous liquid that will be shipped in totes. The totes will be transported via semi-truck and removed from the truck with a pallet jack or skid-steer with fork attachments. Material will be stored in storage containers protected from the environment and weather at a location on the CMR property. The totes will be transported from CMR property to the work area by a pallet truck or skid-steer as needed. A safety data sheets (SDS) for the material is included in Appendix C.

6.8 Equipment Laydown Areas

A portion of the CMR property will utilized for material storage and equipment laydown. Drawing C2 in Appendix A identifies the designated areas available to the remediation contractors for material storage and equipment laydown. Unused material will be returned to the storage area at the end of each workday and will not be left at the work areas overnight.

6.9 Excavation and Trenching

6.9.1 DPE Subgrade Piping Installation

Individual 2-inch PVC DPE System conveyance piping will be run in a dedicated trench which joins with a common trench accommodating all eight DPE well conveyance piping into the DPE system enclosure as shown on Drawing C9 in Appendix A. The conveyance piping trench width will vary between 8 and 50 inches depending on the number of conveyance pipes within the trench. The conveyance piping trench will be excavated to 3 ft-bgs and extend approximately 240 feet in length as shown on Drawing C5 in Appendix A. The 1.5-inch PVC effluent discharge line from the DPE enclosure to the refinery gravity sewer will also be installed within a 3-foot deep trench. The effluent discharge trench will be approximately 12 inches wide and 150 feet long (Drawing C6 and Drawing C9 in Appendix A).

Excavation of both trenches will be conducted with a backhoe. The excavated material will be stockpiled immediately next to the trenches and field screened with a PID.

Plastic sheeting (0.01-inch [10 mil]) will be used to line the bottom of the trenches. The trenches will be backfilled with a 1.5-foot layer of bedding sand. The conveyance piping along with an electrical conduit to supply power to pressure transmitters at each well will be placed within the bedding material as shown on Drawing C9 in Appendix A. If no visible impacts or elevated PID readings are noted in the stockpiled material, the trench spoils will be used to backfill the remaining depth of the trench to the existing grade. Pipe bedding will be placed in 6-inch lifts. Lifts will be lightly compacted using hand tamping or a vibratory device.

If soils excavated during conveyance pipe installation or effluent discharge pipe installation are visually impacted or elevated PID readings are noted, soil will be placed on plastic sheeting, covered, and characterized for disposal.

6.9.2 LNAPL Recovery Trench and Passive Treatment Trench Construction

The upgradient LNAPL recovery trench will be 5-feet wide by 10-feet deep by 50-feet long. The LNAPL recovery trench will be excavated using an excavator and trench box dragged along the length of the trench. The excavated material will be directly loaded into covered, US Department of Transportation (DOT)-compliant dump-trucks and transported to a landfill. Backfilling of the trench with coarse sand can occur before the complete trench length is excavated. Eleven 6-inch diameter, 0.020-inch slotted (20-slot) PVC pipes will be installed within the trench during backfill activities to serve as LNAPL recovery wells.

The downgradient PTT will be 5-feet wide by 12.5-feet deep and 110-feet long. The PTT will be excavated using an excavator and a trench box. The trench will be excavated and backfilled in segments. One segment will be excavated and backfilled before moving onto the next horizontal segment. The excavated material will be directly loaded into covered, US DOT-compliant dump-trucks or roll-off boxes and immediately transported to a landfill. One 2-inch diameter, 0.020-inch slotted PVC pipe will be installed at the center of the trench during backfill activities to serve as a trench performance monitoring well (further discussed in Section 8.2).

The trench excavation, backfilling and application of Petrofix™ amendment will be conducted in the following steps:

1. Excavate a segment of the trench removing native soils and install trench box to open trench and provide stability for mixing.

2. Backfill coarse sand in 1 to 2-foot lifts.
3. Apply Petrofix™ evenly throughout the trench segment. The applied Petrofix™ dosage for a given segment will correspond to the total Petrofix quantity (14,000 pounds or 1,500 gallons) multiplied by the ratio of the backfill volume being treated to the total trench volume. For example, a 20-foot horizontal segment, 2 foot-sand lift corresponds to 3.6% of the total trench volume. 3.6% of the total Petrofix quantity will be mixed into this area or 54 gallons per 200 bank cubic feet of backfill.
4. Mechanically mix Petrofix™ and coarse sand with the excavator bucket.
5. Repeat until the top of the 10-foot treatment interval is met.
6. The top 2.5 feet of the trench will be backfilled with unamended coarse sand and compacted.
7. Move onto the next horizontal segment and repeat Steps 1 through 6.

The coarse sand backfill will be clean imported material in compliance with applicable Montana Regulations. Note that alternative methods for installing the LNAPL Recovery Trench and PTT may be considered.

6.10 Installation of The DPE Enclosure and Vapor Treatment Equipment

The DPE system enclosure and SRCO vapor treatment equipment will be placed on a level, constructed gravel pad foundation. The location of each gravel pad foundation is shown on Drawing C6. The gravel pad foundation material will meet Montana Department of Transportation specification for a crushed aggregate course Grade 2A. The minimum thickness of the gravel pad is 6-inches and will be compacted using a vibratory compactor. The gravel pad foundation will extend a minimum of one foot from the base of the equipment as shown on Drawing C8 in Appendix A. The required surface area dimension of the DPE enclosure gravel pad foundation is 42 feet by 10 feet. The required surface area dimension of the vapor treatment equipment gravel pad foundation is 15 feet by 8 feet.

6.11 Surface Restoration

All areas disturbed by construction activities will be repaired and graded to match adjacent surface elevations. Permanent surficial structures, including DPE equipment, well vaults, piping, and fencing, will remain.

6.12 Site Surveying

Prior to construction, the proposed location of the trenches, DPE wells, and LNAPL recovery wells will be surveyed including offset stakes for locating during construction. During excavation activities the LNAPL Recovery Trench and PTT excavation extents and excavation terminus depths will be measured by the contractor to establish correct installation dimensions. After completion of DPE system and PTT area installation activities the DPE wells, LNAPL recovery wells, and trenches will be surveyed to establish the ground coordinates and final elevation of the DPE wells, LNAPL recovery wells, and PTT.

7. WASTE MANAGEMENT

7.1 Summary Of Waste Streams

This section describes the anticipated volumes of waste that will be generated during construction and implementation.

7.1.1 Water/LNAPL Treatment and Disposal

As described in Section 2.5.2, the anticipated total liquids flow ranges between 0.03 gpm per well during steady-state operation to 1.6 gpm per well during system startup. This corresponds to a flow rate from eight DPE wells ranging from approximately 0.25 gpm during steady-state operation to 21 gpm during start-up or major rain events.

Recovered groundwater and LNAPL will be directed to the CMR WWTP. The condition of the existing PRT effluent discharge line could not be determined during the PDI; therefore, a new discharge line will be installed between the DPE System enclosure and the refinery process sewer located 150 feet north of the DPE system enclosure.

7.1.2 Condensate Treatment and Discharge

The anticipated vapor flow rate is approximately 25 SCFM per well or 200 SCFM from eight wells. The vapor will be treated to allowed permit levels using a SRCO and discharged to the atmosphere as described in Section 3.

7.1.3 DPE Piping Excavation Spoils

Approximately 130 CY of excavation spoils are anticipated to be generated during installation of the DPE conveyance piping and approximately 20 CY of excavation spoils are anticipated to be generated during installation of the DPE effluent discharge piping. Soil generated during excavation activities for DPE transfer piping will be stockpiled immediately next to the trench and returned after piping installation and pressure testing, as practicable. Excess material will be transported by a licensed transporter to a licensed landfill.

If soils excavated during transfer pipe installation are impacted, soil will be placed on plastic sheeting and characterization for disposal.

7.1.4 DPE Well Soil Cuttings and Well Development Water

Approximately five CY of soil cuttings are anticipated to be generated during well installation activities (eight DPE wells). Cuttings from these activities will be containerized in properly labeled US DOT-compliant 55-gallon drums or roll-off boxes and disposed of off-site with the trench spoils. Approximately 300 gallons of fluid generated as part of well development activities are anticipated and will be disposed of at the CMR WWTP facility.

7.1.5 LNAPL Recovery Trench and PTT Trench Excavation Spoils

Approximately 420 CY of excavation spoils are anticipated to be generated during installation of the LNAPL Recovery Trench and PTT.

7.1.6 Miscellaneous Construction Debris

Miscellaneous construction debris will be placed in a dumpster dedicated for this project for off-site disposal by CMR.

7.2 Management of Passive Treatment Trench Spoils

7.2.1 Waste Characterization Sampling

Approximately 420 CY of excavation spoils are anticipated to be generated during installation of the LNAPL recovery trench and PTT.

As described in Section 2.4.2.3, three waste characterization samples were collected during the PDI. The three analytical results support a non-hazardous waste designation. Waste soil generated during the PDI will be managed under a new batch approval for non-hazardous Special Waste Hydrocarbon Stained Soil profile under the 2020 Hydrocarbon Stained Soil Service Agreement with Republic Services and sent to the High Plains Landfill located at 142 Powerline Road, Floweree, Montana.

Upon agreement by Republic Services, the entity that owns and operates High Plains landfill, the waste soil generated during the construction of the AOC 16 remediation system will be directly loaded into tri-axle dump trucks and transported by a licensed transporter to the High Planes Landfill under Special Waste Manifest as Hydrocarbon stained soil. This arrangement will require full support by Republic Services whom currently requires every batch of hydrocarbon stained soil to be sampled and a batch approval to be reviewed and finalized before soil can be accepted by the High Plains Landfill. This arrangement may require the development of an additional special waste profile for non-hazardous waste soil from AOC-16 only.

7.3 Management of Excavation Water

Groundwater is anticipated to be encountered during installation of the PTT based on boring logs and groundwater elevations completed in the area. Storm water runoff or precipitation will not be allowed to enter open excavations. Contractors will divert storm water or cover the excavation during period of time where the excavation is left open. If groundwater is encountered or storm water has entered the excavation, accumulated water will be collected and managed at CMR's WWTP.

8. OPERATIONS, MAINTENANCE AND MONITORING PLAN

The purpose of an OM&M Plan is to develop a guide and reference for proper OM&M of the DPE System and LNAPL Recovery Trench/PTT. Two separate OM&M Plans have been prepared:

1. DPE and LNAPL Recovery Trench/PTT Remediation Systems; and
2. Vapor Control System (SRCO).

The OM&M Plans are included in Appendix E and provide information regarding the treatment system components, operation and maintenance, startup and shutdown, information management, and sampling and analysis requirements. The following sections describe the anticipated performance monitoring.

8.1 DPE System Performance Monitoring

As stated in Section 2.1, the primary goals of the DPE system are to:

- Recover free phase LNAPL mass present in the area south of the Truck Rack to stabilize the LNAPL plume.
- Reduce LNAPL within the vadose and saturated zone soil matrix to stabilize the dissolved phase plume.

Monitoring of contaminant mass recovery over time will be the primary performance monitoring metric for the DPE system. Cumulative vapor and liquid flow rates will be continuously monitored by the PLC. Influent vapor sampling and effluent liquid sampling will be periodically conducted in order to estimate mass removal rates. The combination of flow rates and vapor and liquid VOC concentrations will be used to calculate the mass of contaminants removed from the subsurface over time.

When mass recovery rates from individual wells or the combined system reach diminishing returns (a.k.a. asymptotic levels), operational modifications will be considered. The individual wells with low recovery rates should be turned off and the wells with the highest VOC recovery rates should be continuously operated. Pulsing of the system in which individual or groups of wells are shut off will also be considered. Once the DPE system approaches asymptotic levels with full time operations, a request will be submitted to MDEQ describing modifications to discontinue extracting from individual or groups of DPE wells and/or to operate the system in a pulsed manner. Subsequently once the DPE system approaches asymptotic levels with modified / pulsed system operations, a request will be submitted to MDEQ to place the DPE system in standby mode.

Periodic effluent vapor sampling will also be conducted in accordance with the required air permits. The OM&M Plans are included in Appendix E.

8.2 PTT Performance Monitoring

The primary goal of the PTT is to mitigate dissolved phase groundwater impacts migrating from the Truck Rack Area towards the Missouri River. In 2019, the petroleum COCs detected at or above their respective DEQ-7 HHS and/or Tier 1 RBSLs in AOC-16 included: VOCs (benzene, ethylbenzene, and toluene), semi-volatile organic compounds (SVOCs) (2,4-dimethylphenol, 2-methylnaphthalene, and naphthalene) and VPH (benzene, ethylbenzene, naphthalene, toluene, aliphatic [C5-C8, C9-C12], and aromatic [C9-C10] hydrocarbon fractions (CMR, 2020b). The Montana DEQ-7 numeric quality standards for Petroleum COCs are presented in Table B:

Table B: Numeric Water Quality Standards for Petroleum Constituents of Concern North River Road Area

Constituent of Concern	Montana DEQ-7 HHS (µg/L)	Tier 1 RBSLs (µg/L)
VOCs		
Benzene	5	5
Ethylbenzene	700	700
Toluene	1,000	1,000
SVOCs		
2,4-Dimethylphenol	100	NV
2-Methylnaphthalene	NV	36
Naphthalene	100	100
MTDEQ VPH		
C5 – C8 Aliphatics	NV	650
C9 – C12 Aliphatics	NV	1,400
C9 – C10 Aromatics	NV	1,100

Notes:
DEQ-7 HHS = MQDEQ Human Health Standard
µg/L = micrograms per liter
MDEQ = Montana Department of Environmental Quality
NV = no value
SVOCs = semi-volatile organic compounds
Tier 1 RBSLs = MDEQ Tier 1 Risk Based Screening Levels
VOCs = volatile organic compounds
VPH = volatile petroleum hydrocarbons

Under RCRA, the point of compliance concept provides a distinct boundary where specified levels of groundwater quality must be achieved. The point of compliance, as described in 40 Code of Federal Regulations 264.95(a), is a "vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units." The hydraulically downgradient limit of AOC-16 is defined by the Missouri River.

In the *AOC-16 Interim Measures Evaluation Report* (CMR, 2019c), monitoring well MW-62 was identified as the point of compliance well. However, upon further review of the site lithology it was determined that MW-62 is screened in the deep semi-confined hydro-stratigraphic unit and not the shallow perched unit where the highest dissolved phase concentrations have been historically identified. As part of the PDI, an alternative compliance well (MW-105) was installed north of River Road and screened in the shallow, perched hydro-stratigraphic unit (Drawing C10 in Appendix A).

Monitoring well MW-105 was initially dry at the time of its installation in mid-June 2020, remained dry 2 weeks after its installation, and 6 weeks after installation finally had a sufficient amount of accumulated water to allow for VOC sampling. The initial MW-105 groundwater sample collected in early August 2020 had a benzene concentration of 180 µg/L (Figure 4). Although the detected concentration of benzene in this well exceeds Montana DEQ-7 HHS and the Tier 1 RBSL criteria for benzene of 5 µg/L, this well along with other PTT wells will be sampled in the future to demonstrate that the PTT is serving to mitigate the dissolved phase groundwater impacts migrating from the Truck Rack Area towards the Missouri River. Given the shallow perched zones very low hydraulic conductivities in the vicinity of the PPT, reductions in contaminant concentrations at the MW-105 location may take some time once the PTT is installed.

8.2.1 LNAPL Trench Monitoring

The upgradient LNAPL wells located in the LNAPL recovery trench will be gauged every week for the first 3 months of operation to determine if LNAPL has accumulated in the wells. If LNAPL is recorded in a well, an adsorbent sock will be placed in the well and LNAPL recovery via the adsorbent sock will be monitored on a weekly basis. If passive recovery is insufficient to address LNAPL, the well(s) will be outfitted with active pneumatic pumps. After three months of operation if LNAPL has not accumulated in the recovery wells, the LNAPL gauging frequency will be reduced to monthly.

8.2.2 Groundwater Sampling

For the first year following PTT installation, quarterly groundwater sampling will be conducted at MW-41S, one monitoring well to be installed during construction within the PTT within the trench downgradient of MW-41S, and at compliance well MW-105. To confirm compliance with the remediation goals, the monitoring wells will be sampled for Petroleum COCs including:

- VOCs (USEPA Method SW8260D);
- SVOCs (USEPA Method SW 8270D); and
- MDEQ VPH (Method MTDEQ VPH).

The PTT well and the compliance well will also be sampled semi-annually for additional parameters to assess the biodegradation dynamics of the COCs. Given the groundwater velocity and design timescale of 30 years, semi-annual sampling will be sufficient to understand changes in oxidation-reduction reactions occurring within the PTT. The wells will be sampled for the following parameters:

- pH, dissolved oxygen and oxidation reduction potential (ORP) (field measured);

- filtered and unfiltered total iron, total manganese, dissolved iron, and dissolved manganese (Colorimetric Hach Method or USEEPA Method 6000 Series);
- sulfate and nitrate (USEPA Method 375.3/353.1 or USEPA Method 9056);
- biological oxygen demand (USEPA Method 5210B);
- alkalinity (USEPA 310.2); and
- methane and carbon dioxide (ASTM Method D1945).

As previously stated, the primary goal of the PTT is to mitigate the dissolved phase groundwater impacts from migrating from the Truck Rack to the Missouri River. Accordingly, the primary performance monitoring metric for the PTT will be the reduction is dissolved phase petroleum COCs from the upgradient side of the PTT to the downgradient side of the PTT. After collection and analysis of the first year PTT performance data, a recommendation will be submitted to MDEQ as to the frequency of subsequent PTT groundwater monitoring. The PTT groundwater monitoring program will be discontinued once the groundwater on the upgradient side of the PTT meets the MDEQ-7 Human Health Standards for groundwater.

9. SCHEDULE

A Remedial Action time schedule is provided as Figure 6. Although Calumet will make all reasonable attempts to maintain this schedule, the schedule may be impacted by many factors outside Calumet's control, such as subcontractor availability, delivery times for equipment, the requirements of the property owner, weather, or other factors.

10. REFERENCES

Calumet Montana Refining, LLC (CMR). 2018. AOC 16 Interim Measures Report Addendum. Calumet Montana Refining, LLC, Great Falls Montana. August 2.

CMR. 2019a. AOC-16 Emergency Interim Measure (IM) Investigation Activities Summary Report. Calumet Montana Refining, LLC, Great Falls, Montana. January.

CMR. 2019b. Site-Wide Groundwater Monitoring Work Plan. January.

CMR. 2019c. Area of Concern 16 Interim Measure Evaluation Report. Calumet Montana Refining, LLC, Great Falls, Montana. June.

CMR. 2020a. AOC-16 Pilot Study Evaluation Report. Calumet Montana Refining, LLC, Great Falls, Montana. January.

CMR. 2020b. 2019 Annual Groundwater Sampling Summary Report. Calumet Montana Refining, LLC, Great Falls, Montana. February.

Interstate Technology and Regulatory Council (ITRC). 2011. Permeable Reactive Barrier: Technology Update. June.

Montana Department of Environmental Quality (MDEQ). 2016. Immediate Interim Measures Petroleum Release Near CMR's Loading Rack. October 11.

MDEQ. 2019. Letter entitled "AOC #16- 2019 Interim Measures Work Plan." January 31.

MDEQ. 2020b. Letter entitled "DEQ – Approval – AOC #16 Interim Measures." January 28.

Montana Refining Company (MRC). 2002. I.M. Corrective Measures Draft AOC #16 Light Oil Loading Rack. January.

MRC. 2004. Revised Draft Corrective Action Report Cost Estimate, AOC #16. May.

Trihydro/CMR. 2017. AOC-16 Interim Measures Investigation Report. Calumet Montana Refining, LLC, Great Falls, Montana. July.

United States Department of Agriculture (USDA). 2004. *Estimation of Direct Runoff from Storm Rainfall.* Natural Resources Conservation Service.

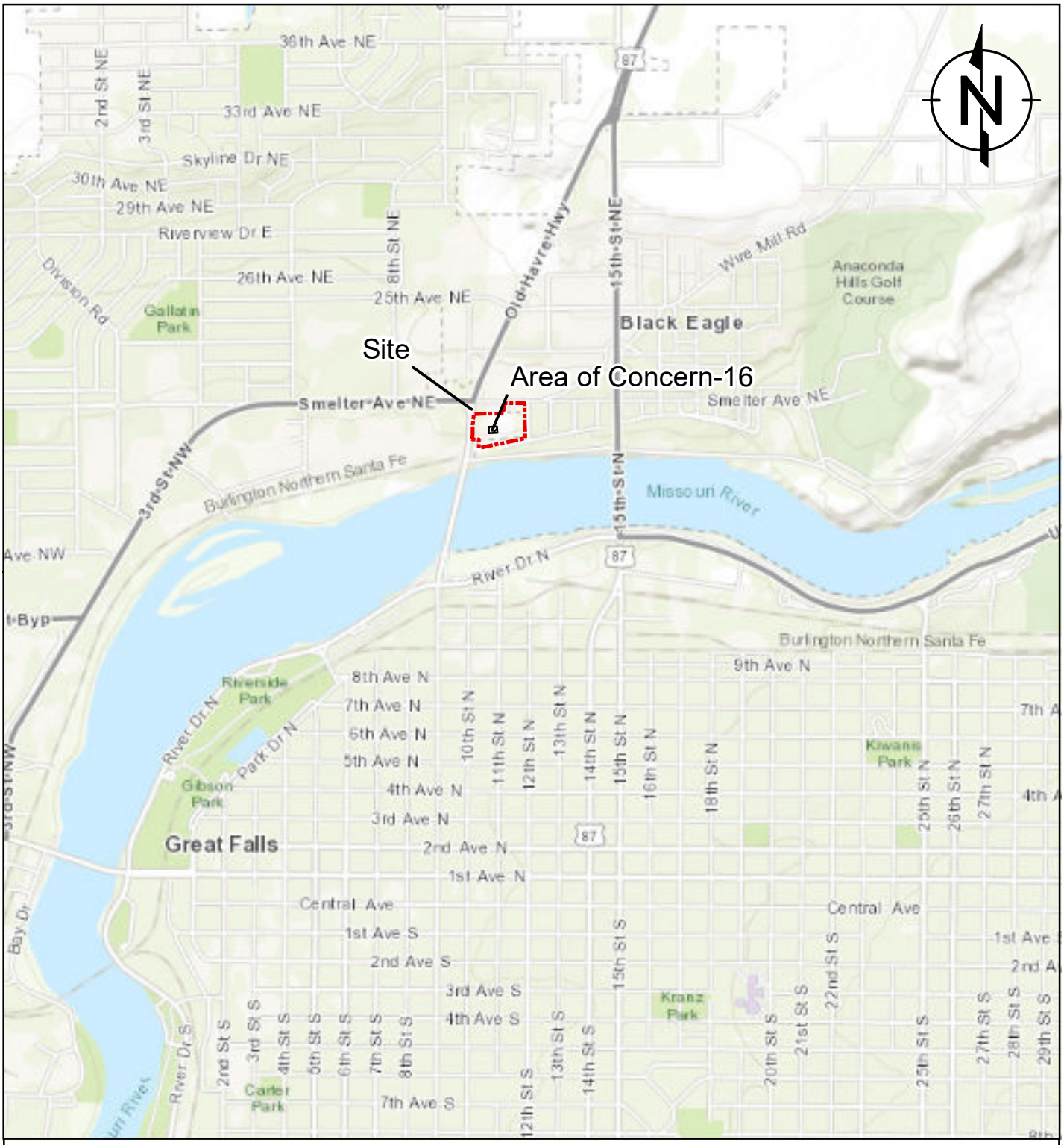
USEPA. 1999. Multi-Phase Extraction: State-of-the-Practice. EPA 543-R-99-004. Office of Soil Waste and Emergency Response. June.

USEPA. 2017. How to Evaluate Alternative Cleanup Technologies For Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers. EPA/510/B-17/003. October.

USACE. 1999. USACE Engineering and Design Multi-Phase Extraction Engineer Manual. EM 1110-1-4010. June.

Wilke, K.R. 1983. Appraisal of Water in Bedrock Aquifers, Northern Cascade County, Montana. Montana Bureau of Mines and Geology Memoir 54. 22 p. 2 sheets.

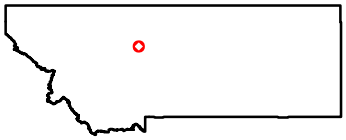
FIGURES



Approximate Site Boundary

0 0.5 1 Miles

1 inch = 3,000 feet



QUADRANGLE LOCATION

RAMBOLL

DRAFTED BY: AAS | Date: 3/12/2020

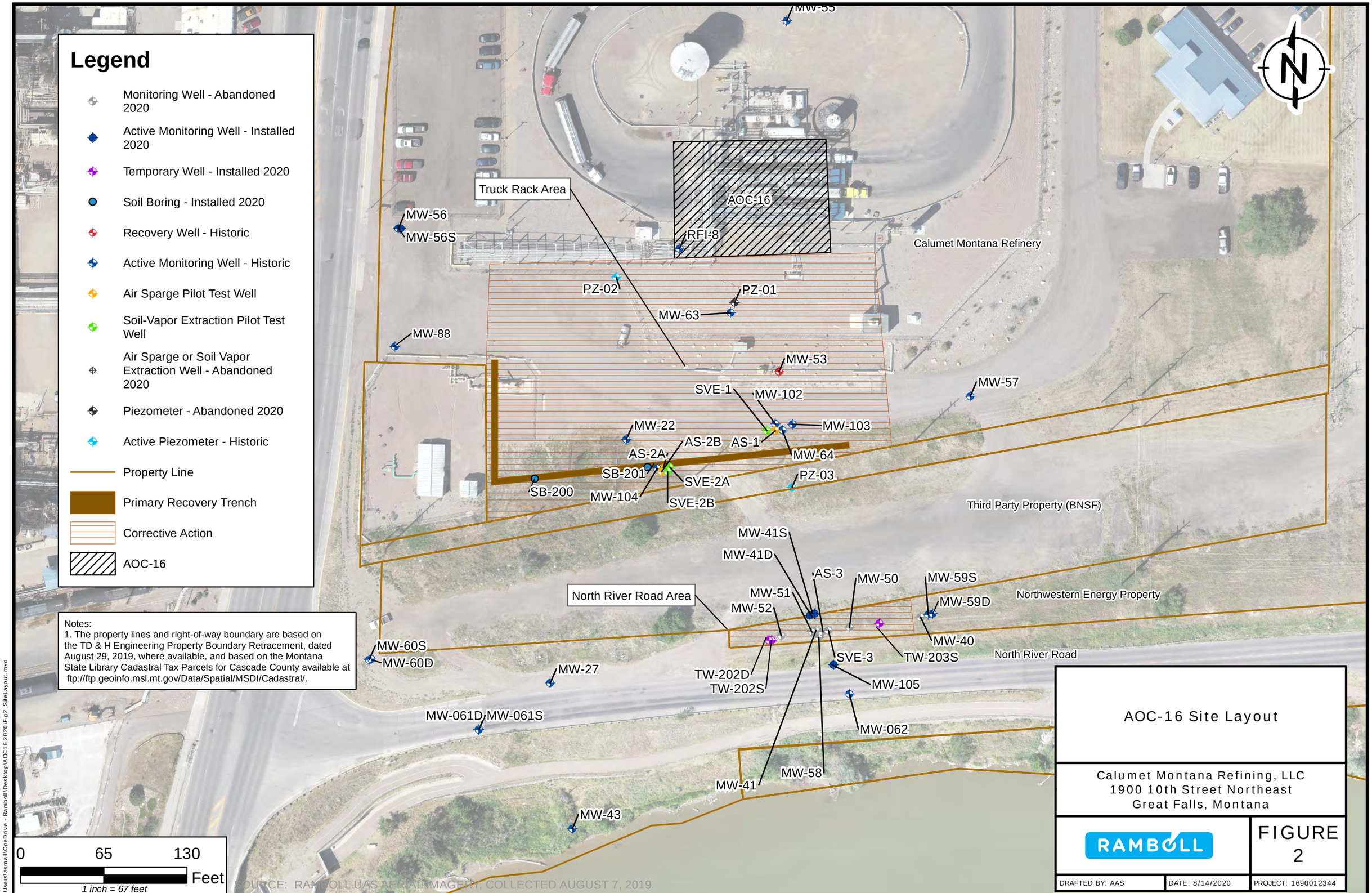
Site Location

CALUMET MONTANA REFINING, LLC
1900 10TH STREET NORTHEAST
GREAT FALLS, MT

FIGURE **1**

PROJECT: 1690012344

C:\Users\asmall\OneDrive - Ramboll\Desktop\AOC16 2020\Fig1SiteLocation.mxd


Legend
Monitoring Well - Abandoned 2020
Active Monitoring Well - Installed 2020
Temporary Well - Installed 2020
Soil Boring - Installed 2020
Recovery Well - Historic
Active Monitoring Well - Historic
Air Sparge Pilot Test Well
Soil-Vapor Extraction Pilot Test Well
Air Sparge or Soil Vapor Extraction Well - Abandoned 2020
Piezometer - Abandoned 2020
Active Piezometer - Historic
Property Line
Primary Recovery Trench
Corrective Action
AOC-16
Notes:
1. The property lines and right-of-way boundary are based on the TD & H Engineering Property Boundary Retracement, dated August 29, 2019, where available, and based on the Montana State Library Cadastral Tax Parcels for Cascade County available at ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Cadastral/.
0 65 130
Feet
1 inch = 67 feet
SOURCE: RAMBOLL UAS AERIAL IMAGERY, COLLECTED AUGUST 7, 2019
N
MW-55
Truck Rack Area
AOC-16
MW-56
MW-56S
RFI-8
Calumet Montana Refinery
PZ-02
PZ-01
MW-63
MW-88
MW-53
MW-57
SVE-1
MW-102
MW-103
MW-22
AS-2B
AS-1
MW-64
AS-2A
SB-201
SVE-2A
PZ-03
SB-200
MW-104
SVE-2B
Third Party Property (BNSF)
MW-41S
MW-41D
AS-3
MW-50
MW-59S
MW-51
MW-59D
Northwestern Energy Property
North River Road Area
MW-52
MW-40
MW-60S
MW-60D
SVE-3
TW-203S
North River Road
MW-27
TW-202D
TW-202S
MW-105
MW-061D
MW-061S
MW-062
MW-58
MW-41
MW-43
AOC-16 Site Layout
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana
RAMBOLL
FIGURE 2
DRAFTED BY: AAS
DATE: 8/14/2020
PROJECT: 1690012344
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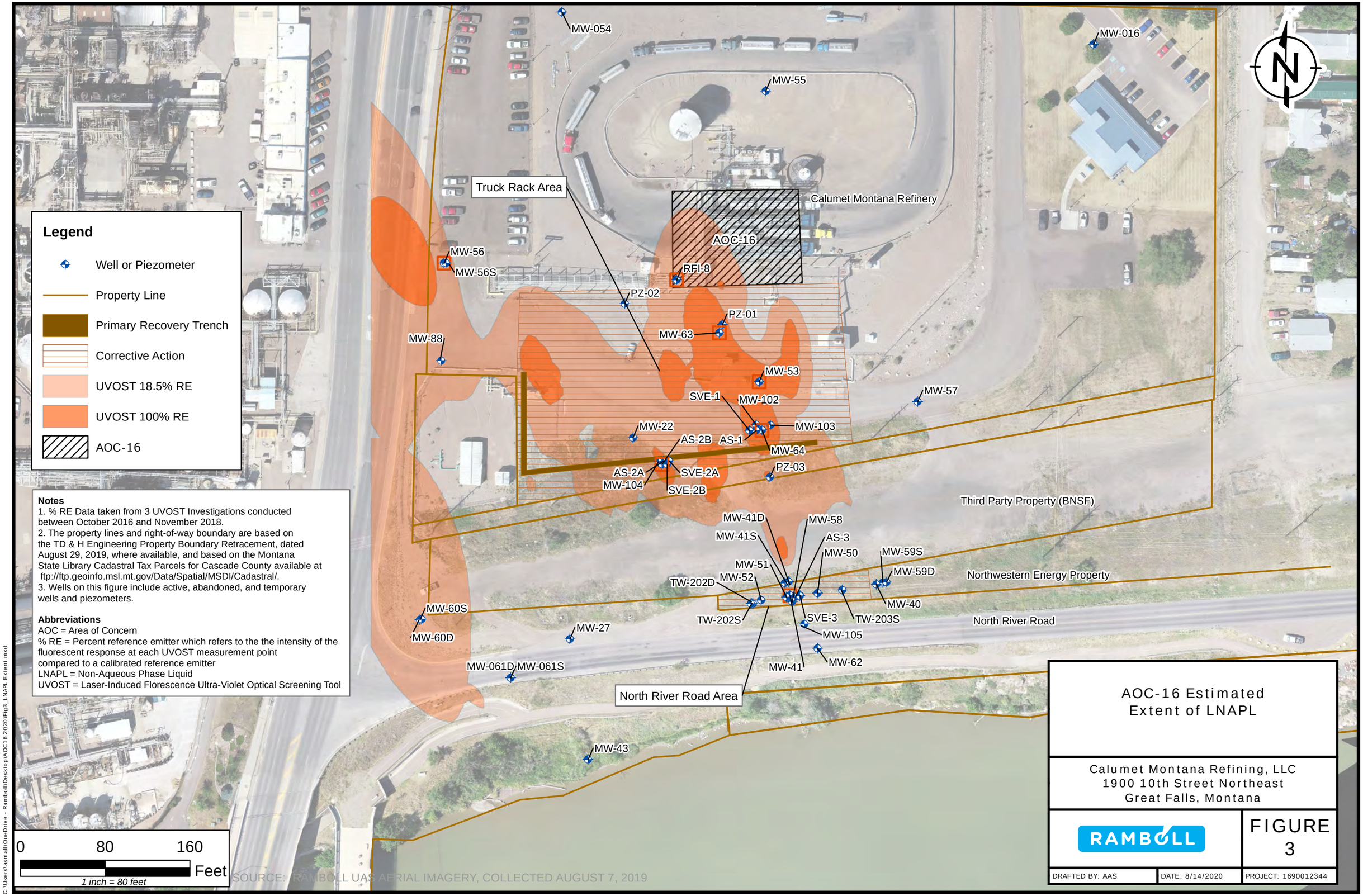
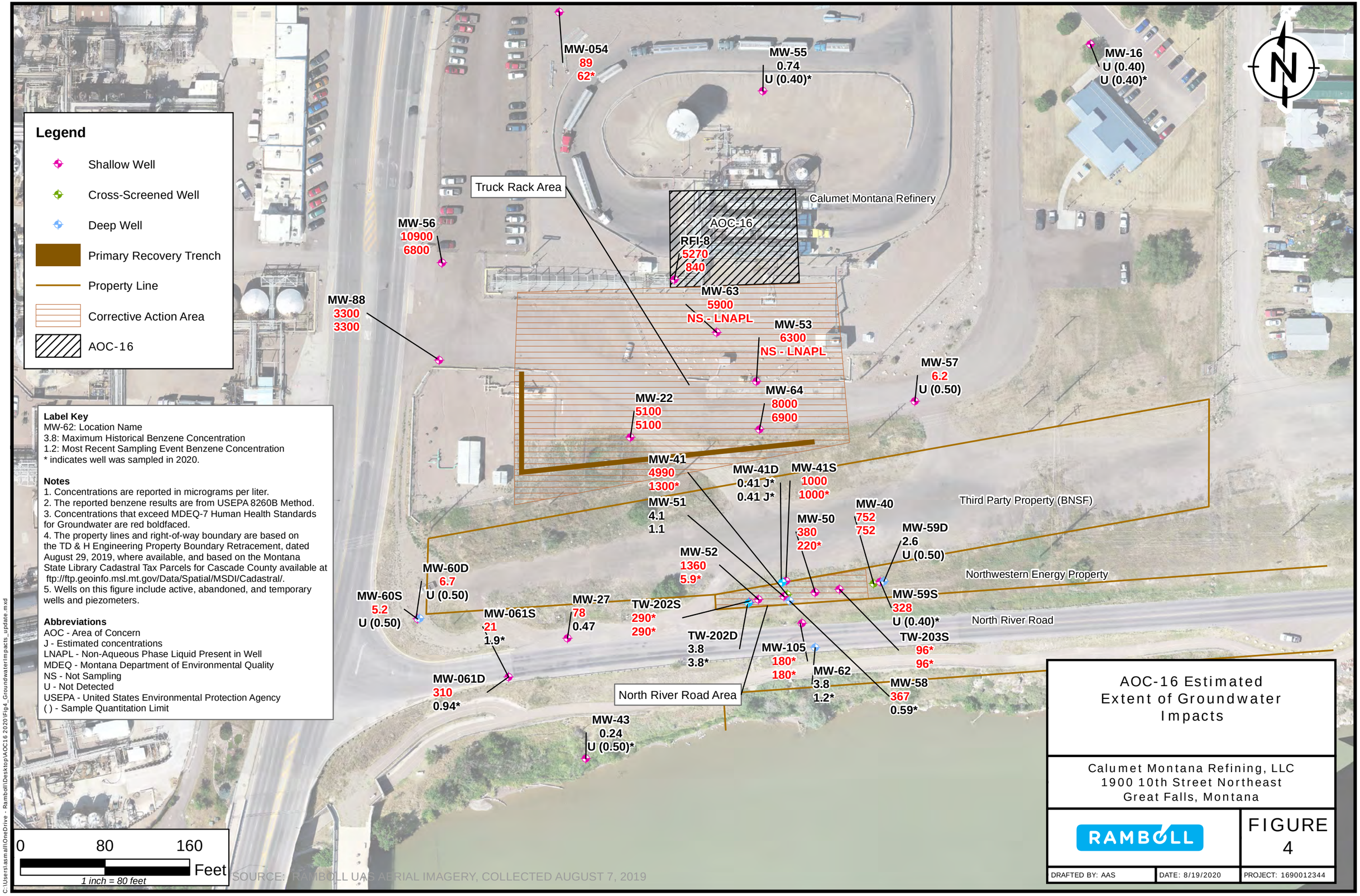

MW-054
MW-016
MW-55
Truck Rack Area
Calumet Montana Refinery
AOC-16
MW-56
MW-56S
RFI-8
PZ-02
PZ-01
MW-63
MW-88
MW-53
MW-57
SVE-1
MW-102
MW-103
MW-22
AS-2B
AS-1
MW-64
AS-2A
SVE-2A
PZ-03
MW-104
SVE-2B
Third Party Property (BNSF)
MW-41D
MW-58
MW-41S
AS-3
MW-50
MW-59S
MW-51
MW-59D
Northwestern Energy Property
TW-202D
MW-52
MW-40
MW-60S
TW-202S
SVE-3
TW-203S
North River Road
MW-27
MW-105
MW-60D
MW-62
MW-061D
MW-061S
MW-41
North River Road Area
MW-43
N
Legend
Well or Piezometer
Property Line
Primary Recovery Trench
Corrective Action
UVOST 18.5% RE
UVOST 100% RE
AOC-16
Notes
1. % RE Data taken from 3 UVOST Investigations conducted between October 2016 and November 2018.
2. The property lines and right-of-way boundary are based on the TD & H Engineering Property Boundary Retracement, dated August 29, 2019, where available, and based on the Montana State Library Cadastral Tax Parcels for Cascade County available at ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Cadastral/.
3. Wells on this figure include active, abandoned, and temporary wells and piezometers.
Abbreviations
AOC = Area of Concern
% RE = Percent reference emitter which refers to the the intensity of the fluorescent response at each UVOST measurement point compared to a calibrated reference emitter
LNAPL = Non-Aqueous Phase Liquid
UVOST = Laser-Induced Florescence Ultra-Violet Optical Screening Tool
0
80
160
Feet
1 inch = 80 feet
SOURCE: RAMBOLL UAS AERIAL IMAGERY, COLLECTED AUGUST 7, 2019
AOC-16 Estimated Extent of LNAPL
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana
RAMBOLL
FIGURE 3
DRAFTED BY: AAS
DATE: 8/14/2020
PROJECT: 1690012344
C:\Users\asmall\OneDrive - Ramboll\Desktop\AOC16 2020\Fig3_LNAPL Extent.mxd



AOC-16 Estimated Extent of Groundwater Impacts

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

RAMBOLL

FIGURE 4

DRAFTED BY: AAS | DATE: 8/19/2020 | PROJECT: 1690012344

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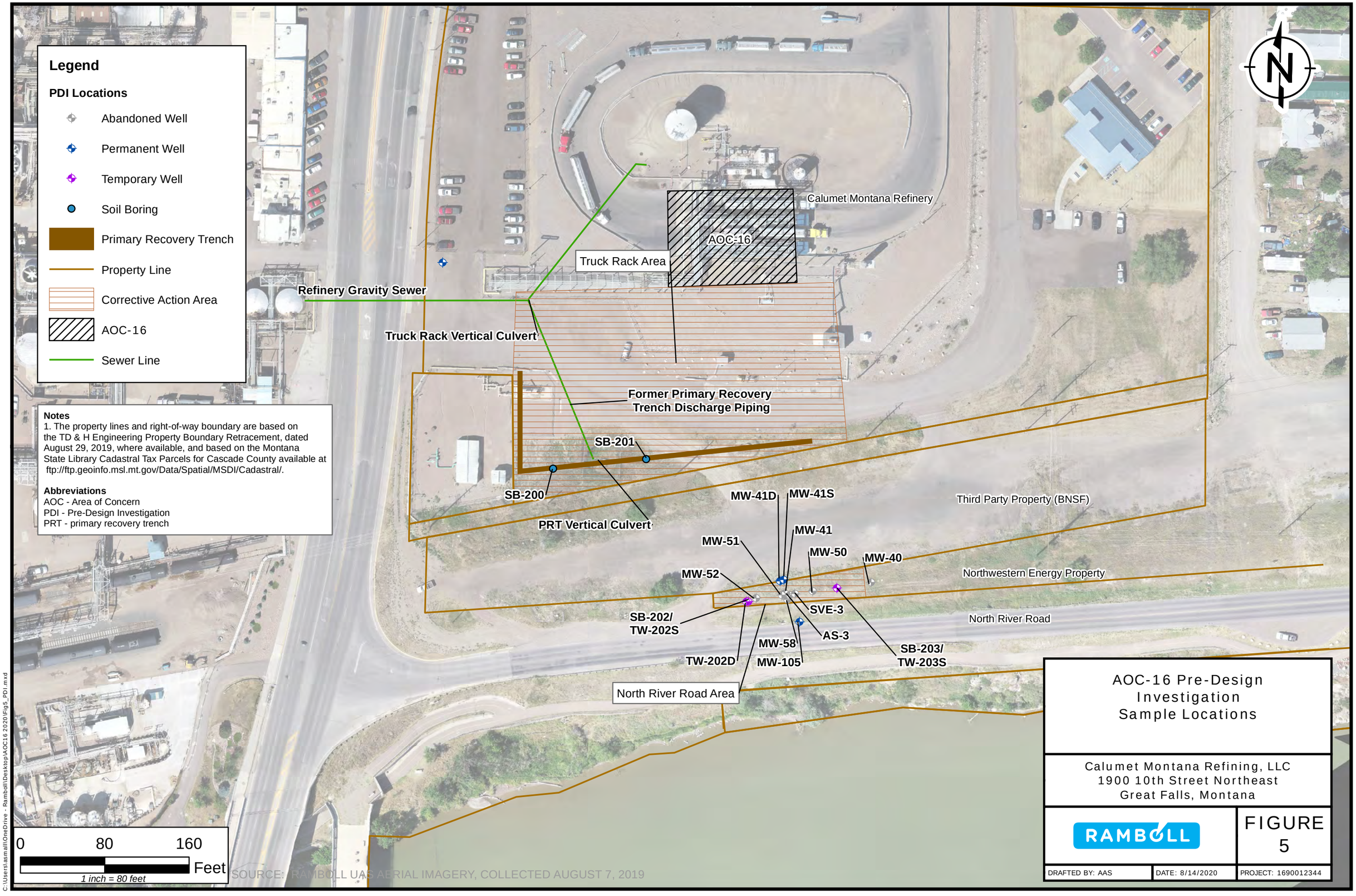
Legend
PDI Locations
Abandoned Well
Permanent Well
Temporary Well
Soil Boring
Primary Recovery Trench
Property Line
Corrective Action Area
AOC-16
Sewer Line
Notes
1. The property lines and right-of-way boundary are based on the TD & H Engineering Property Boundary Retracement, dated August 29, 2019, where available, and based on the Montana State Library Cadastral Tax Parcels for Cascade County available at ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Cadastral/.
Abbreviations
AOC - Area of Concern
PDI - Pre-Design Investigation
PRT - primary recovery trench
N
Calumet Montana Refinery
AOC-16
Truck Rack Area
Refinery Gravity Sewer
Truck Rack Vertical Culvert
Former Primary Recovery Trench Discharge Piping
SB-201
SB-200
PRT Vertical Culvert
MW-41D
MW-41S
MW-41
MW-51
MW-50
MW-40
MW-52
SVE-3
AS-3
SB-202/ TW-202S
TW-202D
MW-58
MW-105
SB-203/ TW-203S
North River Road Area
Third Party Property (BNSF)
Northwestern Energy Property
North River Road
0
80
160
Feet
1 inch = 80 feet
SOURCE: RAMBOLL UAS AERIAL IMAGERY, COLLECTED AUGUST 7, 2019
AOC-16 Pre-Design Investigation Sample Locations
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana
RAMBOLL
FIGURE 5
DRAFTED BY: AAS
DATE: 8/14/2020
PROJECT: 1690012344
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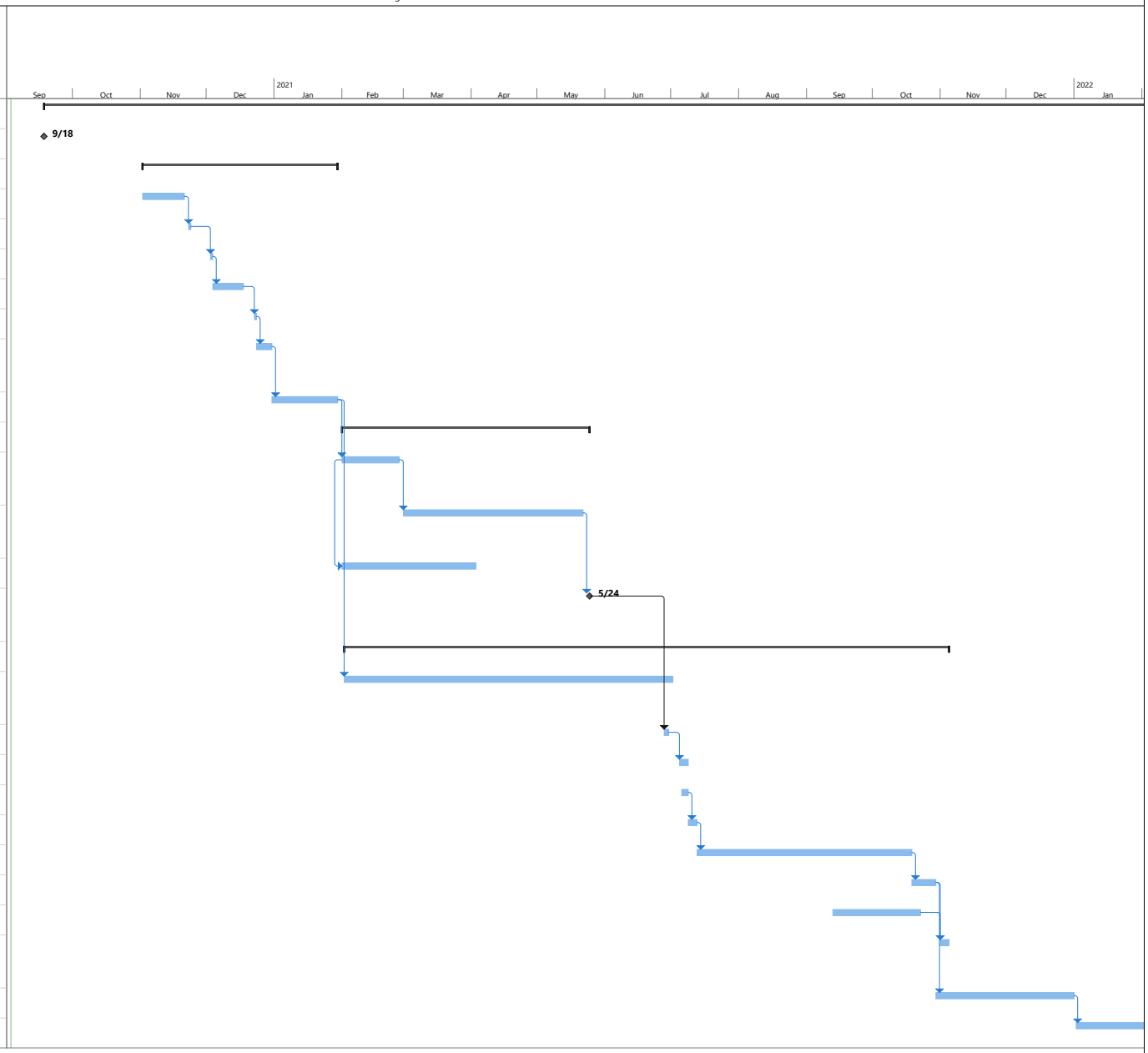
Figure 6
AOC-16 Interim Measure Time Schedule
Calumet Montana Refining

ID	Task Name	Duration	Start	Finish
1	**AOC-16 Interim Measure Remedy**	**1118 days**	**Fri 9/18/20**	**Tue 12/31/24**
2	**Submit 100% Design (Final) to MDEQ**	0 days	Fri 9/18/20	Fri 9/18/20
3	**Bidding and Contracting**	**65 days**	**Mon 11/2/20**	**Fri 1/29/21**
4	Prepare Bidding Docs and RFB	18.38 eday	Mon 11/2/20	Fri 11/20/20
5	Send RFB to Prospective Bidders	1 day	Mon 11/23/20	Mon 11/23/20
6	Conduct Bid Walk	1 day	Thu 12/3/20	Thu 12/3/20
7	Respond to Bidder Questions	10 days	Fri 12/4/20	Thu 12/17/20
8	Bids Due	1 day	Wed 12/23/20	Wed 12/23/20
9	Bid Review and Construction Contractor Selection	5 days	Thu 12/24/20	Wed 12/30/20
10	Contracts and Contract Execution	30 edays	Wed 12/30/20	Fri 1/29/21
11	**Permitting and Access**	**81 days**	**Mon 2/1/21**	**Mon 5/24/21**
12	Prepare and Submit State and Local Permit Applications	20 days	Mon 2/1/21	Fri 2/26/21
13	State/Local Review of Permit Applications	60 days	Mon 3/1/21	Fri 5/21/21
14	Renew Access Agreements	45 days	Mon 2/1/21	Fri 4/2/21
15	State/local acceptance/issuance of permits	1 day	Mon 5/24/21	Mon 5/24/21
16	**IM Construction**	**198 days**	**Mon 2/1/21**	**Thu 11/4/21**
17	Equipment Procurement/Offsite Fabrication of DPE Equipment	150 edays	Mon 2/1/21	Thu 7/1/21
18	Pre-Const Surveying	2 days	Mon 6/28/21	Tue 6/29/21
19	DPE Well Installation	4 days	Mon 7/5/21	Thu 7/8/21
20	Mobilization for Construction	3 days	Tue 7/6/21	Thu 7/8/21
21	Install Sediment and Erosion Controls	2 days	Fri 7/9/21	Mon 7/12/21
22	DPE System Construction	70 days	Tue 7/13/21	Mon 10/18/21
23	DPE System Functional Testing & Startup	9 days	Tue 10/19/21	Fri 10/29/21
24	Product Recovery & PTT Construction	30 days	Mon 9/13/21	Fri 10/22/21
25	Site Restoration and Const Contr Demobilization	4 days	Mon 11/1/21	Thu 11/4/21
26	**DPE System Commissioning**	**63 edays**	**Fri 10/29/21**	**Fri 12/31/21**
27	**Operation, Maintenance & Monitoring**	**1095 edays**	**Sat 1/1/22**	**Tue 12/31/24**



Project: IM Time Schedule
Date: Thu 9/3/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

TABLES

Table 1
North River Road Area Lithology
Calumet Montana Refining, LLC - Great Falls, Montana

Unit #	Unit	Description	Indication of Hydrocarbons	Moisture	Start Depth (ft-bgs)	Unit Thickness (ft)	Hydrostratigraphic Unit
1	Silty Sand	Mottling; roots; medium dense	Odor	Moist	Surface	3.5 - 6	Vadose Zone
2	Sandstone	Thinly bedded	Odor	---	3.5 - 6	2.5 - 3	
3	Weakly Laminated Siltstone with Sand	Mottling and/or weakly laminated; dense to very dense; gray color then transitions to dusky-red	Odor/Staining (dissipates with depth)	Slightly moist	6 – 8	5 – 6	Shallow Perched
4	Poorly Lithified Sandstone	Hard	None	Dry	12 – 14	2 – 4	Aquitard
5	Mudstone/Siltstone	Varies in sand content; varies in color (dusky-red to gray); weakly laminated	None	Dry to slightly moist	16 – 19	1 - 3	
6	Siltstone/Shale	Mottling; medium dense to dense	None	Dry to slightly moist	18 – 23	> 2	Semi-confined

Notes:

bgs – below ground surface

ft – feet

APPENDIX A

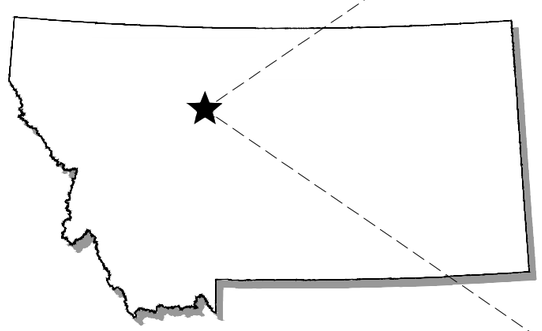
AOC-16 INTERIM MEASURE DESIGN DRAWINGS

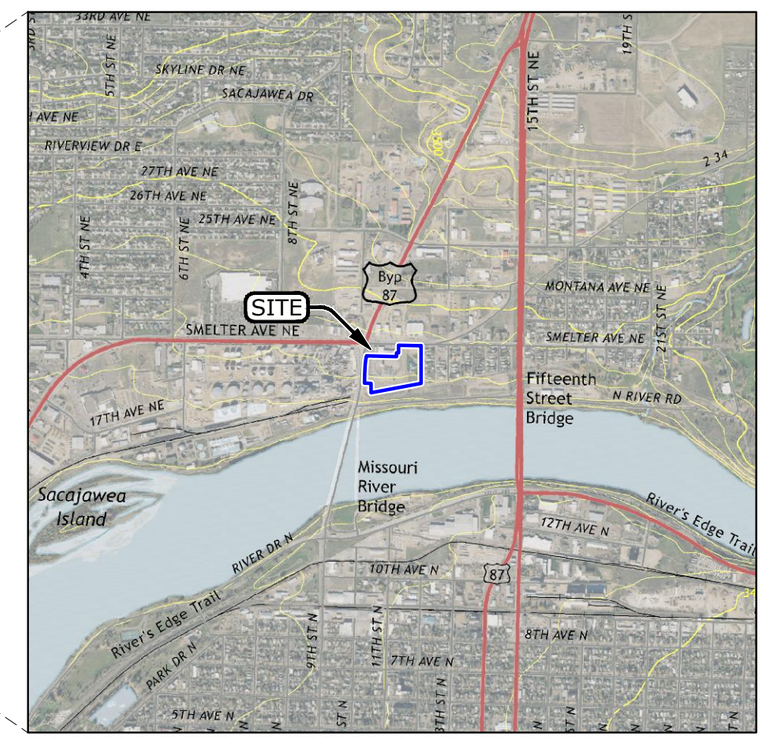
AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%) DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION

CALUMET MONTANA REFINING, LLC, 1900 10TH STREET, GREAT FALLS, MONTANA

INDEX TO DRAWINGS

CIVIL
C1 - AOC-16 Site Layout
C2 - Work Area Boundaries and Equipment/Material Laydown Areas
C3 - Erosion and Sedimentation Control Measures
C4 - Erosion and Sedimentation Control Details (4 Sheets)
C5 - Dual-Phase Extraction System Plan
C6 - Dual-Phase Extraction Equipment Layout
C7 - Dual-Phase Extraction Well Details
C8 - Existing Recovery Sump and Gravel Foundation Details
C9 - Dual-Phase Extraction Conveyance Piping Details
C10 - Passive Treatment Trench Plan
C11 - Passive Treatment Trench Area Pre-Construction Geologic Cross-Section
C12 - Passive Treatment Trench Cross-Sections (3 Sheets)
C13 - Passive Treatment Trench Well Details
PROCESS
PFD-01 - Process Flow Diagram
PID-01 - Piping and Instrumentation Diagram
PID-02 - Piping and Instrumentation Diagram
PID-03 - Piping and Instrumentation Diagram
PID-04 - Piping and Instrumentation Diagram
PID-05 - Piping and Instrumentation Diagram
PID-06 - Piping and Instrumentation Diagram
PID-07 - Piping and Instrumentation Diagram
MECHANICAL
M1 - Dual-Phase Extraction System General Arrangement
M2 - Self-Recuperative Catalytic Oxidizer General Arrangement
ELECTRICAL
E1 - General Notes, Symbols, & Abbreviations
E2 - Dual-Phase Extraction System Electrical One-Line Diagram
E3 - Self-Recuperative Catalytic Oxidizer Electrical One-Line Diagram (7 Sheets)





2017 USGS 7.5 MINUTE SERIES NORTHWEST GREAT FALLS, MONTANA TOPOGRAPHIC QUADRANGLE.

FILE LOCATION:
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DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 9/30/2020

SIGNATURE
DATE

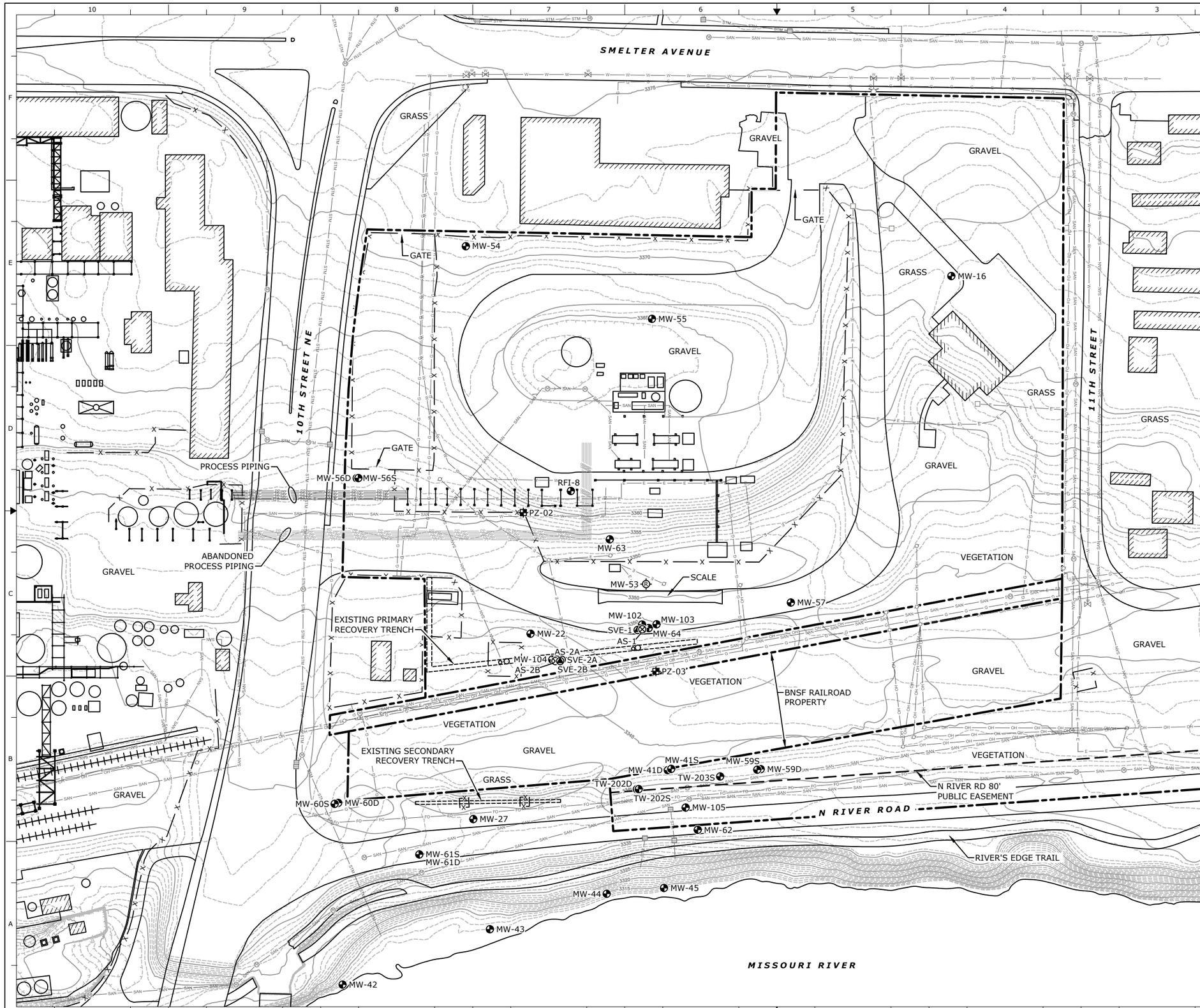
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

COVER SHEET

PROJECT # 1690014124-003

DRAWING
CS1



LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

0 100
SCALE IN FEET

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C1_AOC-16 Site Layout.dwg

DRAFTED BY: HJW
DESIGNED BY: AS/PL
DATE: 9/30/2020
APPROVED BY: ST

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

AOC-16 SITE LAYOUT

PROJECT # 1690014124-003

DRAWING
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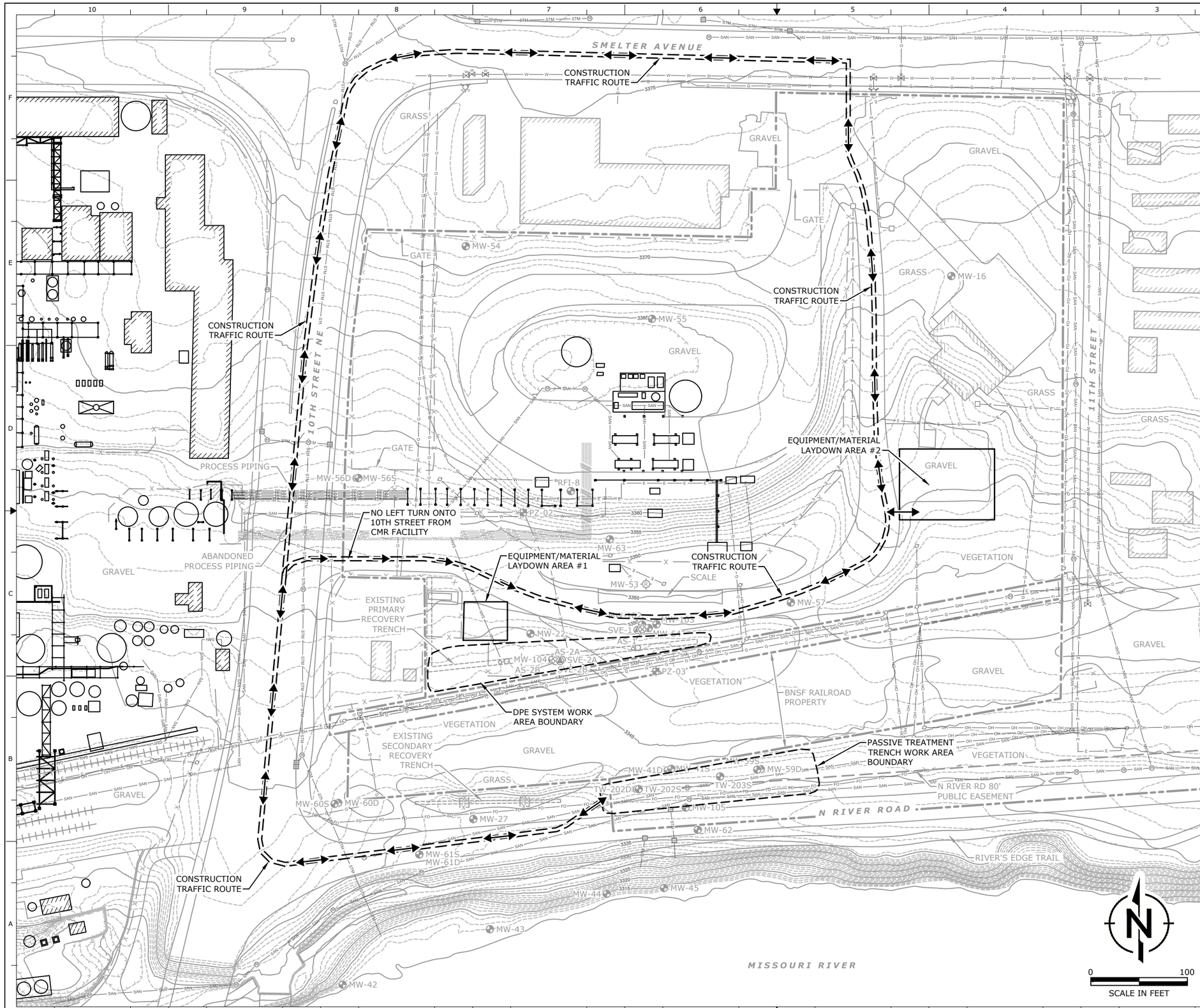

LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING
- TRAFFIC FLOW DIRECTION

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

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2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

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DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 9/10/2020

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

WORK AREA BOUNDARIES AND EQUIPMENT/MATERIAL LAYDOWN AREAS

PROJECT# 1690014124-003

DRAWING
C2

LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
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- RAILROAD TRACKS
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- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

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SCALE IN FEET

DATE
SIGNATURE

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DRAFTED BY: HJW
DESIGNED BY: AS/PL
DATE: 9/10/2020
APPROVED BY: ST

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

EROSION AND SEDIMENTATION CONTROL MEASURES

PROJECT # 1690014124-003

DRAWING
C3

SYMBOL: ——— SF ———

SILT FENCE SC-1:

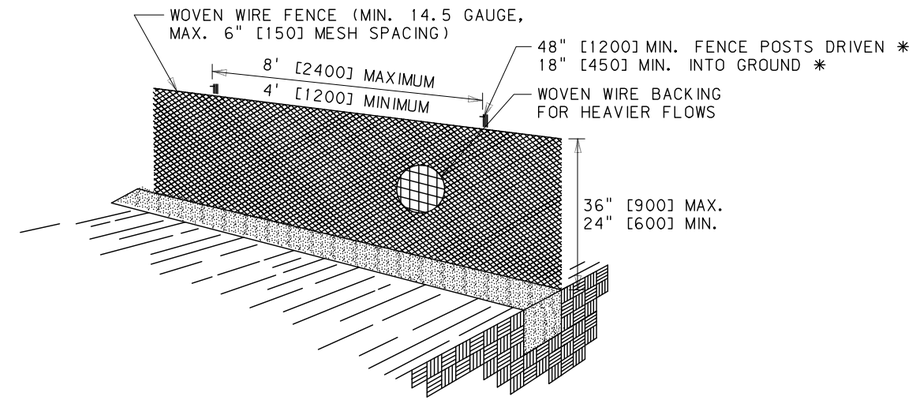
1. SILT FENCE IS A SINGLE OR SERIES OF FILTER FABRIC SEDIMENT BARRIER STRETCHED AND ATTACHED TO SUPPORTING POSTS. THE FENCE BOTTOM IS ENTRENCHED.

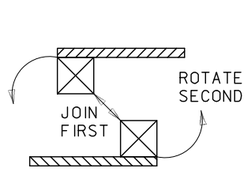
2. SILT FENCES ARE USED FOR SHEET FLOWS TO ASSIST IN SEDIMENT CONTROL BY RETAINING SOME OF THE ERODED SOIL PARTICLES AND SLOWING THE RUNOFF VELOCITY TO ALLOW PARTICLE SETTLING. INSTALL SILT FENCES IN ACCORDANCE WITH SECTION 622.

3. THERE ARE TWO TYPES OF SILT FENCE INSTALLATIONS:
   - UNSTABILIZED - SILT FENCE SUPPORTED WITH EITHER WOOD OR METAL FENCE POSTS.
   - STABILIZED - SILT FENCE SUPPORTED WITH METAL POSTS AND WITH WOVEN WIRE BACKING.

4. ENTRENCHMENT - THE INITIAL SILT FENCE INSTALLATION REQUIRES ONLY THE VERTICAL ENTRENCHMENT COMPONENT UNLESS THE PROJECT MANAGER DETERMINES BOTH VERTICAL AND HORIZONTAL ENTRENCHMENT COMPONENTS ARE NECESSARY. IF THE FENCE REQUIRES REPLACEMENT DUE TO FAILURE FROM PULLOUT OR UNDERCUTTING, THE SUBSEQUENT INSTALLATION WILL INCLUDE BOTH VERTICAL AND HORIZONTAL ENTRENCHMENT COMPONENTS.

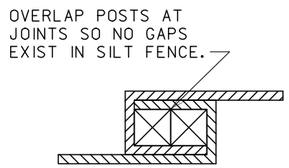
5. USE SILT FENCES BETWEEN THE EDGE OF CONSTRUCTION DISTURBANCE AND A WATER RESOURCE, AND AT A CRITICAL RESOURCE OR RIGHT-OF-WAY LINE THAT IS ADJACENT TO CONSTRUCTION ACTIVITY. POSITION THE BARRIER TO PREVENT SEDIMENT FROM ENTERING DRAINAGES. DO NOT PLACE THE BARRIER ACROSS LIVE STREAMS OR WHERE CONCENTRATED FLOWS MAY OCCUR. WOVEN WIRE BACKING IS NECESSARY WHEN DEALING WITH HEAVIER FLOW VELOCITIES AND SEDIMENT OR AS A ROCK BARRIER. REMOVE SEDIMENT FROM BEHIND THE FENCE WHEN IT ACCUMULATES TO ONE-THIRD THE ORIGINAL HEIGHT. EITHER GRADE AND SEED OR REMOVE THE SEDIMENT DEPOSITS PRIOR TO REMOVAL OF THE FENCE. DISTANCES BETWEEN SILT FENCE WHEN USED FOR SEDIMENT RETENTION ARE AS FOLLOWS:
   - FROM 2% TO 3% PLACE SILT FENCE AT 500 FT. [150 m]SPACING
   - FROM 3% TO 4% PLACE SILT FENCE AT 300 FT. [90 m]SPACING
   - FROM 4% + PLACE SILT FENCE AT 150 FT. [45 m]SPACING

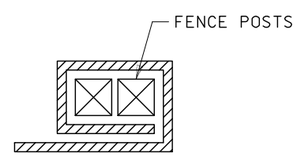




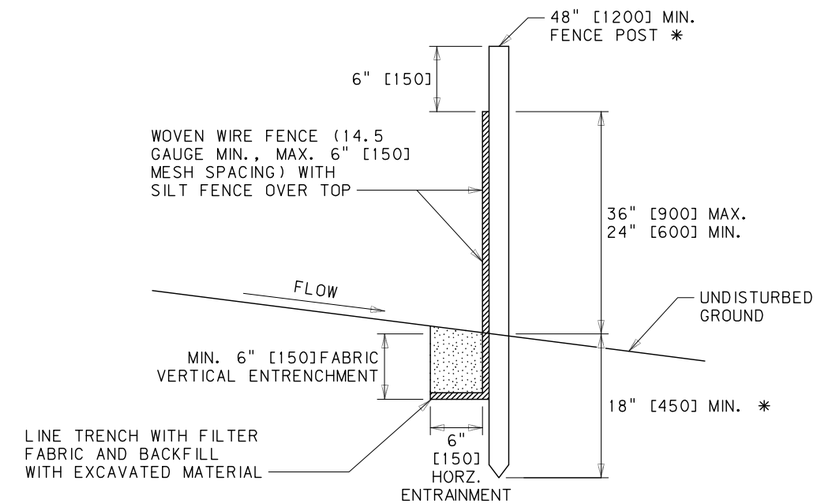
SILT FENCE JOINTS

JOIN POSTS AS SHOWN, ROTATE 180° IN DIRECTION SHOWN AND DRIVE INTO THE GROUND.

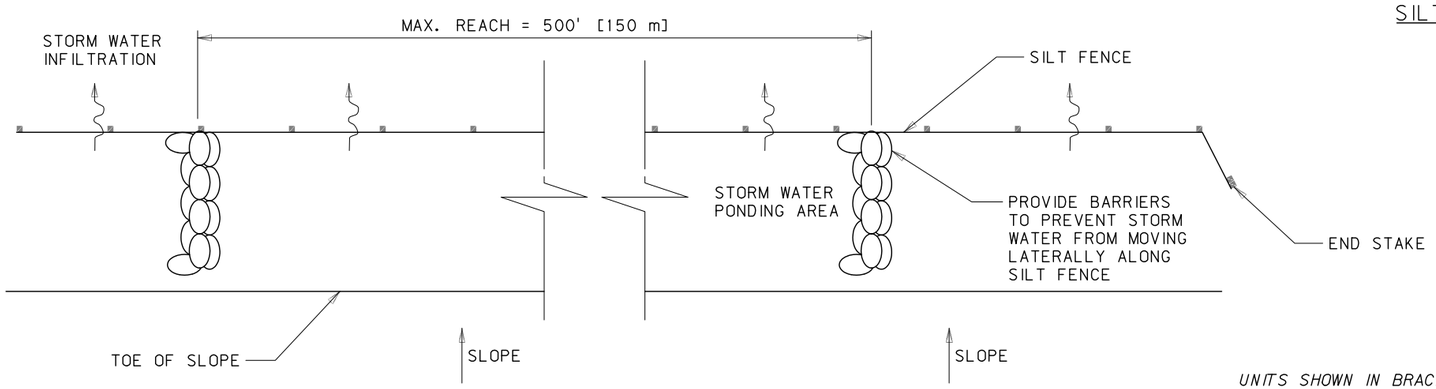




END STAKE DETAIL



SILT FENCE - CROSS SECTION



SILT FENCE - PLAN VIEW

* FOR CLEAR ZONE APPLICATIONS USE MAX. POST LENGTH OF 60" [1500] WITH A MAX. BURIAL DEPTH OF 18" [450].

UNITS SHOWN IN BRACKETS [] ARE METRIC AND ARE IN MILLIMETERS (mm) UNLESS OTHER UNITS ARE SHOWN.

SOURCE: MONTANA DEPARTMENT OF TRANSPORTATION, DRAWING NO. 208-03, DATED SEPTEMBER 2014.

DATE

SIGNATURE

FILE LOCATION: M:\CAD\169001\4124-003_Calumet_AOC-16\100% Design\C4 Erosion and Sedimentation Control Details (Sheet 1 of 4).dwg

DESIGNED BY: AS/PL | DRAFTED BY: HJW

APPROVED BY: ST | DATE: 7/31/2020

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

EROSION AND SEDIMENTATION CONTROL DETAILS

PROJECT# 1690014124-003

DRAWING

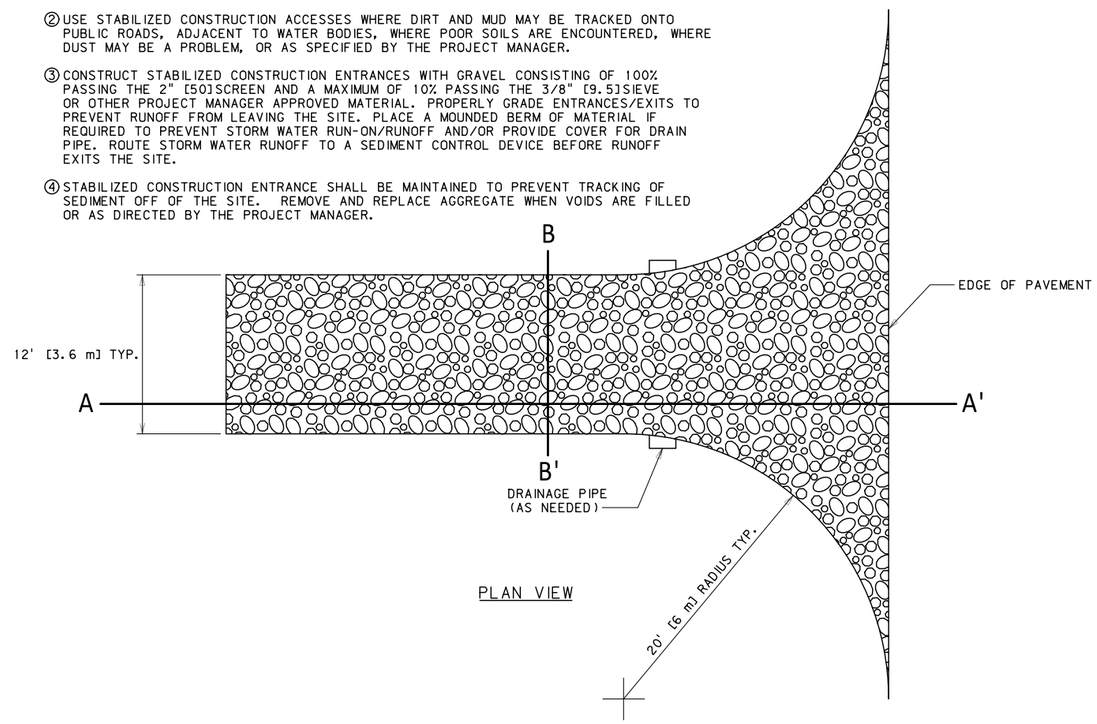
C4

SHEET 1 OF 4

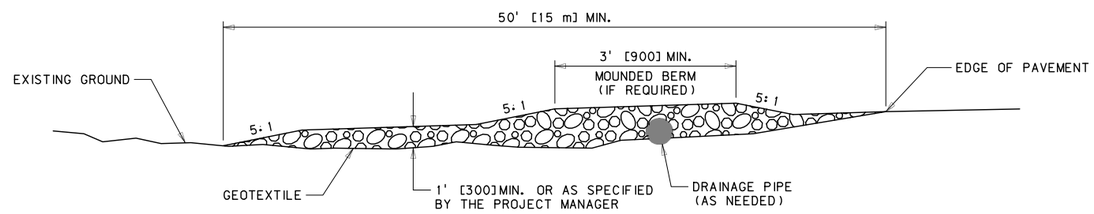
SYMBOL: SCEE

STABILIZED CONSTRUCTION ENTRANCE/EXIT TC-1:

1. A STABILIZED CONSTRUCTION ACCESS IS A DEFINED POINT OF ENTRANCE/EXIT TO A CONSTRUCTION SITE THAT IS STABILIZED TO REDUCE THE TRACKING OF MUD AND DIRT ONTO PUBLIC ROADS BY CONSTRUCTION VEHICLES.
2. USE STABILIZED CONSTRUCTION ACCESSES WHERE DIRT AND MUD MAY BE TRACKED ONTO PUBLIC ROADS, ADJACENT TO WATER BODIES, WHERE POOR SOILS ARE ENCOUNTERED, WHERE DUST MAY BE A PROBLEM, OR AS SPECIFIED BY THE PROJECT MANAGER.
3. CONSTRUCT STABILIZED CONSTRUCTION ENTRANCES WITH GRAVEL CONSISTING OF 100% PASSING THE 2" [50]SCREEN AND A MAXIMUM OF 10% PASSING THE 3/8" [9.5]SIEVE OR OTHER PROJECT MANAGER APPROVED MATERIAL. PROPERLY GRADE ENTRANCES/EXITS TO PREVENT RUNOFF FROM LEAVING THE SITE. PLACE A MOUNDED BERM OF MATERIAL IF REQUIRED TO PREVENT STORM WATER RUN-ON/RUNOFF AND/OR PROVIDE COVER FOR DRAIN PIPE. ROUTE STORM WATER RUNOFF TO A SEDIMENT CONTROL DEVICE BEFORE RUNOFF EXITS THE SITE.
4. STABILIZED CONSTRUCTION ENTRANCE SHALL BE MAINTAINED TO PREVENT TRACKING OF SEDIMENT OFF OF THE SITE. REMOVE AND REPLACE AGGREGATE WHEN VOIDS ARE FILLED OR AS DIRECTED BY THE PROJECT MANAGER.

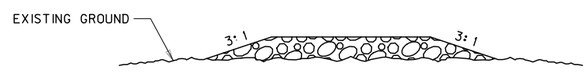


PLAN VIEW



PROFILE VIEW (A-A')

UNITS SHOWN IN BRACKETS [] ARE METRIC AND ARE IN MILLIMETERS (mm) UNLESS OTHER UNITS ARE SHOWN.



END VIEW (B-B')

SOURCE: MONTANA DEPARTMENT OF TRANSPORTATION, DRAWING NO. 208-56, DATED SEPTEMBER 2014.

FILE LOCATION:
M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C4 Erosion and Sedimentation Control Details (Sheet 2 of 4).dwg

DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 8/20/2020

SIGNATURE
DATE

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

EROSION AND SEDIMENTATION CONTROL DETAILS

PROJECT# 1690014124-003

DRAWING
C4
SHEET 2 OF 4

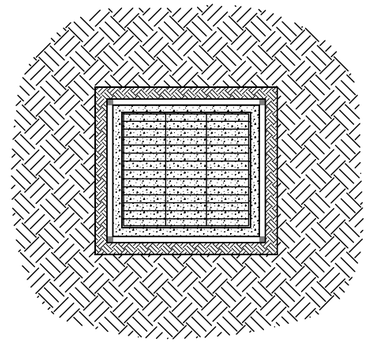
SYMBOL: (SDP)

STORM DRAIN INLET PROTECTION SC-10:

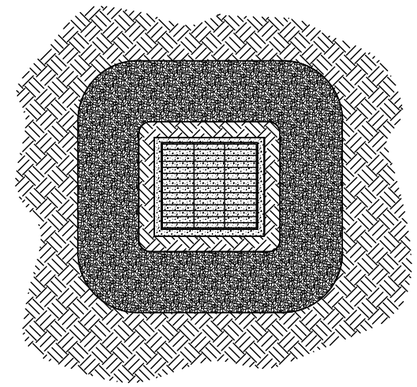
1. STORM DRAIN INLET PROTECTION IS USED AT STORM DRAIN INLETS THAT ARE SUBJECT TO RUNOFF FROM CONSTRUCTION ACTIVITIES. THESE DEVICES DRAIN AND/OR FILTER SEDIMENT-LADEN RUNOFF AND ALLOW SEDIMENT TO SETTLE PRIOR TO DISCHARGE OF STORM WATER INTO STORM WATER DRAINAGE SYSTEMS OR WATERCOURSES.

2. USE STORM DRAIN INLET PROTECTION WHEN PONDING WILL NOT ENCROACH INTO HIGHWAY AND FOR DRAINAGE AREAS OF 1 ACRE [0.4 ha]OR LESS. FOR FLOWS LESS THAN 0.5 CFS [0.014 m^3/s]SILT FENCE OR STRAW BALES MAY BE USED. WHEN FLOWS EXCEED 0.5 CFS [0.014 m^3/s]USE SANDBAG BARRIERS OR GRAVEL CHECK DAMS. FOLLOW SILT FENCE (SC-1), STRAW BALE BARRIERS (SC-9), SANDBAG BARRIERS (SC-8) AND CHECK DAMS (SC-4) FOR INSTALLATION REQUIREMENTS FOR EACH TYPE OF MATERIAL.

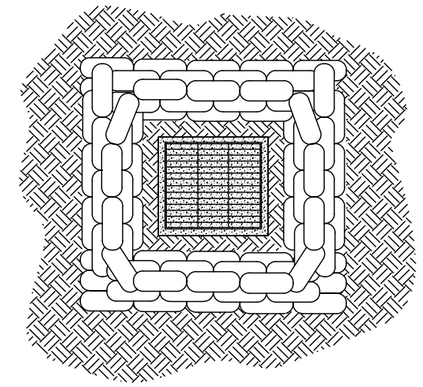
3. STRAW BALES, SAND BAGS, AND GRAVEL BERMS MAY BE USED WITHIN THE CLEAR ZONE UPON PROJECT MANAGER'S APPROVAL. EXPEDIENTLY REMOVE ALL STRAW BALES, SAND BAGS, AND GRAVEL BERMS FROM THE CLEAR ZONE UPON COMPLETION OF CONSTRUCTION ACTIVITIES.



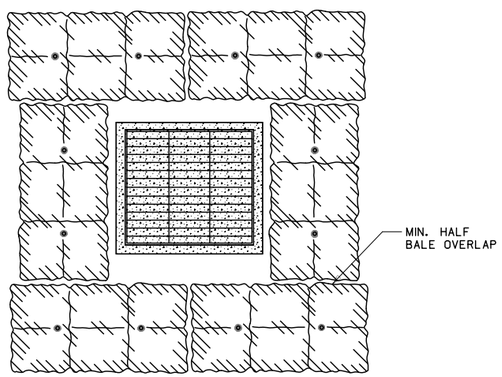
SILT FENCE - PLAN VIEW



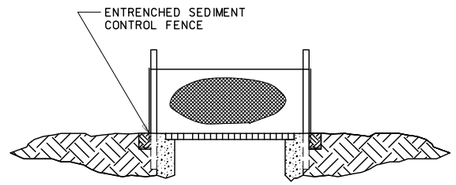
GRAVEL CHECK DAM - PLAN VIEW



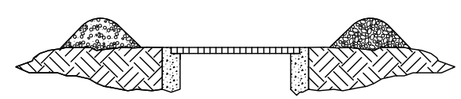
SANDBAG BARRIER - PLAN VIEW



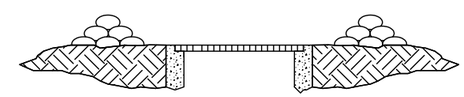
STRAW BALE BARRIER - PLAN VIEW



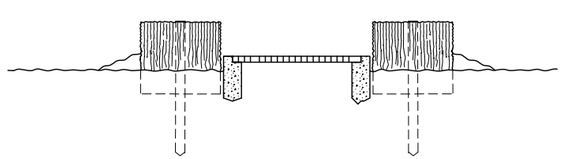
SILT FENCE - PROFILE VIEW



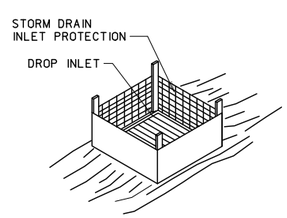
GRAVEL CHECK DAM - PROFILE VIEW



SANDBAG BARRIER - PROFILE VIEW



STRAW BALE BARRIER - PROFILE VIEW



EXAMPLE ISOMETRIC VIEW

UNITS SHOWN IN BRACKETS [] ARE METRIC AND ARE IN MILLIMETERS (mm) UNLESS OTHER UNITS ARE SHOWN.

SOURCE: MONTANA DEPARTMENT OF TRANSPORTATION, DRAWING NO. 208-46, DATED SEPTEMBER 2014.

FILE LOCATION:
M:\CAD\169001\4124-003_Calumet_AOC-16\100% Design\C4 Erosion and Sedimentation Control Details (Sheet 3 of 4).dwg

DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 7/31/2020

SIGNATURE
DATE

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

EROSION AND SEDIMENTATION CONTROL DETAILS

PROJECT# 1690014124-003

DRAWING
C4
SHEET 3 OF 4

SYMBOL: ——— STRAW-B ———

STRAW BALE BARRIERS SC-9:

1. STRAW BALE BARRIERS ARE A SEDIMENT BARRIER CONSISTING OF ENTRENCHED, OVERLAPPING AND ANCHORED STRAW BALES THAT REDUCE RUNOFF VELOCITIES AND RETAIN SEDIMENT. DO NOT USE STRAW BALE BARRIERS INSIDE THE CLEAR ZONE. STRAW BALES MUST BE CERTIFIED WEED-FREE.

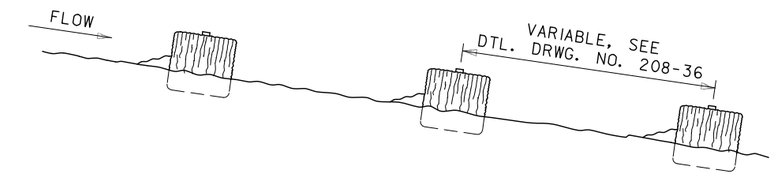
2. STRAW BALE BARRIERS ARE USED FOR SHEET OR CONCENTRATED FLOWS TO REDUCE RUNOFF VELOCITY, PROMOTE SEDIMENT RETENTION AND ALLOW SETTLING. DO NOT USE STRAW BALES IN HIGH FLOWS SUCH AS CHANNELS OR LIVE STREAMS. IN ADDITION, STRAW BALES CANNOT BE USED ON SURFACES WHICH DO NOT ALLOW FOR ENTRENCHMENT.

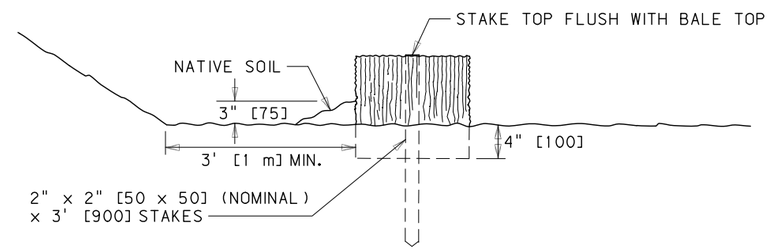
3. MINIMUM STRAW BALES SIZE REQUIREMENTS ARE A WIDTH OF 1'-2" [360], HEIGHT OF 1'-6" [450], LENGTH OF 3 FT. [900] AND A MASS OF 50 LB [23 kg]. USE STEEL WIRE (16 GAUGE [1.57 DIAMETER] MIN.), NYLON OR POLYPROPYLENE STRING (1/16" [2] MIN. DIAMETER) TO BIND BALES. MINIMUM BREAKING STRENGTH OF BINDING MATERIAL IS 80 LB [360 N]. USE 2" BY 2" [50 x 50] (NOMINAL) BY 3 FT. [900] LONG WOODEN STAKES. DO NOT USE METAL STAKES.

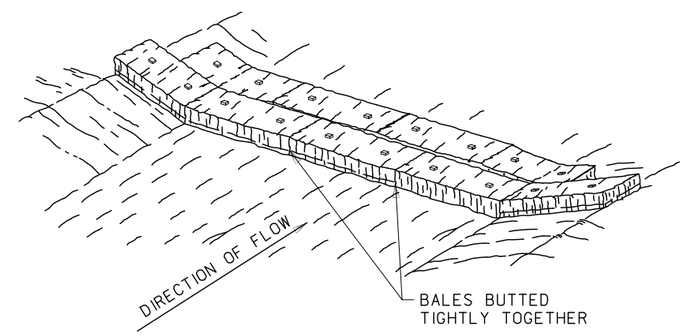
4. INSTALL STRAW BALES ALONG A LEVEL CONTOUR, WITH THE LAST BALE TURNED UP SLOPE. PLACE BALES IN A 4" [100] DEEP TRENCH, TIGHTLY ABUT ADJACENT BALES, AND STAKE USING A MINIMUM OF TWO STAKES PER BALE. IF SLOPES EXCEED 10:1 THE LENGTH OF SLOPE UP STREAM OF THE BARRIER MUST BE LESS THAN 50 FT. [15 m]. OFFSET BALES AT LEAST 3 FT. [1 m] FROM THE TOE OF SLOPES. IF SITE CONDITIONS DO NOT ALLOW FOR OFFSET, BALES MAY BE PLACED AT TOE.

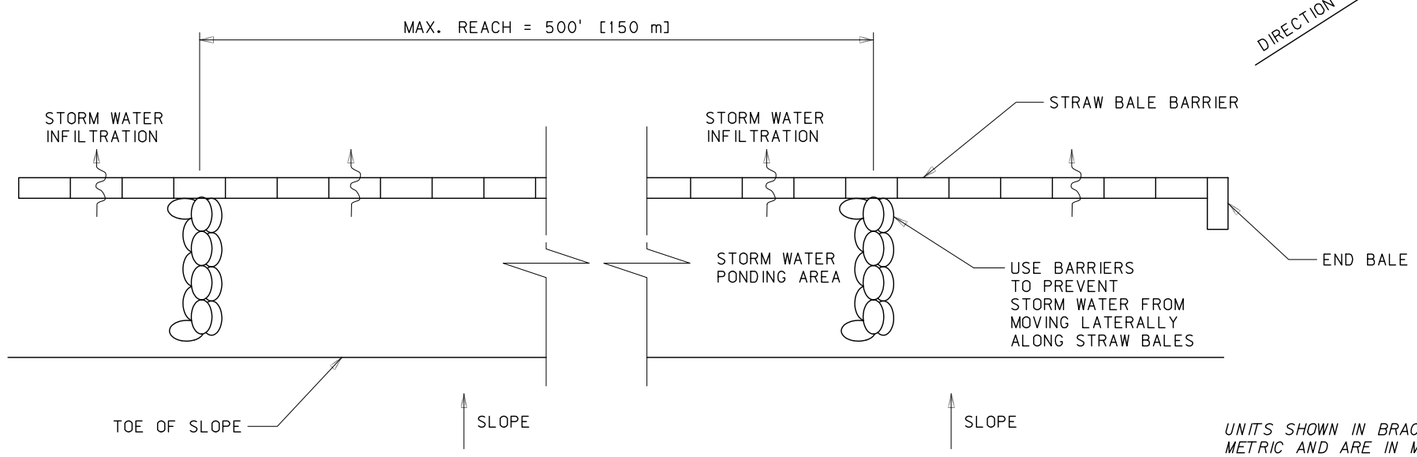
5. FOLLOW GUIDELINES IN DTL. DRWG. NO. 208-36 IF BALES ARE USED AS CHECK DAMS.

6. REPAIR OR REPLACE DAMAGED, UNDER-CUT OR END RUN BALES. REMOVE SEDIMENT BUILDUP FROM BALES ONCE IT REACHES A HEIGHT OF 1/3 THE BALE HEIGHT.









UNITS SHOWN IN BRACKETS [] ARE METRIC AND ARE IN MILLIMETERS (mm) UNLESS OTHER UNITS ARE SHOWN.

SOURCE: MONTANA DEPARTMENT OF TRANSPORTATION, DRAWING NO. 208-44, DATED SEPTEMBER 2014.

DATE

SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C4 Erosion and Sedimentation Control Details (Sheet 4 of 4).dwg

DESIGNED BY: AS/PL | DRAFTED BY: HJW

APPROVED BY: ST | DATE: 7/31/2020

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

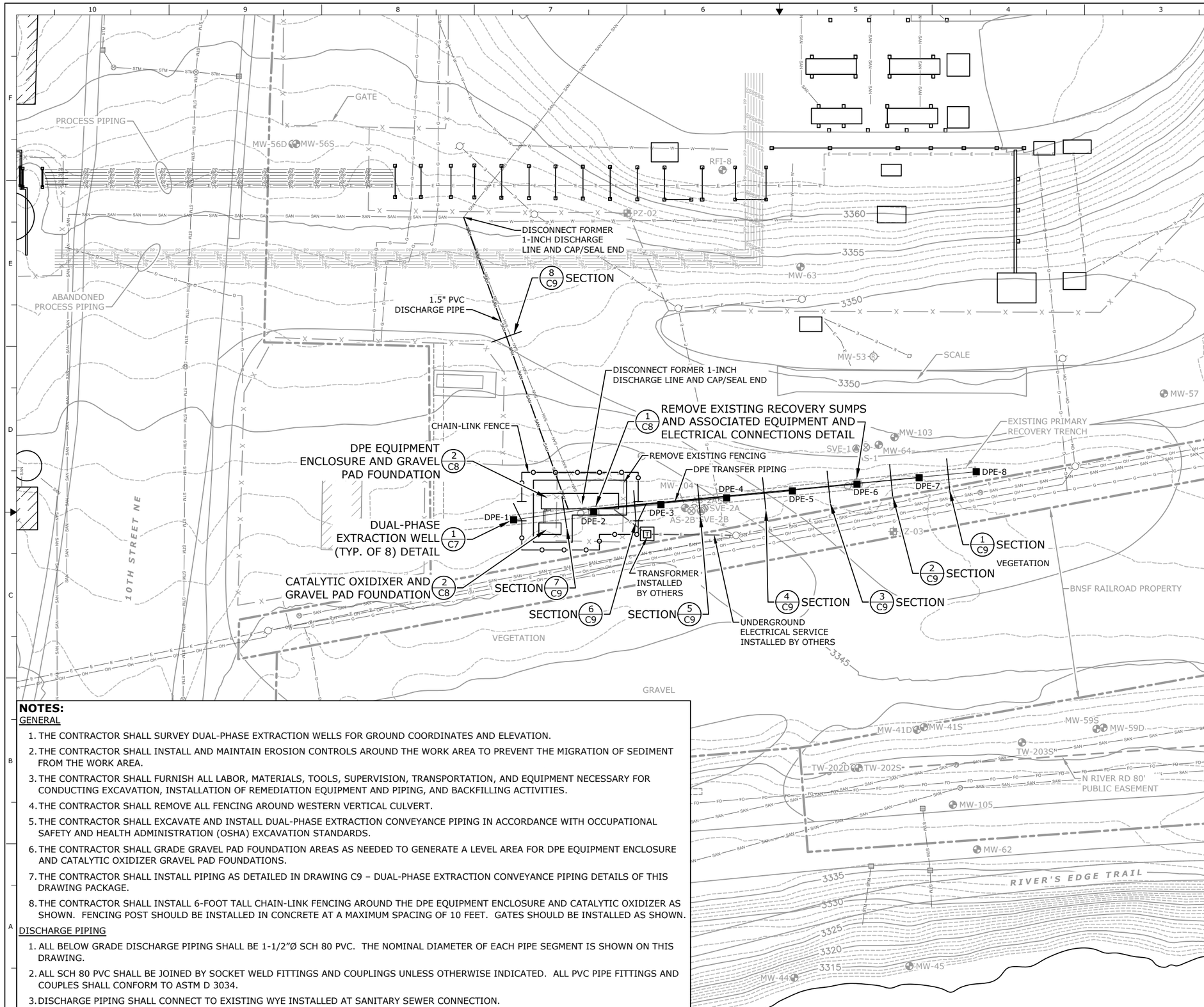
EROSION AND SEDIMENTATION CONTROL DETAILS

PROJECT# 1690014124-003

DRAWING

C4

SHEET 4 OF 4



NOTES:

GENERAL

1. THE CONTRACTOR SHALL SURVEY DUAL-PHASE EXTRACTION WELLS FOR GROUND COORDINATES AND ELEVATION.
2. THE CONTRACTOR SHALL INSTALL AND MAINTAIN EROSION CONTROLS AROUND THE WORK AREA TO PREVENT THE MIGRATION OF SEDIMENT FROM THE WORK AREA.
3. THE CONTRACTOR SHALL FURNISH ALL LABOR, MATERIALS, TOOLS, SUPERVISION, TRANSPORTATION, AND EQUIPMENT NECESSARY FOR CONDUCTING EXCAVATION, INSTALLATION OF REMEDIATION EQUIPMENT AND PIPING, AND BACKFILLING ACTIVITIES.
4. THE CONTRACTOR SHALL REMOVE ALL FENCING AROUND WESTERN VERTICAL CULVERT.
5. THE CONTRACTOR SHALL EXCAVATE AND INSTALL DUAL-PHASE EXTRACTION CONVEYANCE PIPING IN ACCORDANCE WITH OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) EXCAVATION STANDARDS.
6. THE CONTRACTOR SHALL GRADE GRAVEL PAD FOUNDATION AREAS AS NEEDED TO GENERATE A LEVEL AREA FOR DPE EQUIPMENT ENCLOSURE AND CATALYTIC OXIDIZER GRAVEL PAD FOUNDATIONS.
7. THE CONTRACTOR SHALL INSTALL PIPING AS DETAILED IN DRAWING C9 – DUAL-PHASE EXTRACTION CONVEYANCE PIPING DETAILS OF THIS DRAWING PACKAGE.
8. THE CONTRACTOR SHALL INSTALL 6-FOOT TALL CHAIN-LINK FENCING AROUND THE DPE EQUIPMENT ENCLOSURE AND CATALYTIC OXIDIZER AS SHOWN. FENCING POST SHOULD BE INSTALLED IN CONCRETE AT A MAXIMUM SPACING OF 10 FEET. GATES SHOULD BE INSTALLED AS SHOWN.

DISCHARGE PIPING

1. ALL BELOW GRADE DISCHARGE PIPING SHALL BE 1-1/2"Ø SCH 80 PVC. THE NOMINAL DIAMETER OF EACH PIPE SEGMENT IS SHOWN ON THIS DRAWING.
2. ALL SCH 80 PVC SHALL BE JOINED BY SOCKET WELD FITTINGS AND COUPLINGS UNLESS OTHERWISE INDICATED. ALL PVC PIPE FITTINGS AND COUPLES SHALL CONFORM TO ASTM D 3034.
3. DISCHARGE PIPING SHALL CONNECT TO EXISTING WYE INSTALLED AT SANITARY SEWER CONNECTION.

LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

0 50
SCALE IN FEET

DATE
SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C5_Dual-Phase Extraction System Plan.dwg

DRAFTED BY: HJW
DATE: 9/11/2020
DESIGNED BY: AS/PL
APPROVED BY: ST

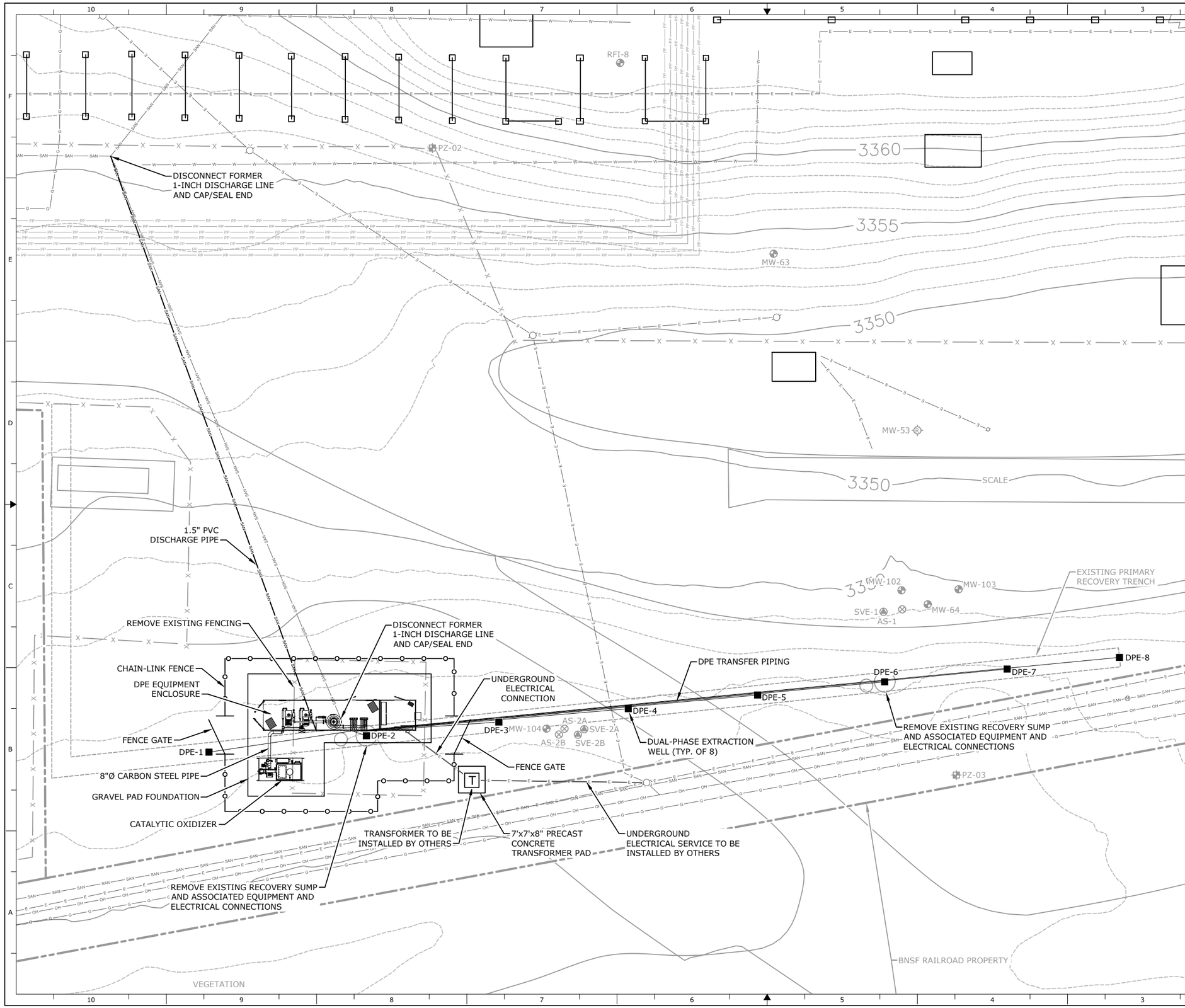
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

DUAL-PHASE EXTRACTION SYSTEM PLAN

PROJECT # 1690014124-003

DRAWING
C5



LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

0 25
SCALE IN FEET

DATE
SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C6_Dual-Phase Extraction Equipment Layout.dwg

DRAFTED BY: HJW
DATE: 9/11/2020
DESIGNED BY: AS/PL
APPROVED BY: ST

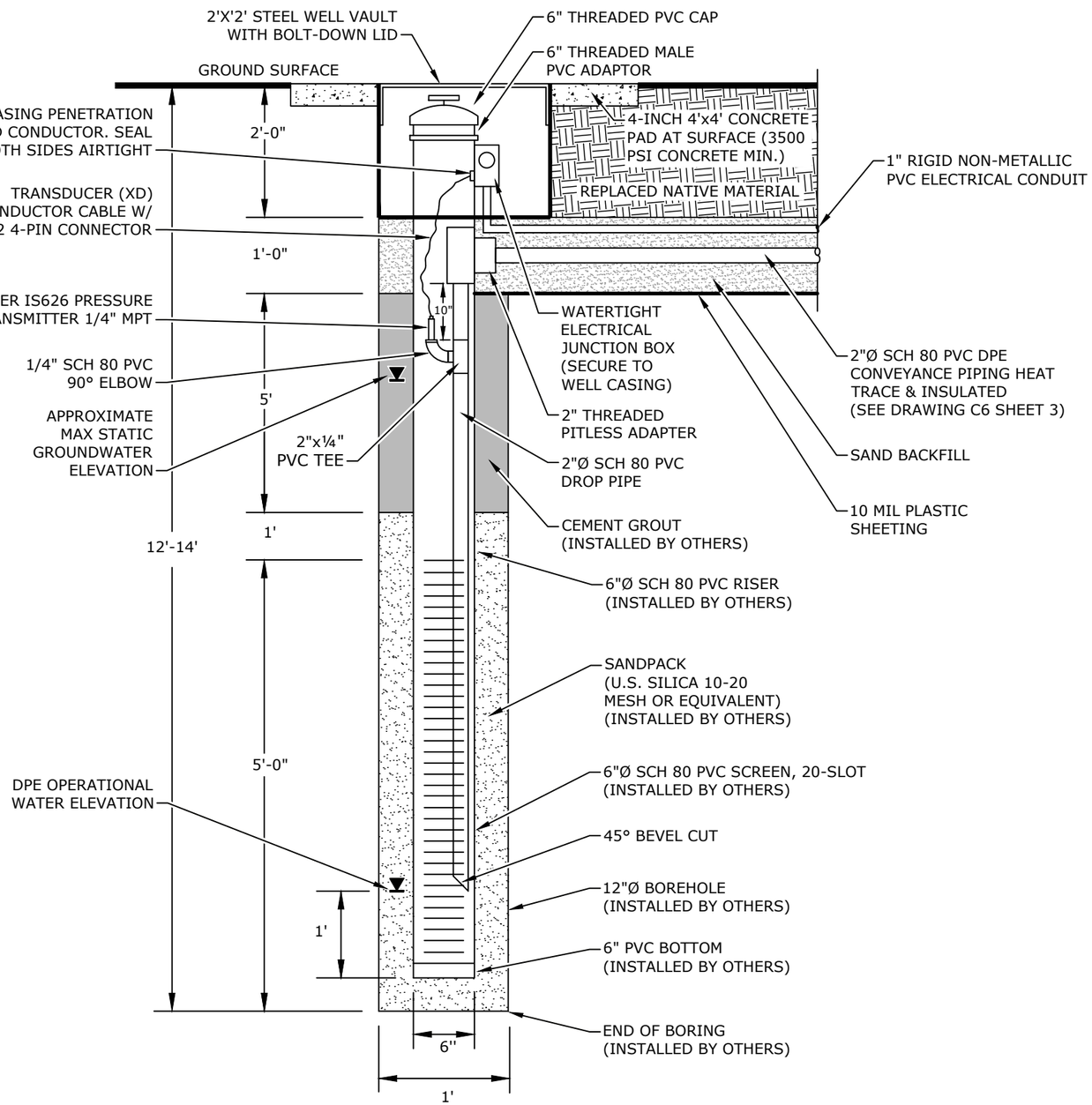
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

DUAL-PHASE EXTRACTION EQUIPMENT LAYOUT

PROJECT# 1690014124-003

DRAWING
C6



TYPICAL DUAL-PHASE EXTRACTION WELL DETAIL

1 NOT TO SCALE

NOTES:

GENERAL

1. CONTRACTOR SHALL FURNISH ALL LABOR, EQUIPMENT, AND MATERIALS NECESSARY FOR TRENCHING, BACKFILLING, AND INSTALLATION OF WELLHEAD COMPLETIONS AND PIPING IN ACCORDANCE WITH THESE DESIGN DRAWINGS.
2. ALL PRODUCTS, EQUIPMENT, AND MATERIALS SHALL BE COMPATIBLE WITH THEIR INTENDED USE AS SHOWN IN THE DRAWINGS.
3. ALL PRODUCTS, EQUIPMENT, AND MATERIALS SHALL BE INSTALLED OR APPLIED IN ACCORDANCE WITH MANUFACTURER INSTRUCTIONS.
4. ALL CONCRETE OR ASPHALT TO BE REMOVED SHALL BE SAW CUT.

DUAL-PHASE EXTRACTION WELL

1. ALL DUAL-PHASE EXTRACTION WELLS TO BE COMPLETED BY OTHERS AS INDICATED ON THE DRAWING.

DUAL-PHASE EXTRACTION VAULT

1. CONTRACTOR SHALL FURNISH EIGHT NEW BELOW GRADE VAULTS INCLUDING NECESSARY PIPING, APPURTENANCES, AND CONTROLS.
2. VAULTS SHALL BE A MINIMUM DIMENSION OF 2 FEET BY 2 FEET SQUARE WITH AN ACCESS COVER OR HATCH.
3. VAULTS SHALL BE ABLE TO WITHSTAND A LOAD RATING OF H-20 AND A MINIMUM OF 300 POUNDS PER SQUARE FOOT.
4. VAULTS SHALL BE INSTALLED A MINIMUM OF ONE-INCH ABOVE THE GROUND SURFACE.
5. VAULTS SHALL BE SELF-DRAINING AND CONSTRUCTED SUCH THAT BOTTOM INTERSECTS SAND BACKFILL/PIPE BEDDING MATERIAL. FINE-GRAINED MATERIALS (E.G., SILTS OR CLAYS) SHALL NOT BE PLACED AT BOTTOM OF VAULT.

TRENCHING

1. ALL TRENCHES FOR UNDERGROUND PIPE INSTALLATION SHALL BE EXCAVATED TO THE DEPTHS INDICATED. TRENCH DEPTHS AND DIMENSIONS MAY BE MODIFIED IN THE FIELD BY THE ENGINEER AS NECESSARY TO ADDRESS UNANTICIPATED SITE CONDITIONS.
2. 1/100TH (0.01)-INCH (10-MIL) PLASTIC SHEETING SHALL BE PLACED AT THE BOTTOM OF PIPING TRENCH PRIOR TO INSTALLATION OF PIPE BEDDING MATERIAL OR PIPE. PLASTIC SHEETING SHALL EXTEND A MINIMUM OF 12-INCHES BEYOND THE WIDTH OF THE TRENCH ON EACH EDGE. PLASTIC SHEETING SEAMS WILL BE OVERLAPPED BY A MINIMUM OF 4-FEET.
3. PIPE BEDDING SHALL BE PLACED BY HAND IN MAXIMUM 6-INCH LIFTS TO THE DIMENSIONS INDICATED. EACH LIFT SHALL BE COMPACTED USING HAND TAMPING OR VIBRATORY PLACE DEVICE WITH A MINIMUM OF TWO FULL PASSES PER LIFT. THE BEDDING MATERIAL SHALL CONSIST OF SAND FILL MATERIAL.

PIPING

1. ALL BELOW GRADE PIPING SHALL BE 2"Ø SCH 80 PVC OR APPROVED EQUIVALENT. THE NOMINAL DIAMETER OF EACH PIPE SEGMENT IS SHOWN ON THIS DRAWING.
2. ALL SCH 80 PVC SHALL BE JOINED BY SOCKET WELD FITTINGS AND COUPLINGS UNLESS OTHERWISE INDICATED. ALL PVC PIPE FITTINGS AND COUPLES SHALL CONFORM TO ASTM D 3034.
3. ALL BELOW GRADE PIPING SHALL BE SLOPED ONE VERTICAL FOOT PER 500 LINEAR FEET FROM THE WELLHEAD TO THE DUAL-PHASE EXTRACTION REMEDIATION SYSTEM ENCLOSURE. ALL FLUIDS SHALL GRAVITY DRAIN TOWARD THE WELLHEAD.

DATE

SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C7_Dual-Phase Extraction Well Details.dwg

DRAFTED BY: HJW

DATE: 8/19/2020

DESIGNED BY: AS/PL

APPROVED BY: ST

RAMBOLL

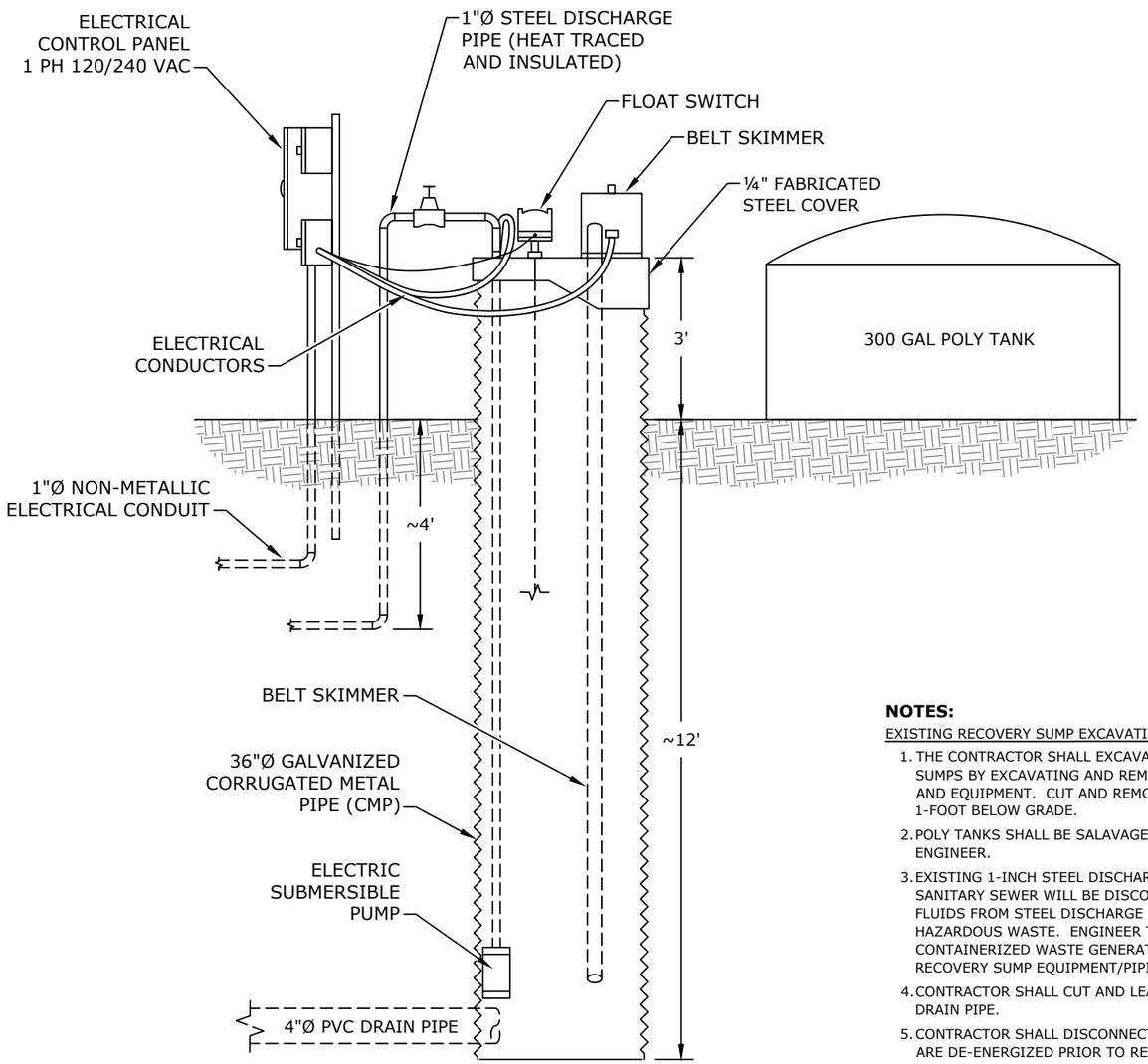
AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

DUAL-PHASE EXTRACTION WELL DETAILS

PROJECT# 1690014124-003

DRAWING

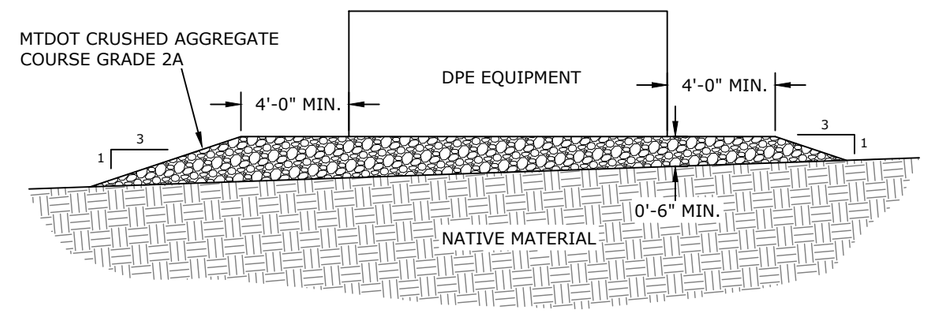
C7



TYPICAL EXISTING RECOVERY SUMP DETAIL

1

NOT TO SCALE



GRAVEL FOUNDATION DETAIL

2

NOT TO SCALE

NOTES:

EXISTING RECOVERY SUMP EXCAVATION AND REMOVAL

1. THE CONTRACTOR SHALL EXCAVATE AND REMOVE THE TWO EXISTING RECOVERY SUMPS BY EXCAVATING AND REMOVING ALL PIPING, ELECTRICAL CONDUITS/PANELS AND EQUIPMENT. CUT AND REMOVE PIPING AND CONDUITS TO A MINIMUM OF 1-FOOT BELOW GRADE.
2. POLY TANKS SHALL BE SALAVAGED AND MOVED TO A LOCATION SPECIFIED BY ENGINEER.
3. EXISTING 1-INCH STEEL DISCHARGE PIPING FROM WESTERN RECOVERY SUMP TO SANITARY SEWER WILL BE DISCONNECTED ON BOTH ENDS AND CAPPED/SEALED. FLUIDS FROM STEEL DISCHARGE PIPE SHALL BE CONTAINED AND MANAGED AS HAZARDOUS WASTE. ENGINEER TO COORDINATE THE DISPOSAL OF ANY CONTAINERIZED WASTE GENERATED FROM THE REMOVAL OF THE EXISTING RECOVERY SUMP EQUIPMENT/PIPING.
4. CONTRACTOR SHALL CUT AND LEAVE IN-PLACE THE 4-INCH POLYVINYL CHLORIDE DRAIN PIPE.
5. CONTRACTOR SHALL DISCONNECT ELECTRICITY AND VERIFY THAT ALL CONDUCTORS ARE DE-ENERGIZED PRIOR TO REMOVAL.

BACKFILLING

1. THE CONTRACTOR SHALL BACKFILL THE VOID WITH FINE GRAVEL/COARSE SAND MATERIAL TO WITHIN 3 FEET OF THE GROUND SURFACE. THE COARSE SAND GRADATION SHALL BE AS FOLLOWS:

SIEVE SIZE	PERCENT PASSING BY WEIGHT
3/4-INCH	>100
NO.4	>95
NO.10	>5
NO.40	>1

GRAVEL FOUNDATION

1. GRAVEL FOUNDATION SHALL BE CONSTRUCTED OF MONTANA DEPARTMENT OF TRANSPORTATION CRUSHED AGGREGATE COURSE GRADE 2A MATERIAL TO THE DIMENSIONS SHOWN.
2. AREA SHALL BE GRADED PRIOR TO GRAVEL FOUNDATION PAD CONSTRUCTION AND CLEARED OF ALL VEGETATION AND DELETERIOUS MATERIALS.
3. GRAVEL FOUNDATION PAD SHALL BE COMPACTED PRIOR TO PLACEMENT OF DPE EQUIPMENT ENCLOSURE AND DPE TREATMENT EQUIPMENT.

FILE LOCATION:
M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C8_Existing Recovery Sump and Gravel Foundation Details.dwg

DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 9/2/2020

RAMBOLL

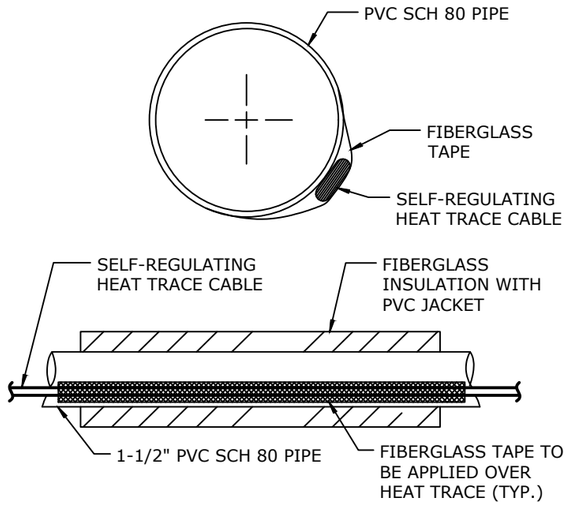
AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

EXISTING RECOVERY SUMP AND GRAVEL FOUNDATION DETAILS

PROJECT# 1690014124-003

DRAWING

C8



TYPICAL HEAT TRACE INSTALLATION DETAIL

NOT TO SCALE

HEAT TRACE SCHEDULE

ID	SERVICE	APPROX. LENGTH	PIPE SIZE	PIPE TYPE	INSULATION TYPE	INSULATION THICKNESS	HEAT TRACE CABLE	VOLTAGE	TOTAL APPROX. WATTAGE	MAINT. TEMP. (F)
HT-1	DPE INFLUENT	10'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-2	DPE INFLUENT	40'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-2	DPE INFLUENT	70'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-4	DPE INFLUENT	110'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-5	DPE INFLUENT	140'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-6	DPE INFLUENT	170'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-7	DPE INFLUENT	210'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-8	DPE INFLUENT	240'	2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40
HT-SAN	WATER/LNAPL EFFULENT	150'	1-1/2"	PVC SCH 80	FIBERGLASS WITH PVC JACKET	1-1/2"	5W/FT	TBD	TBD	40

NOTES:
1. HEAT TRACE SHALL BE SELF-REGULATING TYPE.
2. ALL HEAT TRACE CABLE SHALL BE INSTALLED IN CONTINUOUS LENGTHS. NO SPLICES ARE ACCEPTABLE.
3. ALL CABLE SHALL BE INSTALLED PER MANUFACTURER'S INSTALLATION. THIS SHALL INCLUDE METHODS FOR INSTALLATIONS, BENDS, VALVES, ETC.
4. LENGTHS OF PIPE INDICATED ARE APPROXIMATE, FIELD VERFICATION OF ACTUAL LENGTH IS REQUIRED.
5. PROVIDE CAUTION LABELS, ETL TAGS. TO PIPE INSULATION PVC JACKET ON 5'-0" INTERVALS MINIMUM, BUT AT LEAST ONE LABEL ON PIPE SECTION SHORTER THAN 5'-0".

NOTES:

GENERAL

1. CONTRACTOR SHALL FURNISH ALL LABOR, EQUIPMENT, AND MATERIALS NECESSARY FOR TRENCHING, BACKFILLING, AND INSTALLATION OF PIPING IN ACCORDANCE WITH THESE DESIGN DRAWINGS.
2. ALL PRODUCTS, EQUIPMENT, AND MATERIALS SHALL BE COMPATIBLE WITH THEIR INTENDED USE AS SHOWN IN THE DRAWINGS.
3. ALL PRODUCTS, EQUIPMENT, AND MATERIALS SHALL BE INSTALLED OR APPLIED IN ACCORDANCE WITH MANUFACTURER INSTRUCTIONS.
4. ALL CONCRETE OR ASPHALT TO BE REMOVED SHALL BE SAW CUT.

TRENCHING

1. ALL TRENCHES FOR UNDERGROUND PIPE INSTALLATION SHALL BE EXCAVATED TO THE DEPTHS INDICATED. TRENCH DEPTHS AND DIMENSIONS MAY BE MODIFIED IN THE FIELD BY THE ENGINEER AS NECESSARY TO ADDRESS UNANTICIPATED SITE CONDITIONS.
2. 1/100TH (0.01)-INCH (10-MIL) PLASTIC SHEETING SHALL BE PLACED AT THE BOTTOM OF PIPING TRENCH PRIOR TO INSTALLATION OF PIPE BEDDING MATERIAL OR PIPE. PLASTIC SHEETING SHALL EXTEND A MINIMUM OF 12-INCHES BEYOND THE WIDTH OF THE TRENCH ON EACH EDGE. PLASTIC SHEETING SEAMS WILL BE OVERLAPPED BY A MINIMUM OF 4-FEET.
3. PIPE BEDDING SHALL BE PLACED BY HAND IN MAXIMUM 6-INCH LIFTS TO THE DIMENSIONS INDICATED. EACH LIFT SHALL BE COMPACTED USING HAND TAMPING OR VIBRATORY PLACE DEVICE WITH A MINIMUM OF TWO FULL PASSES PER LIFT. THE BEDDING MATERIAL SHALL CONSIST OF SAND FILL MATERIAL.

PIPING

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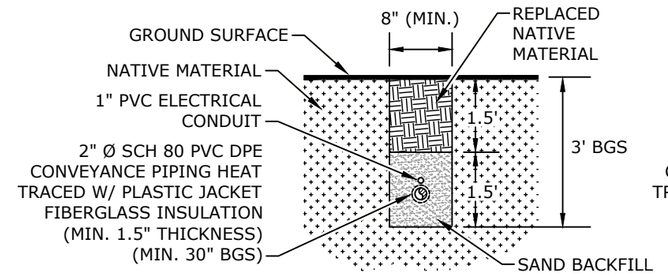
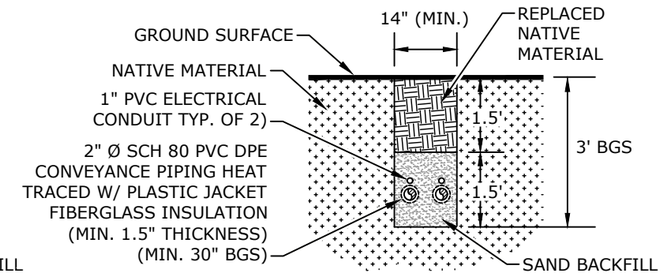
2. ALL SCH 80 PVC SHALL BE JOINED BY SOCKET WELD FITTINGS AND COUPLINGS UNLESS OTHERWISE INDICATED. ALL PVC PIPE FITTINGS AND COUPLES SHALL CONFORM TO ASTM D 3034.
3. ALL BELOW GRADE PIPING SHALL BE SLOPED ONE VERTICAL FOOT PER 500 LINEAR FEET FROM THE WELLHEAD TO THE DUAL-PHASE EXTRACTION REMEDIATION SYSTEM ENCLOSURE.



DPE CONVEYANCE PIPING CROSS-SECTION (1)

NOT TO SCALE



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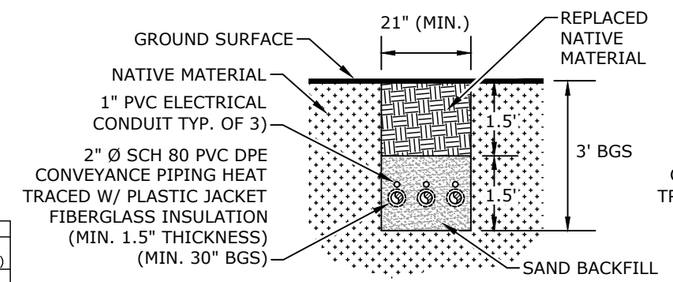

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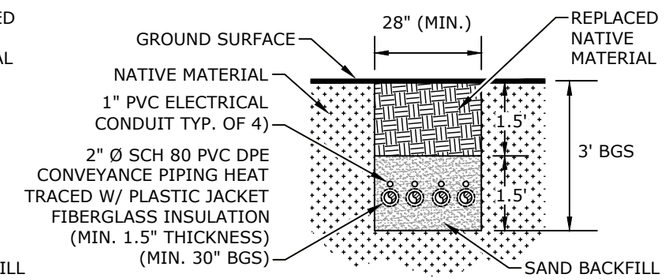

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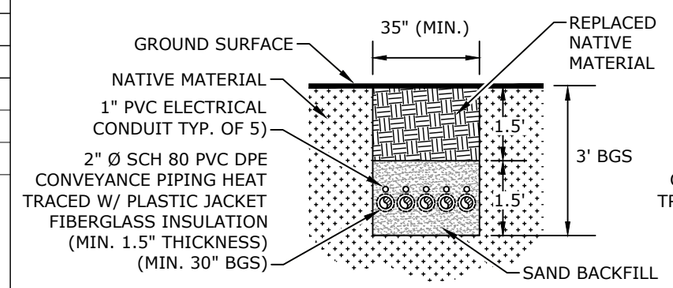

DPE CONVEYANCE PIPING CROSS-SECTION (5)

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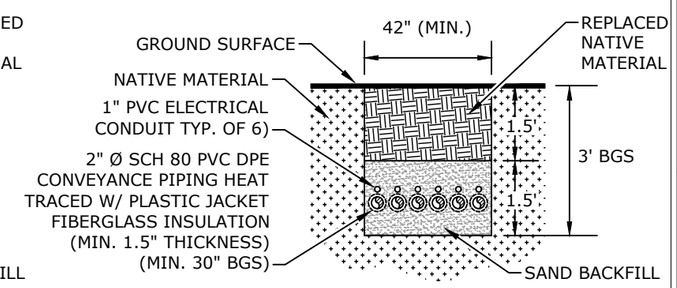

DPE CONVEYANCE PIPING CROSS-SECTION (6)

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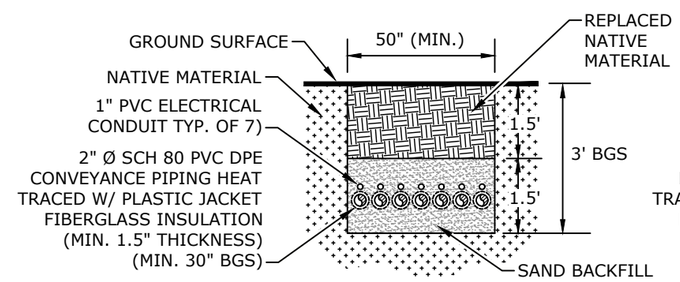

DPE CONVEYANCE PIPING CROSS-SECTION (7)

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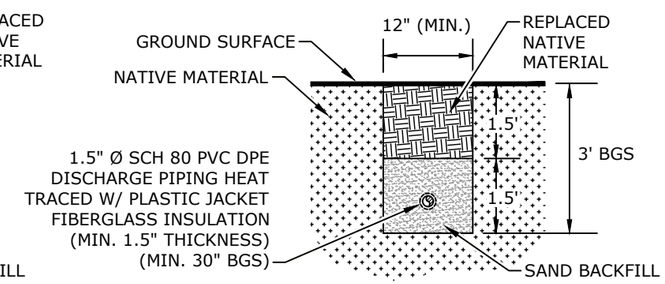


DPE DISCHARGE PIPING CROSS-SECTION (8)

NOT TO SCALE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Designs\03-Dual-Phase Extraction Conveyance Piping Details.dwg

DRAFTED BY: HJW | DATE: 8/18/2020

DESIGNED BY: AS/PL | APPROVED BY: ST

SIGNATURE | DATE

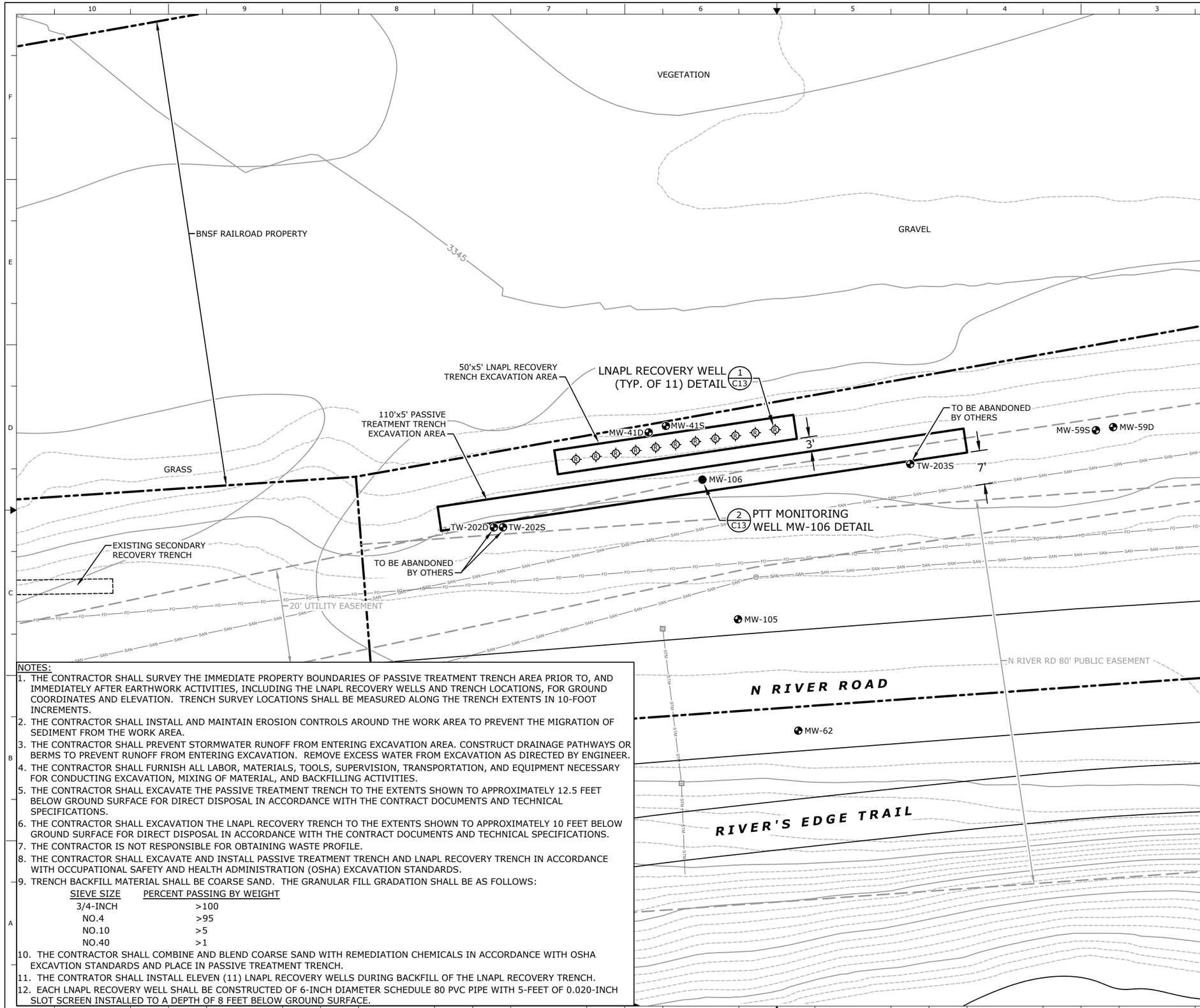
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

DUAL-PHASE EXTRACTION CONVEYANCE PIPING DETAILS

PROJECT# 1690014124-003

DRAWING **C9**



NOTES:

1. THE CONTRACTOR SHALL SURVEY THE IMMEDIATE PROPERTY BOUNDARIES OF PASSIVE TREATMENT TRENCH AREA PRIOR TO, AND IMMEDIATELY AFTER EARTHWORK ACTIVITIES, INCLUDING THE LNAPL RECOVERY WELLS AND TRENCH LOCATIONS, FOR GROUND COORDINATES AND ELEVATION. TRENCH SURVEY LOCATIONS SHALL BE MEASURED ALONG THE TRENCH EXTENTS IN 10-FOOT INCREMENTS.
2. THE CONTRACTOR SHALL INSTALL AND MAINTAIN EROSION CONTROLS AROUND THE WORK AREA TO PREVENT THE MIGRATION OF SEDIMENT FROM THE WORK AREA.
3. THE CONTRACTOR SHALL PREVENT STORMWATER RUNOFF FROM ENTERING EXCAVATION AREA. CONSTRUCT DRAINAGE PATHWAYS OR BERMS TO PREVENT RUNOFF FROM ENTERING EXCAVATION. REMOVE EXCESS WATER FROM EXCAVATION AS DIRECTED BY ENGINEER.
4. THE CONTRACTOR SHALL FURNISH ALL LABOR, MATERIALS, TOOLS, SUPERVISION, TRANSPORTATION, AND EQUIPMENT NECESSARY FOR CONDUCTING EXCAVATION, MIXING OF MATERIAL, AND BACKFILLING ACTIVITIES.
5. THE CONTRACTOR SHALL EXCAVATE THE PASSIVE TREATMENT TRENCH TO THE EXTENTS SHOWN TO APPROXIMATELY 12.5 FEET BELOW GROUND SURFACE FOR DIRECT DISPOSAL IN ACCORDANCE WITH THE CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS.
6. THE CONTRACTOR SHALL EXCAVATION THE LNAPL RECOVERY TRENCH TO THE EXTENTS SHOWN TO APPROXIMATELY 10 FEET BELOW GROUND SURFACE FOR DIRECT DISPOSAL IN ACCORDANCE WITH THE CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS.
7. THE CONTRACTOR IS NOT RESPONSIBLE FOR OBTAINING WASTE PROFILE.
8. THE CONTRACTOR SHALL EXCAVATE AND INSTALL PASSIVE TREATMENT TRENCH AND LNAPL RECOVERY TRENCH IN ACCORDANCE WITH OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) EXCAVATION STANDARDS.
9. TRENCH BACKFILL MATERIAL SHALL BE COARSE SAND. THE GRANULAR FILL GRADATION SHALL BE AS FOLLOWS:

SIEVE SIZE	PERCENT PASSING BY WEIGHT
3/4-INCH	>100
NO.4	>95
NO.10	>5
NO.40	>1

10. THE CONTRACTOR SHALL COMBINE AND BLEND COARSE SAND WITH REMEDIATION CHEMICALS IN ACCORDANCE WITH OSHA EXCAVTION STANDARDS AND PLACE IN PASSIVE TREATMENT TRENCH.
11. THE CONTRATOR SHALL INSTALL ELEVEN (11) LNAPL RECOVERY WELLS DURING BACKFILL OF THE LNAPL RECOVERY TRENCH.
12. EACH LNAPL RECOVERY WELL SHALL BE CONSTRUCTED OF 6-INCH DIAMETER SCHEDULE 80 PVC PIPE WITH 5-FEET OF 0.020-INCH SLOT SCREEN INSTALLED TO A DEPTH OF 8 FEET BELOW GROUND SURFACE.

LEGEND

- MONITORING WELL
- PROPOSED MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

0 20
SCALE IN FEET

DATE
SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C10_Passive Treatment Trench Plan.dwg

DRAFTED BY: HJW
DATE: 9/9/2020
DESIGNED BY: AS/PL
APPROVED BY: ST

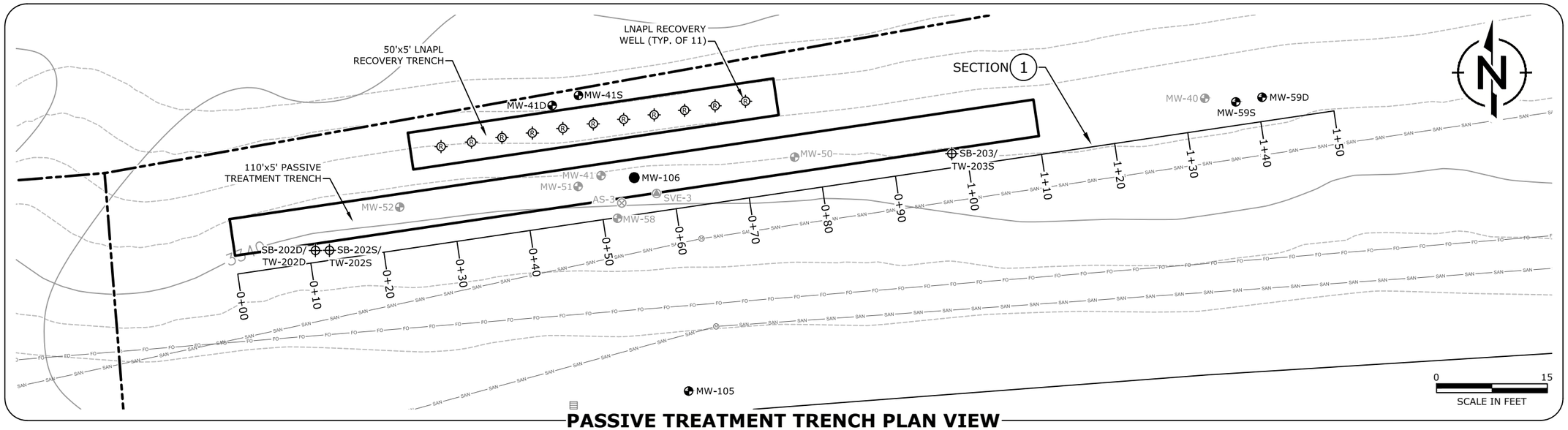
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

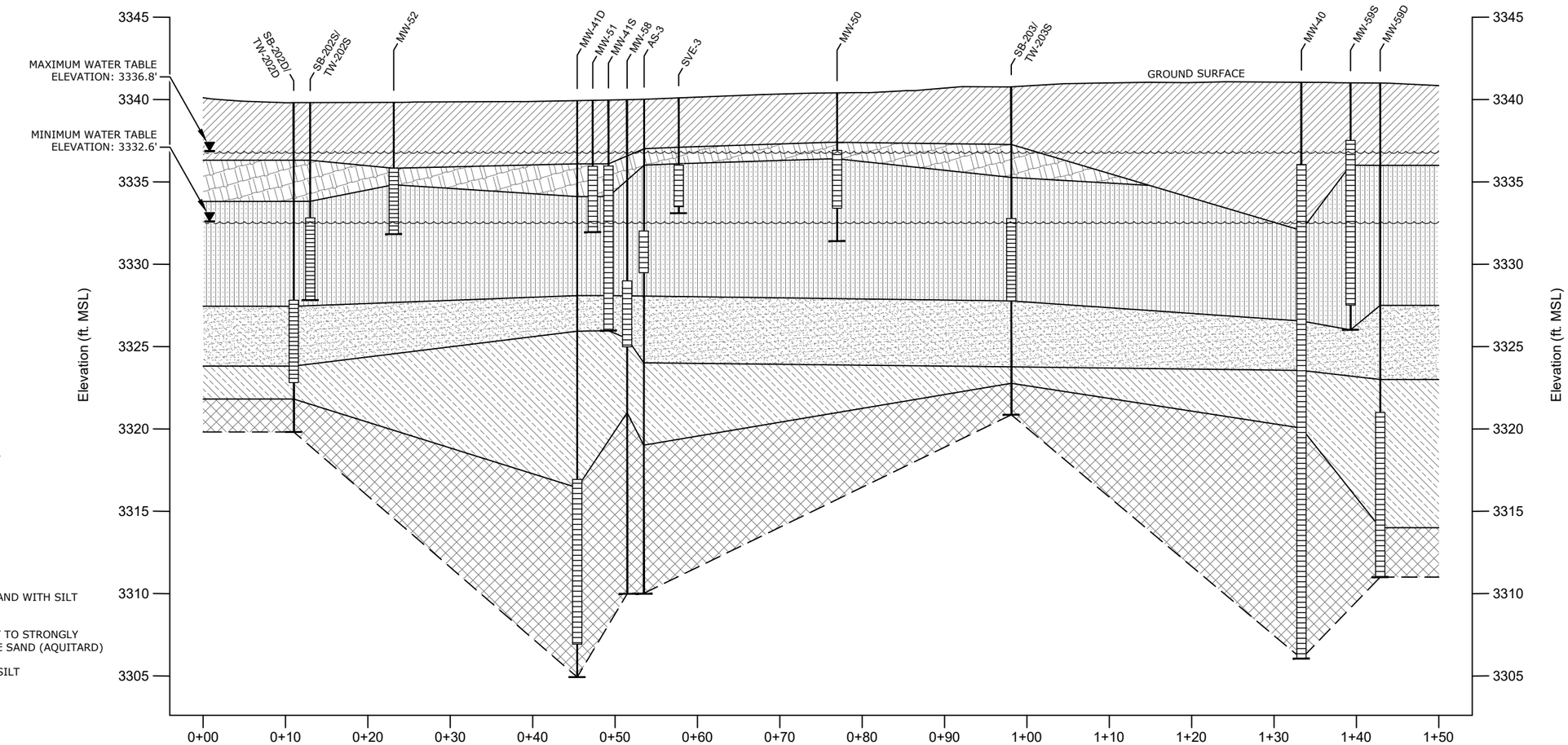
PASSIVE TREATMENT TRENCH PLAN

PROJECT # 1690014124-003

DRAWING
C10



PASSIVE TREATMENT TRENCH PLAN VIEW



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DRAFTED BY: HJW
DATE: 9/9/2020
DESIGNED BY: AS/PL
APPROVED BY: ST

DATE
SIGNATURE

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PASSIVE TREATMENT TRENCH AREA PRE-CONSTRUCTION GEOLOGIC CROSS-SECTION

PROJECT # 1690014124-003

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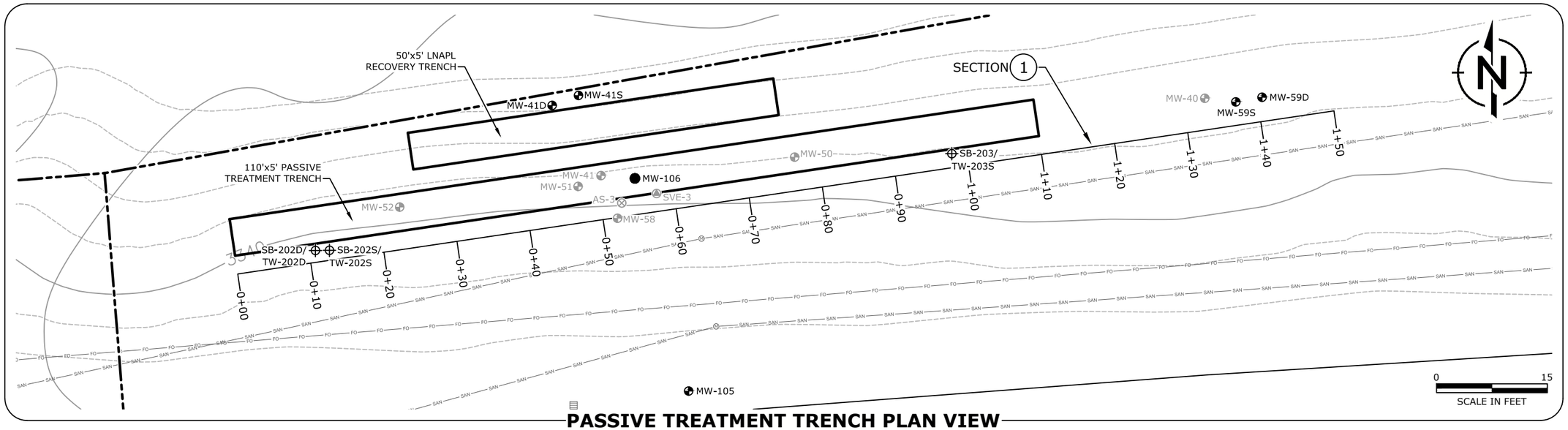
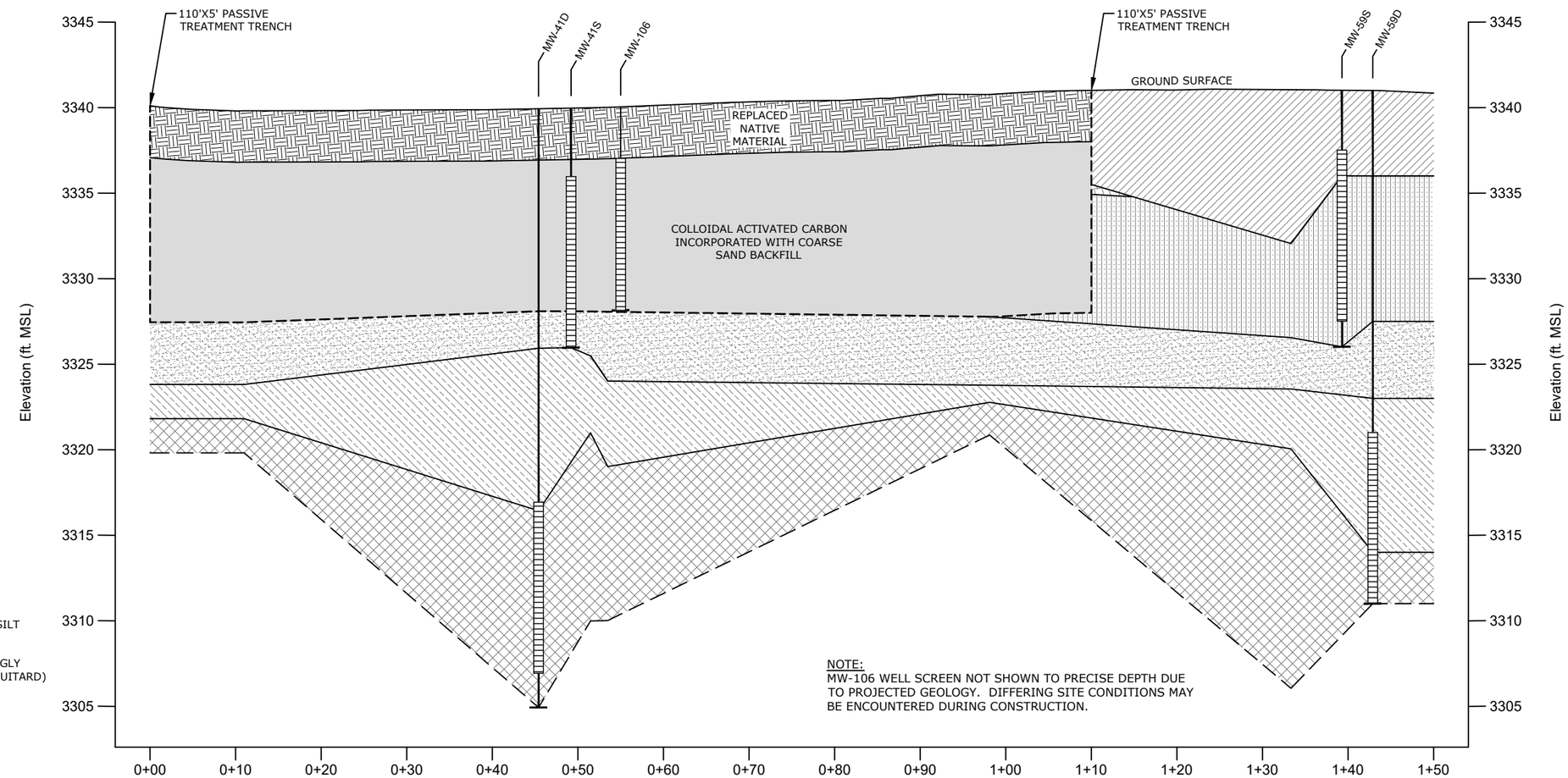


PASSIVE TREATMENT TRENCH PLAN VIEW



NOTE:
MW-106 WELL SCREEN NOT SHOWN TO PRECISE DEPTH DUE TO PROJECTED GEOLOGY. DIFFERING SITE CONDITIONS MAY BE ENCOUNTERED DURING CONSTRUCTION.

DATE

SIGNATURE

FILE LOCATION:
M:\CAD\1690014124-003_Calumet_AOC-16\100%
Design\C12-Passive Treatment Trench Cross-Sections
(Sheet 1 of 3).dwg

DESIGNED BY: AS/PL

DRAFTED BY: HJW

APPROVED BY: ST

DATE: 9/9/2020

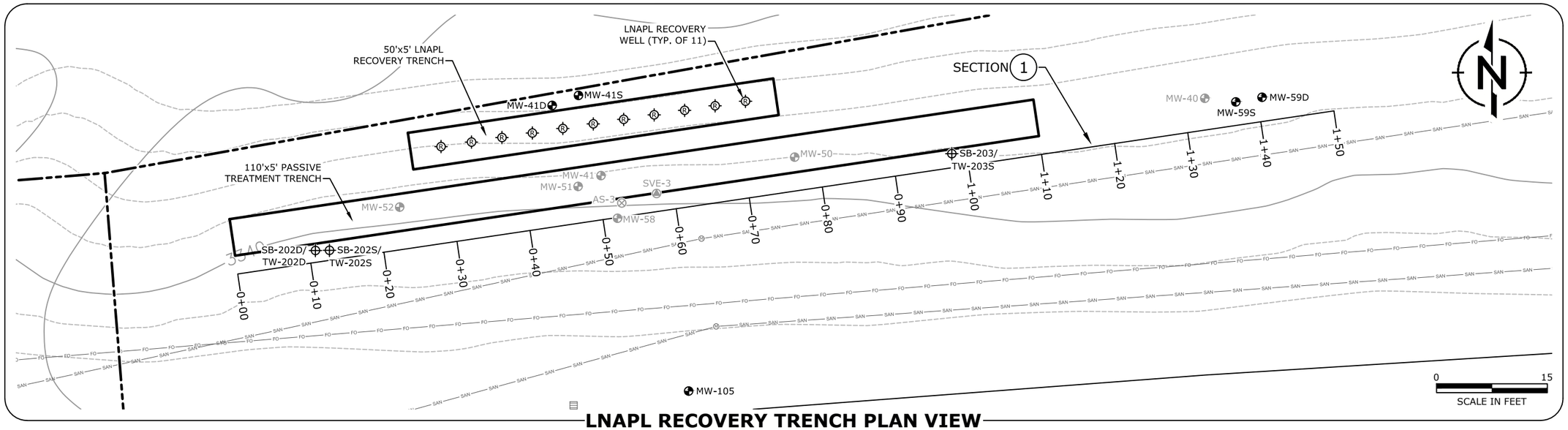
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

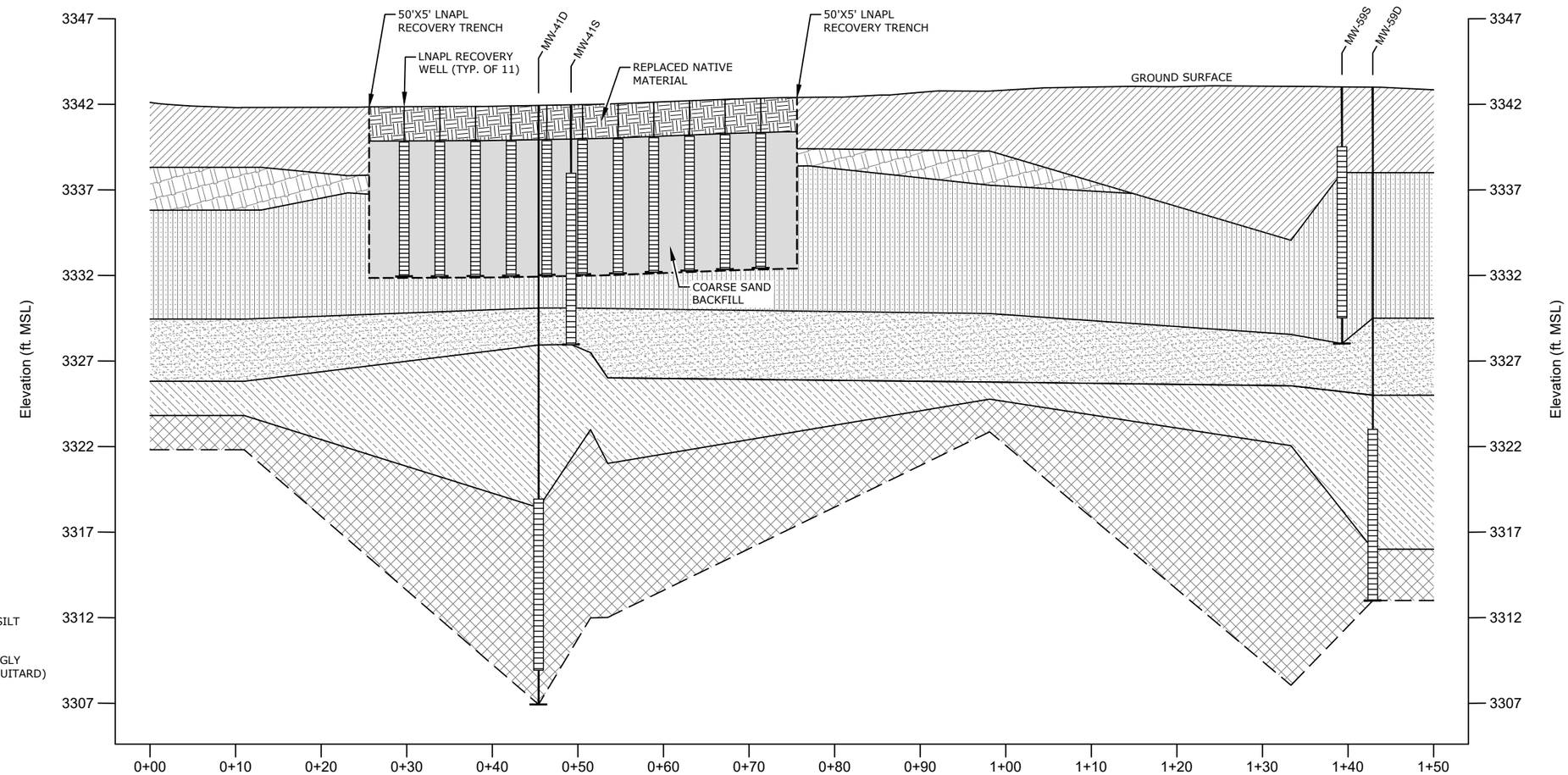
PASSIVE TREATMENT TRENCH CROSS-SECTIONS

PROJECT # 1690014124-003

DRAWING
C12
SHEET 1 OF 3



LNAPL RECOVERY TRENCH PLAN VIEW



LEGEND

- SAMPLE LOCATION
- END OF BORING
- LITHOLOGY CONTACT
- MONITORING WELL SCREEN INTERVAL
- UNIT 1: SILTY SAND (VADOSE ZONE)
- UNIT 2: SANDSTONE (VADOSE ZONE)
- UNIT 3: VERY FINE SAND WITH SILT (SHALLOW PERCHED)
- UNIT 4: MODERATELY TO STRONGLY CEMENTED VERY FINE SAND (AQUITARD)
- UNIT 5: DUSKY-RED SILT (AQUITARD)
- UNIT 6: GRAY SILT (SEMI-CONFINED)

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C12-Passive Treatment Trench Cross-Sections (Sheet 2 of 3).dwg

DRAFTED BY: HJW

DATE: 9/9/2020

DESIGNED BY: AS/PL

APPROVED BY: ST

DATE

SIGNATURE

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

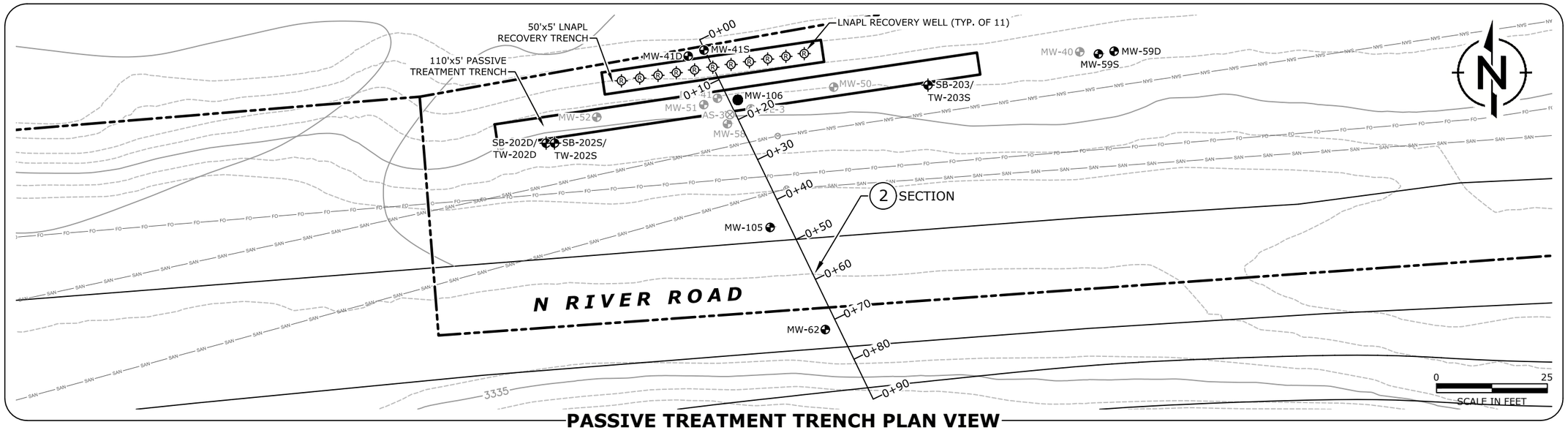
PASSIVE TREATMENT TRENCH CROSS-SECTIONS

PROJECT # 1690014124-003

DRAWING

C12

SHEET 2 OF 3

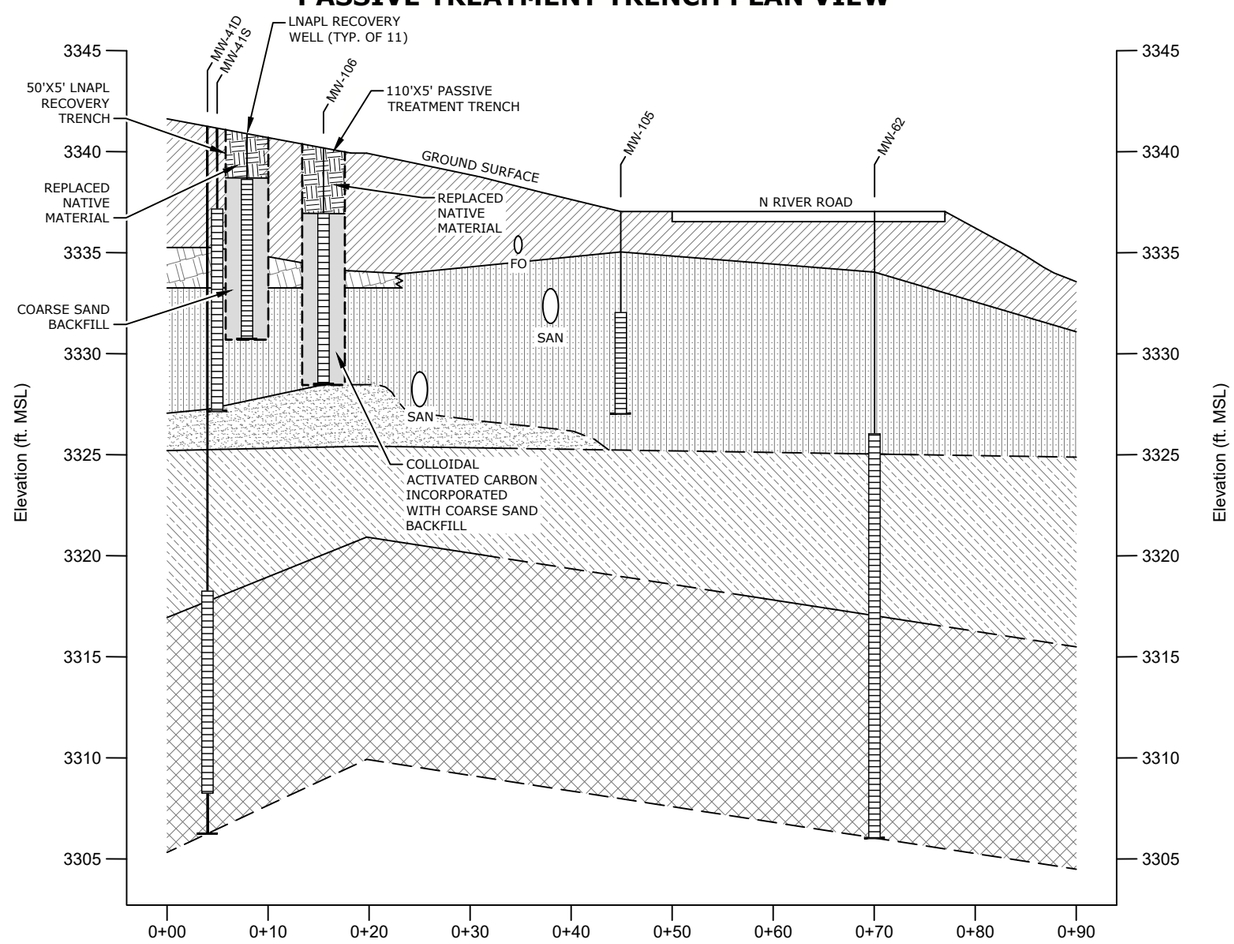


PASSIVE TREATMENT TRENCH PLAN VIEW

NOTE:
MW-106 WELL SCREEN NOT SHOWN TO PRECISE DEPTH DUE TO PROJECTED GEOLOGY. DIFFERING SITE CONDITIONS MAY BE ENCOUNTERED DURING CONSTRUCTION.

LEGEND

- SAMPLE LOCATION
- END OF BORING
- LITHOLOGY CONTACT
- INFERRED LITHOLOGY UNIT BOUNDARY
- MONITORING WELL SCREEN INTERVAL
- UNIT 1: SILTY SAND (VADOSE ZONE)
- UNIT 2: SANDSTONE (VADOSE ZONE)
- UNIT 3: VERY FINE SAND WITH SILT (SHALLOW PERCHED)
- UNIT 4: MODERATELY TO STRONGLY CEMENTED VERY FINE SAND (AQUITARD)
- UNIT 5: DUSKY-RED SILT (AQUITARD)
- UNIT 6: GRAY SILT (SEMI-CONFINED)
- SAN — SANITARY SEWER
- FO — FIBER OPTIC



FILE LOCATION:
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DESIGNED BY: AS/PL
DRAFTED BY: HJW
DATE: 9/9/2020
APPROVED BY: ST

DATE
SIGNATURE

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
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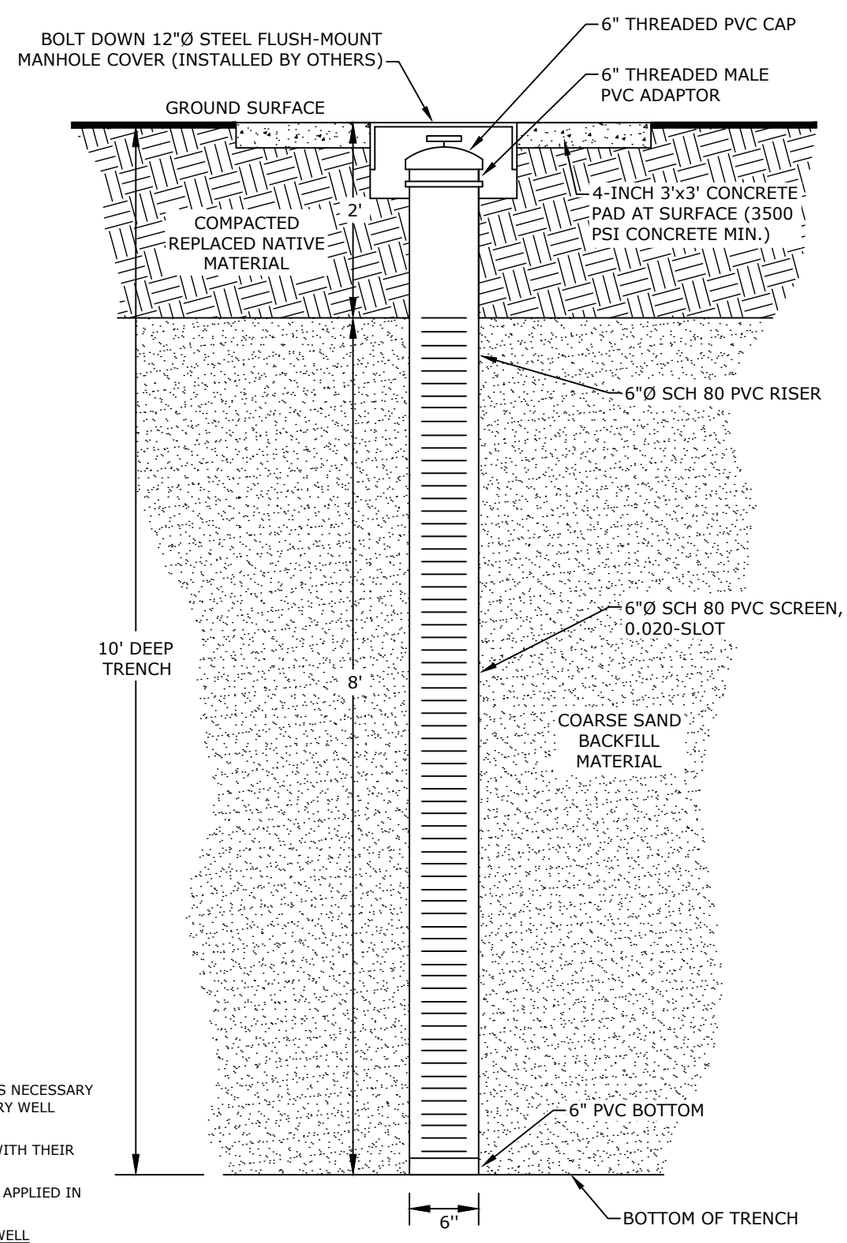
PASSIVE TREATMENT TRENCH CROSS-SECTIONS

PROJECT # 1690014124-003

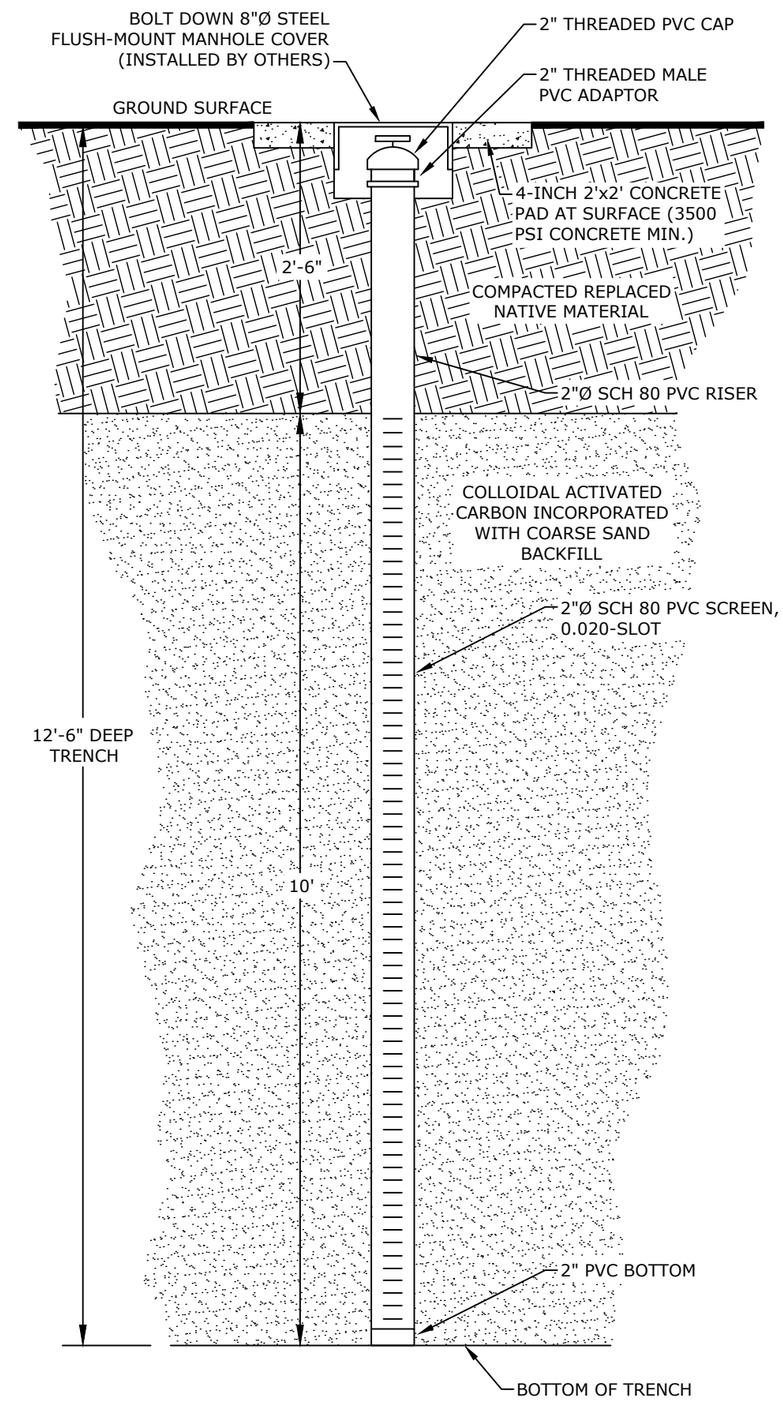
DRAWING
C12
SHEET 3 OF 3



TYPICAL LNAPL RECOVERY WELL DETAIL

1

NOT TO SCALE



PASSIVE TREATMENT TRENCH MONITORING WELL MW-106 DETAIL

2

NOT TO SCALE

NOTES:

GENERAL

1. CONTRACTOR SHALL FURNISH ALL LABOR, EQUIPMENT, AND MATERIALS NECESSARY FOR TRENCHING, BACKFILLING, AND INSTALLATION OF LNAPL RECOVERY WELL PIPING IN ACCORDANCE WITH THESE DESIGN DRAWINGS.
2. ALL PRODUCTS, EQUIPMENT, AND MATERIALS SHALL BE COMPATIBLE WITH THEIR INTENDED USE AS SHOWN IN THE DRAWINGS.
3. ALL PRODUCTS, EQUIPMENT, AND MATERIALS SHALL BE INSTALLED OR APPLIED IN ACCORDANCE WITH MANUFACTURER INSTRUCTIONS.

LNAPL RECOVERY WELLS AND PASSIVE TREATMENT TRENCH MONITORING WELL

1. ALL LNAPL RECOVERY WELLS AND PASSIVE TREATMENT TRENCH WELL TO BE INSTALLED BY CONTRACTOR DURING BACKFILLING ACTIVITIES.
2. ALL LNAPL RECOVERY WELL MATERIALS SHALL BE 6"Ø SCH 80 PVC OR APPROVED EQUIVALENT. LNAPL WELL SCREEN SHALL BE 6"Ø SCH 80 PVC OR APPROVED EQUIVALENT, 0.020-INCH SLOT.
3. PASSIVE TREATMENT TRENCH MONITORING WELL SHALL BE 2"Ø SCH 80 PVC OR APPROVED EQUIVALENT. PASSIVE TREATMENT MONITORING WELL SCREEN SHALL BE 2"Ø SCH 80 PVC OR APPROVED EQUIVALENT, 0.020-INCH SLOT.
4. PASSIVE TREATMENT TRENCH MONITORING WELL WILL BE COMPLETED AT THE SURFACE WITH A BOLT DOWN 12-INCH DIAMETER STEEL FLUSH-MOUNT MANHOLE COVER SET IN A 3-FEET BY 3-FEET SQUARE CONCRETE PAD.
5. LNAPL RECOVERY WELLS WILL BE COMPLETED AT THE SURFACE WITH A BOLT DOWN 8-INCH DIAMETER STEEL FLUSH-MOUNT MANHOLE COVER SET IN A 2-FEET BY 2-FEET SQUARE CONCRETE PAD.

DATE

SIGNATURE

FILE LOCATION:
M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C13_Passive Treatment Trench Well Details.dwg

DRAFTED BY: HJW

DATE: 9/9/2020

DESIGNED BY: AS/PL

APPROVED BY: ST

RAMBOLL

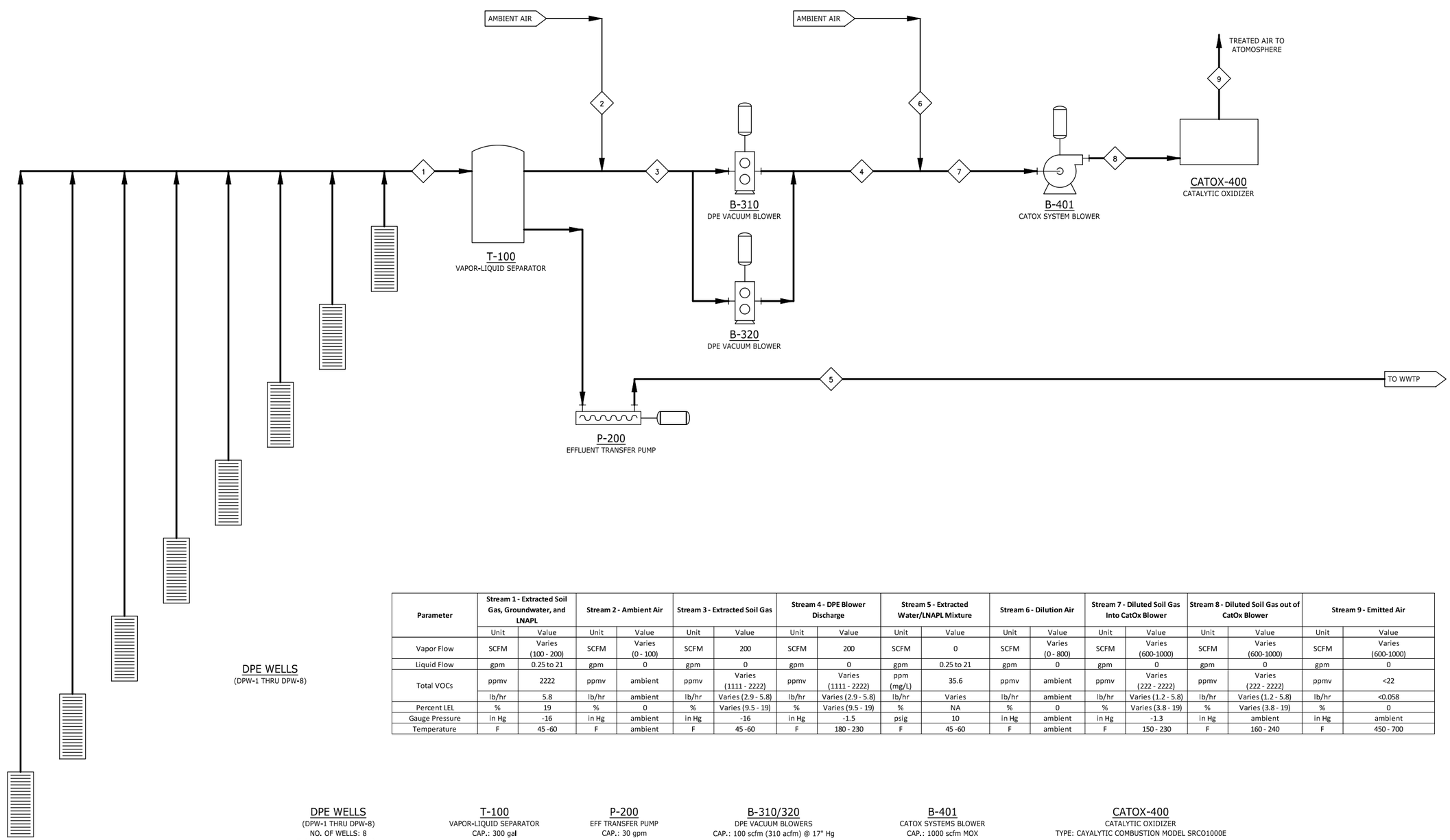
AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PASSIVE TREATMENT TRENCH WELL DETAILS

PROJECT # 1690014124-003

DRAWING

C13



Parameter	Stream 1 - Extracted Soil Gas, Groundwater, and LNAPL		Stream 2 - Ambient Air		Stream 3 - Extracted Soil Gas		Stream 4 - DPE Blower Discharge		Stream 5 - Extracted Water/LNAPL Mixture		Stream 6 - Dilution Air		Stream 7 - Diluted Soil Gas Into CatOx Blower		Stream 8 - Diluted Soil Gas out of CatOx Blower		Stream 9 - Emitted Air	
	Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value
Vapor Flow	SCFM	Varies (100 - 200)	SCFM	Varies (0 - 100)	SCFM	200	SCFM	200	SCFM	0	SCFM	Varies (0 - 800)	SCFM	Varies (600-1000)	SCFM	Varies (600-1000)	SCFM	Varies (600-1000)
Liquid Flow	gpm	0.25 to 21	gpm	0	gpm	0	gpm	0	gpm	0.25 to 21	gpm	0	gpm	0	gpm	0	gpm	0
Total VOCs	ppmv	2222	ppmv	ambient	ppmv	Varies (1111 - 2222)	ppmv	Varies (1111 - 2222)	ppm (mg/L)	35.6	ppmv	ambient	ppmv	Varies (222 - 2222)	ppmv	Varies (222 - 2222)	ppmv	<22
	lb/hr	5.8	lb/hr	ambient	lb/hr	Varies (2.9 - 5.8)	lb/hr	Varies (2.9 - 5.8)	lb/hr	Varies	lb/hr	ambient	lb/hr	Varies (1.2 - 5.8)	lb/hr	Varies (1.2 - 5.8)	lb/hr	<0.058
Percent LEL	%	19	%	0	%	Varies (9.5 - 19)	%	Varies (9.5 - 19)	%	NA	%	0	%	Varies (3.8 - 19)	%	Varies (3.8 - 19)	%	0
Gauge Pressure	in Hg	-16	in Hg	ambient	in Hg	-16	in Hg	-1.5	psig	10	in Hg	ambient	in Hg	-1.3	in Hg	ambient	in Hg	ambient
Temperature	F	45 -60	F	ambient	F	45 -60	F	180 - 230	F	45 -60	F	ambient	F	150 - 230	F	160 - 240	F	450 - 700

DPE WELLS
(DPW-1 THRU DPW-8)
NO. OF WELLS: 8
FLOW PER WELL: 25 scfm
LIQUID PROD RATE: 0.24-21 gpm

T-100
VAPOR-LIQUID SEPARATOR
CAP.: 300 gal

P-200
EFF TRANSFER PUMP
CAP.: 30 gpm

B-310/320
DPE VACUUM BLOWERS
CAP.: 100 scfm (310 acfm) @ 17" Hg

B-401
CATOX SYSTEMS BLOWER
CAP.: 1000 scfm MOX
SIZE: TBD

CATOX-400
CATALYTIC OXIDIZER
TYPE: CAYALYTIC COMBUSTION MODEL SRCO1000E
MAX AIR FLOW: ~1000 scfm
VOC DESTRUCTION EFF: 99%
OUTLET OPER. TEMP.: 1160°F

FILE LOCATION:
M:\CAD\1690014124-003_Calumet_AOC-16\100%
Design\P&IDs\PFD-01_CALUMET MONTANA
REFINING_1690014124.dwg

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DRAFTED BY: LTE
APPROVED BY: SWT
DATE: 9/30/2020

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PROCESS FLOW DIAGRAM

PROJECT# 1690014124-003

DRAWING
PFD-01

PIPE MATERIAL ABBREVIATIONS

CS	CARBON STEEL
PVC	POLYVINYL CHLORIDE
SSA	STAINLESS STEEL 304
SS6	STAINLESS STEEL 316
HDPE	HIGH DENSITY POLYETHELYNE
DI	DUCTILE IRON
GS	GALVANIZED STEEL
CU	COPPER
VC	VITROUS CLAY
FRP	FIBERGLASS
PE	POLYETHLENE

LINE SERVICE CODE

AIR	AMBIENT AIR
AV	ATMOSPHERIC VENT
BA	BREATHING AIR
BD	BLOWDOWN
BFW	BOILER FEED WATER
BRR	BRINE RETURN
BRS	BRINE SUPPLY
CA	COMPRESSED AIR
CC	CONTAMINATED CONDENSATE
CF	COLD FLARE
CHS	CHEMICAL SEWER
CV	COLD VENT
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
DMW	DEMINERALIZED WATER
DR	DRAIN
DS	DILUTION STEAM
DW	DRINKING WATER
ER	ETHYLENE REFRIGERANT
FF	FLUSHING FLUID
FG	FUEL GAS
FO	FUEL OIL
FW	FIRE WATER
GLR	GLYCOL RETURN
GLS	GLYCOL SUPPLY
H	HYDROGEN
HS	HIGH PRESSURE STEAM
IA	INSTRUMENT AIR
IS	INTERMEDIATE PRESSURE STEAM
LNG	LIQUIFIED NATURAL GAS
LO	LUBE OIL
LPG	LIQUIFIED PETROLEUM GAS
LS	LOW PRESSURE STEAM
ME	METHANOL
MR	MIXED REFRIGERANT
MS	MEDIUM PRESSURE STEAM
N	NITROGEN
NA	CAUSTIC
NAS	CAUSTIC SEWER
NG	NATURAL GAS
NH	AMMONIA
NPW	NON POTABLE WATER
OWS	OILY WATER SEWER
OX	OXYGEN
P	GENERAL PROCESS
PA	PLANT AIR
PC	PROCESS CONDENSATE
PR	PROPYLENE REFRIGERANT
PW	PROCESS WATER
QO	QUENCH OIL
RS	RECOVERED SLOPS
RV	RELIEF VENT
RW	RAW WATER
SC	STEAM CONDENSATE
SG	SYNTHESIS GAS
SO	SEAL OIL
SS	SANITARY SEWER
STS	STORM SEWER
SV	SOIL VAPORS
SW	SERVICE WATER
SWR	SEA WATER RETURN
SWS	SEA WATER SUPPLY
TS	SODIUM THIOSULFATE
VAC	VACUUM

PIPING LINES

- PRIMARY PIPING
- PRIMARY PIPING EXISTING
- SECONDARY PIPING
- SECONDARY PIPING EXISTING
- UTILITY PIPING

SIGNAL LINES

- ELECTRICAL SIGNAL ANALOG
- ELECTRICAL SIGNAL BINARY/DISCRETE
- PNEUMATIC SIGNAL
- SOFTWARE SIGNAL
- SONIC SIGNAL

EQUIPMENT LINES

- EQUIPMENT
- EQUIPMENT EXISTING
- EQUIPMENT VENDOR PACKAGE

MISCELLANEOUS LINES

- CAPILARY
- HYDRAULIC
- MECHANICAL LINK
- TUBING
- WATER ELEVATION

INSULATED PIPING CODE

- XX — PIPING INSULATED
- XX — PIPING INSULATED AND TRACED

AC	ACOUSTIC CONTROL INSULATION
CC	COLD SERVICE INSULATION
CJ	CHILLED FLUID JACKETED
CP	CONDENSATION CONTROL
CT	CHILLED FLUID TRACED
ES	INSTRUMENT ELECTRIC POWER SUPPLY
ET	ELECTRIC TRACED
FP	FIRE PROTECTION INSULATION
HC	HEAT CONSERVATION INSULATION
HJ	HOT FLUID JACKETING
HT	HOT FLUID TRACED
PF	PREVENTION FROM FREEZING INSULATION
PP	PERSONAL PROTECTION INSULATION
PS	PROCESS STABILITY INSULATION
SJ	STEAM JACKETED
ST	STEAM TRACED

FLOW DIRECTION ARROW

PROCESS/PAGE CONNECTOR

DESCRIPTION 1
DESCRIPTION 2
PID TO/FROM # XXXXX
DESCRIPTION 3
DESCRIPTION 4

DESCRIPTION 1
DESCRIPTION 2
XXXXX PID TO/FROM #
DESCRIPTION 3
DESCRIPTION 4

INSTRUMENT#

INSTRUMENT#

LINE DATA IDENTIFICATION

LINE SIZE (NUMERIC)		PIPE MAT'L (ALPHA)		SERVICE (ALPHA)		SEQUENCE (NUMERIC)
XX	–	XXX	–	XXX	–	XXXX

OPEN DRAIN

CONNECTOR NUMBER — XXXXX
DESTINATION — YYY
LINE SERVICE CODE — P&ID NO

CLOSED DRAIN

CONNECTOR NUMBER — XXXXX
DESTINATION — YYY
LINE SERVICE CODE — P&ID NO

VALVE SYMBOLS

- GATE
- CHECK
- STOP CHECK
- GLOBE
- BUTTERFLY
- NEEDLE
- BALL
- PLUG
- DIAPHRAGM
- 3–WAY
- 4–WAY
- PINCH
- ANGLE
- FLOAT
- HAND
- KNIFE

PIPE FITTING SYMBOLS

- FLANGE
- BLIND FLANGE
- CONCENTRIC (OR GENERIC) REDUCER
- ECCENTRIC REDUCER
- CHEMICAL SEAL
- PLUG
- CAP
- HOSE CONNECTION
- WELDED CONNECTION
- SPACER
- BLANK
- OPEN FIGURE 8 BLIND
- CLOSED FIGURE 8 BLIND

PIPE SPECIALTY SYMBOLS

- EXCESS FLOW VALVE
- DIVERTER
- ROTARY

PIPE SPECIALTY SYMBOLS CONT.

- Y–TYPE STRAINER
- CONE STRAINER
- T–TYPE STRAINER
- DUPLEX STRAINER
- BASKET STRAINER
- TEMPORARY STRAINER
- FILTER
- D — DETONATION ARRESTOR
- F — FLAME ARRESTOR
- DT — DRIP TRAP
- T — STEAM TRAP
- WATER TRAP
- EXHAUST HEAD
- S — IN–LINE SILENCER
- S — VENT SILENCER
- EJECTOR/EDUCTOR
- RS — REMOVALBLE SPOOL
- DS — DESUPERHEATER
- FLEXIBLE HOSE
- EXPANSION JOINT
- DAMPER
- BREATHER
- VENT COVER
- IN–LINE MIXER
- STATIC MIXER
- CLEANOUT
- PULSATION DAMPENER
- CALIBRATION COLUMN
- OPEN VENT CAP

CONTROL VALVE ACTUATOR SYMBOLS

- MANUAL OPERATOR
- DIAPHRAGM
- PRESSURE BALANCED DIAPHRAGM
- HANDWHEEL – USED WITH ANY ACTUATOR
- CYLINDER/PISTON
- M — MOTOR OPERATED
- E/H — ELECTRO–HYDRAULIC
- S — SOLENOID
- S R — SOLENOID RESET

SELF–ACTUATED DEVICE SYMBOLS

- PRESSURE RELIEF RUPTURE DISC
- VACUUM RELIEF RUPTURE DISC
- PRESSURE RELIEF VALVE
- VACUUM RELIEF VALVE
- PRESSURE AND VACUUM RELIEF VALVE
- PRESSURE REDUCING REGULATOR
- BACK PRESSURE REGULATOR
- BACK PRESSURE REGULATOR WITH EXTERNAL TAP
- PRESSURE REDUCING REGULATOR WITH EXTERNAL TAP
- DIFFERENTIAL PRESSURE REDUCING REGULATOR
- TEMPERATURE REGULATOR FILLED SYTEM TYPE

PRIMARY FLOW ELEMENT SYMBOLS

- XX — GENERAL SYMBOL IN–LINE ELEMENT XX = FS, FG, FE, FT
- ORIFICE
- M — MAGNETIC
- D — DENSITY
- TURBINE OR PROPELLER
- ULTRASONIC
- VORTEX
- PITOT TUBE
- AVERAGING PITOT TUBE
- FLOW NOZZLE
- VENTURI
- WEDGE METER
- FLUME
- WEIR
- POSITIVE DISPLACEMENT
- ORIFICE IN QUICK CHANGE FITTING
- h — TARGET
- FLOW CONDITIONING DEVICE (e.g. STRAIGHTENING VANES)
- FE — ROTOMETER

UTILITY SYMBOLS

PA	PLANT AIR
IA	INSTRUMENT AIR
SW	SERVICE WATER
NG	NATURAL GAS
PW	POTABLE WATER

DATE
SIGNATURE

FILE LOCATION:
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Design\169001014124-003-LCBD_CALUMET MONANTA
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DUAL-PHASE EXTRACTION AND
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CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

DRAWING
PID-01

INSTRUMENTATION LEGEND

	FIRST LETTER		SUCCEEDING–LETTERS		
	MEASURED OR INITIATING VARIBLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION				
C	CONDUCTIVITY			CONTROL	
D	DENSITY OR MASS	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G	GAGING (DIMENSIONAL)		GLASS, VIEWING DEVICE		
H	HAND				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	MOISTURE OR HUMIDITY	MOMENTARY			MIDDLE INTERMEDIATE
N					
O			ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIBLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

INSTRUMENT SYMBOLS

LOCATION/ACCESSIBILITY	DISCRETE INSTRUMENTS	SHARED DISPLAY AND CONTROL (DCS)	PLC	DISCRETE HARDWARE INTERLOCK
FIELD MOUNTED 1. FIELD OR LOCALLY MOUNTED. 2. ACCESSIBLE TO AN OPERATOR AT DEVICE.				
PRIMARY LOCATION NORMALLY ACCESSIBLE TO AN OPERATOR 1. CENTRAL OR MAIN CONTROL ROOM. 2. FRONT OF MAIN PANEL OR CONSOLE MOUNTED. 3. VISIBLE ON VIDEO DISPLAY. 4. ACCESSIBLE TO AN OPERATOR AT DEVICE OR CONSOLE.				
PRIMARY LOCATION NORMALLY INACCESSIBLE TO AN OPERATOR 1. CENTRAL OR MAIN CONTROL ROOM. 2. REAR OF PANEL OR CABINET MOUNTED. 3. NOT VISIBLE ON VIDEO DISPLAY. 4. NOT NORMALLY ACCESSIBLE TO AN OPERATOR AT DEVICE OR CONSOLE.				
AUXILIARY LOCATION NORMALLY ACCESSIBLE TO AN OPERATOR 1. SECONDARY OR LOCAL CONTROL ROOM. 2. FIELD OR LOCAL CONTROL PANEL. 3. FRONT OF SECONDARY OR LOCAL PANEL MOUNTED. 4. VISIBLE ON VIDEO DISPLAY. 5. ACCESSIBLE TO AN OPERATOR AT DEVICE OR CONSOLE.				
AUXILIARY LOCATION NORMALLY INACCESSIBLE TO AN OPERATOR 1. SECONDARY OR LOCAL CONTROL ROOM. 2. FIELD OR LOCAL CONTROL PANEL. 3. REAR OF SECONDARY OR LOCAL PANEL OR CABINET MOUNTED. 4. NOT VISIBLE ON VIDEO DISPLAY. 5. NOT NORMALLY ACCESSIBLE TO AN OPERATOR AT DEVICE OR CONSOLE.				

MISCELLANEOUS INSTRUMENT SYMBOLS

PILOT LIGHT OR GAUGE GLASS ILLUMINATOR

DUAL FUNCTION OR INSTRUMENTS SHARING COMMON HOUSING

UNDEFINED INTERLOCK LOGIC

FC 1230–99 — INSTRUMENT WITH LONG TAG NUMBER

MISCELLANEOUS SYMBOLS

VFD	VARIABLE FREQUENCY DRIVE
MCC	MOTOR CONTROL CENTER
	LEVEL SWITCH
XX	NOTE REFERENCE SYMBOL (XX = NOTE NUMBER, ROTATE ARROW AS REQUIRED)
UNASSIGNED1 UNASSIGNED2	POINT OF CHANGE (LINE CLASS OR INSULATION REQUIREMENT)
P XXXX	PURGE CONNECTION (XXXX = PURGE PRESSURE AND MEDIUM)
SC XX/YY	SAMPLE CONNECTION (XX/YY = TYPE/NUMBER)
T XXXX	TIE POINT CONNECTION (XXXX = IDENTIFICATION NUMBER)
	WATER LEVEL
	LINE BREAK
	FLOW ARROW
	SLOPE
HOA	HAND–OFF–AUTO
DEV	DEVIATION
LEL	LOWER EXPLOSIVE LIMIT

FUNCTIONAL ELEMENT SYMBOLS

Σ	SUMMING
Σ/n	AVERAGING
Δ	DIFFERENCE
X	MULTIPLYING
÷	DIVIDING
√	SQUARE ROOT
X^n	EXPONENTIAL
I/O	CONVERSION INPUT/OUTPUT
>	HIGH SELECT
<	LOW SELECT
	HIGH LIMIT
	LOW LIMIT
±	BIAS
f(x)	UNSPECIFIED FUNCTION
AND	AND INTERLOCK
OR	OR INTERLOCK

PUMPS

HORIZONTAL CENTRIFUGAL PUMP

POSITIVE DISPLACEMENT PUMP

AIR DIAPHRAGM PUMP

VACUUM PUMP

VERTICAL INLINE PUMP

LIQUID RING VACUUM PUMP

SUBMERSIBLE PUMP

CENTRIFUGAL SUMP PUMP

VERTICAL CAN PUMP

VERTICAL TURBINE PUMP

PROGRESSIVE CAVITY PUMP

SCREW PUMP

METERING PUMP

BLOWERS

POSITIVE DISPLACEMENT BLOWER

CENTRIFUGAL BLOWER

COMPRESSORS

CENTRIFUGAL COMPRESSOR

RECIPROCATING COMPRESSOR

SCREW COMPRESSOR

DRIVERS

ELECTRIC MOTOR

TURBINE DRIVER

DIESEL ENGINE

AGITATORS

MIXER

FLOC PADDLE

FANS

CENTRIFUGAL FAN

EXHAUST FAN

FILTERS

VACUUM FILTER

HEAT EXCHANGERS

HEAT EXCHANGER

MISC. EQUIPMENT

ELECTRIC HEATER

ELECTRIC HEATER

AIR INTAKE FILTER/SILENCER

FLAME ARRESTOR

CATALYST REACTOR

FILE LOCATION:
M:\CAD\1690014124-003_CalumetAOC-16\100%
Design\PID\01-PID-PFD\1690014124-CBBD_CALUMET MONANTA
REFINING_1690014124.dwg

DRAFTED BY: LTE
DATE: 9/30/2020
DESIGNED BY: SWT
APPROVED BY: SWT

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

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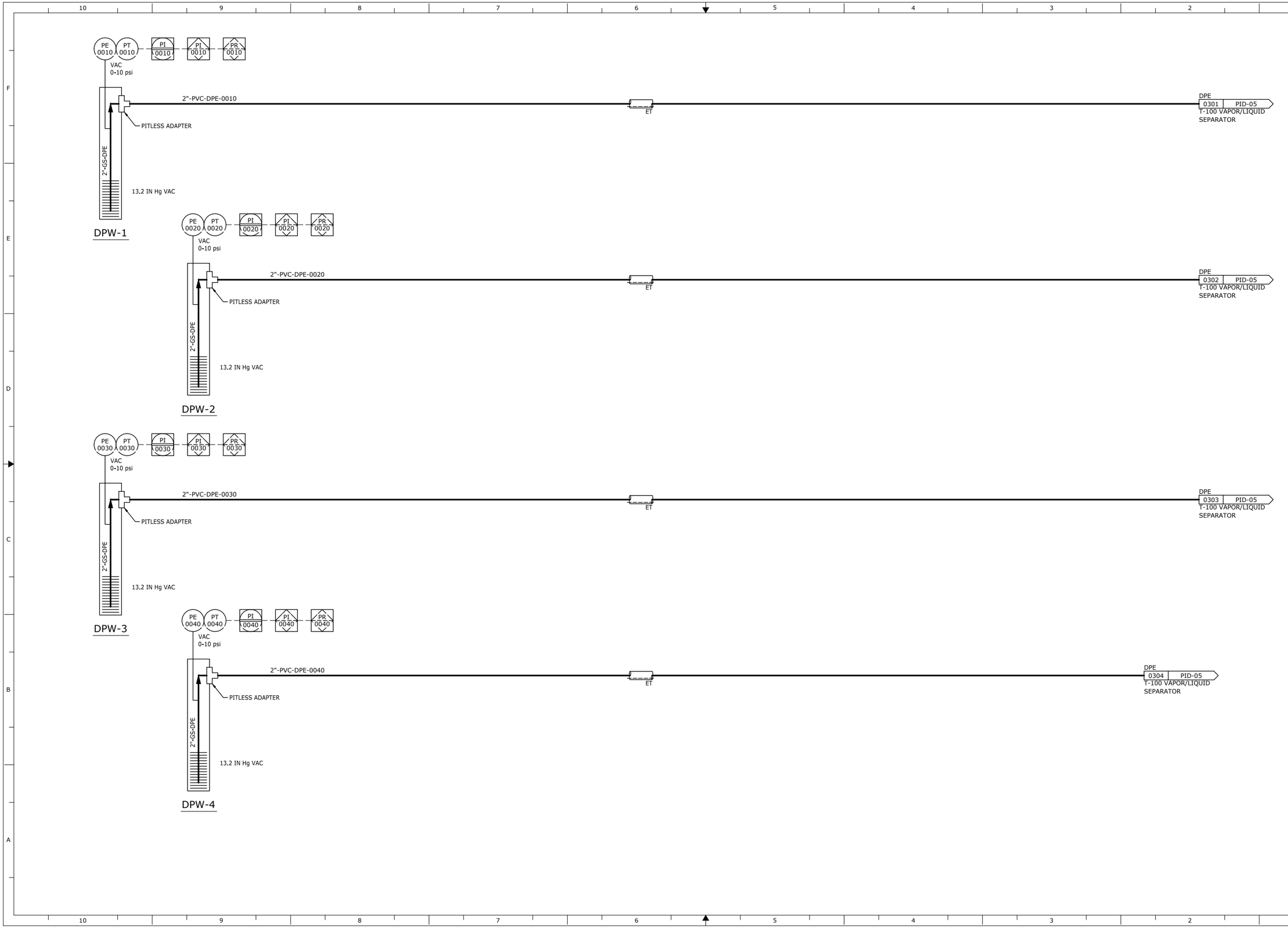
PID-02



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DESIGNED BY: SWT
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APPROVED BY: SWT
DATE: 9/30/2020

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DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

DRAWING
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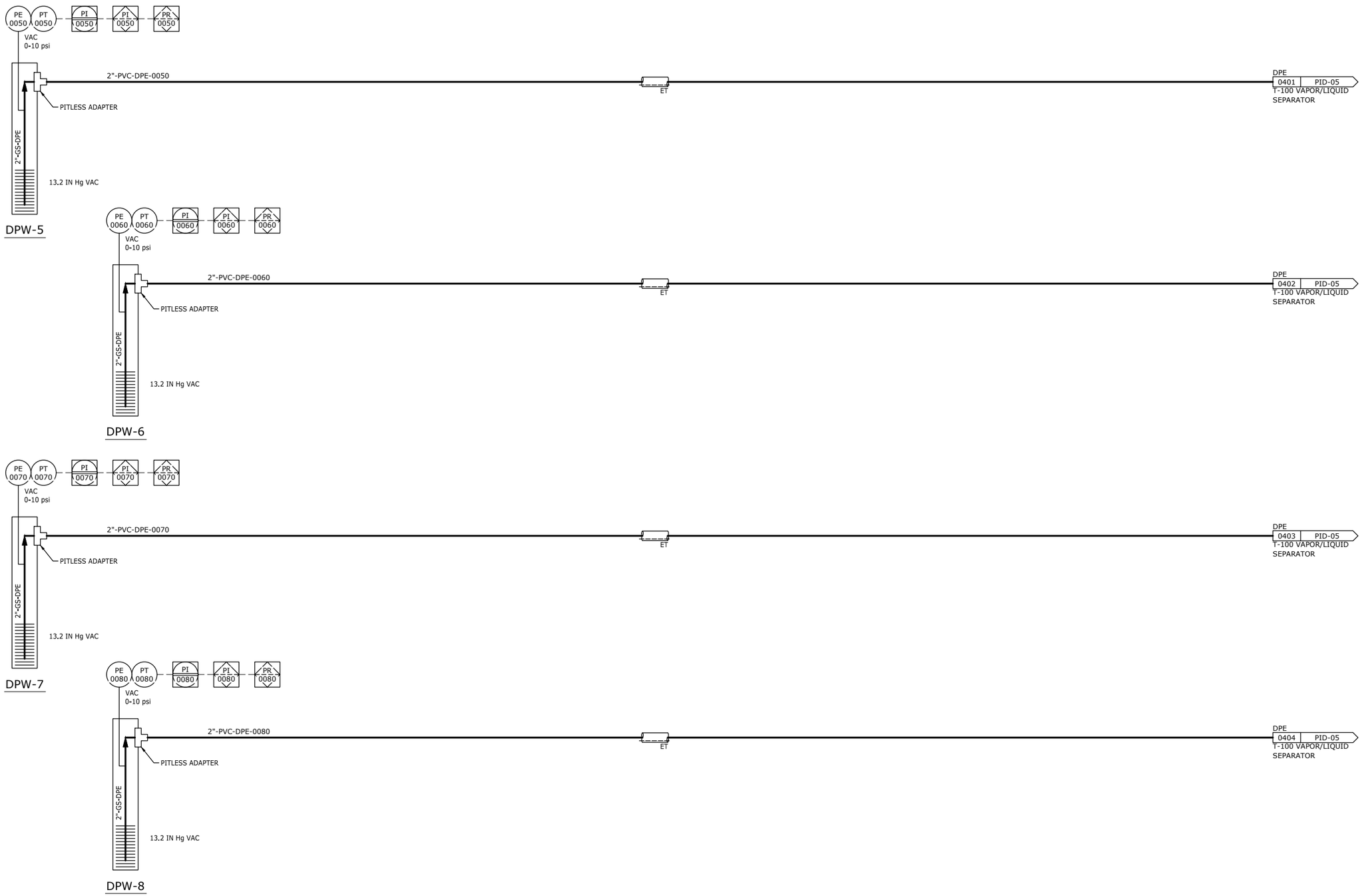

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DESIGNED BY: SWT
APPROVED BY: SWT

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

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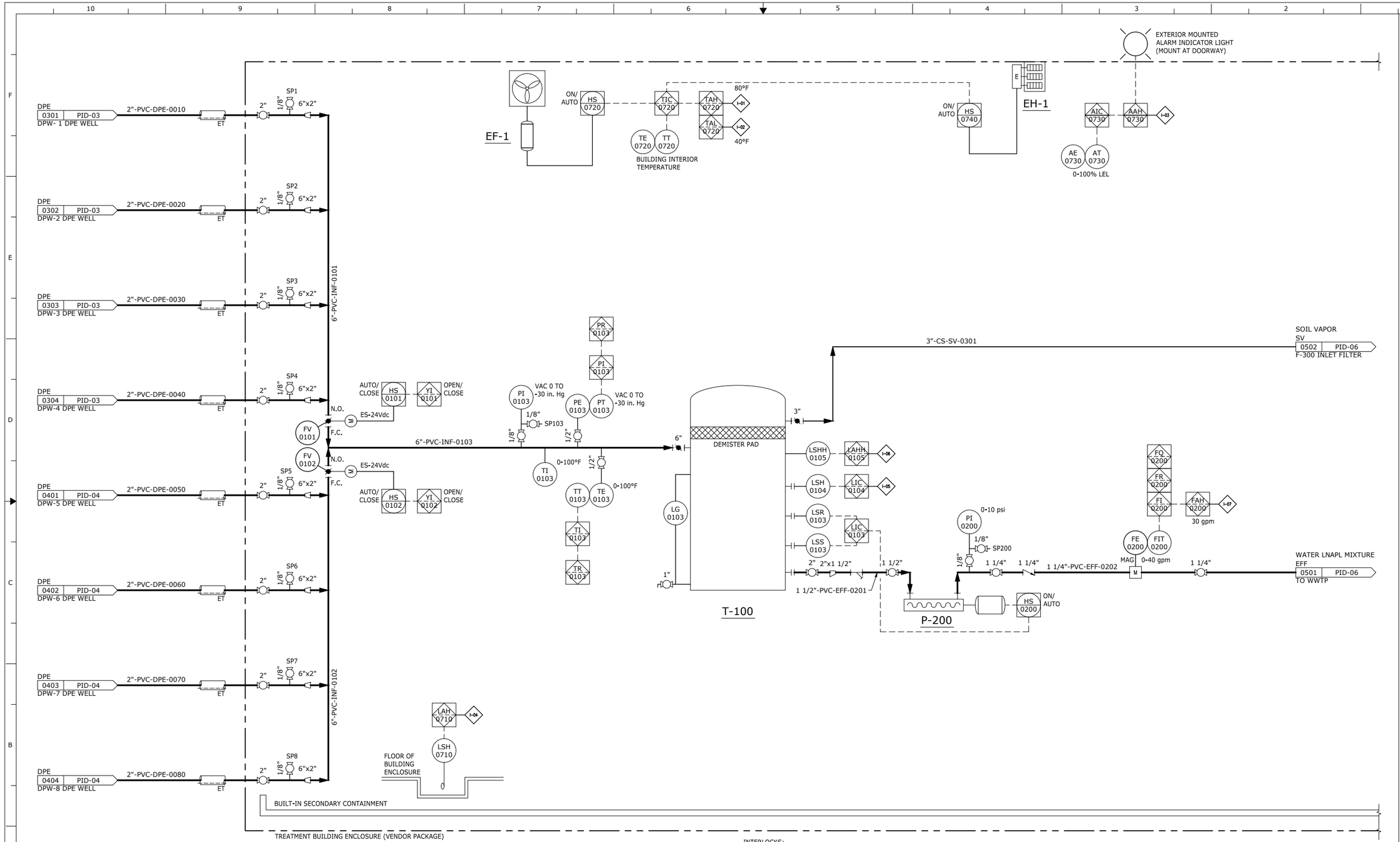

T-100

VAPOR / LIQUID SEPARATOR
TYPE: ASME
OPER. CAP.: BY VENDOR
SIZE: 300 gal
M.O.C.: CARBON STEEL

P-200

EFFLUENT TRANSFER PUMP
TYPE: PROGRESSIVE CAVITY PUMP
OPER. CAP.: 30 gpm @ 23' TDH
POWER: 1.5 HP
M.O.C.: TBD

EF-1

EXHAUST FAN
TYPE: BY VENDOR
OPER. CAP.: 200-300 cfm OR 12 AIR EXCH PER HR
M.O.C.: BY VENDOR

EH-1

ELECTRIC HEATER
TYPE: BY VENDOR
OPER. CAP.: BY VENDOR
SIZE: BY VENDOR

INTERLOCKS:

I-01: BUILDING INTERIOR TEMPERATURE IS HIGH. INDICATE HIGH BUILDING TEMP WARNING ON HMI SCREEN.

I-02: BUILDING INTERIOR TEMPERATURE IS LOW. INDICATE LOW BUILDING TEMP WARNING ON HMI SCREEN. TURN ON ELECTRIC HEATER EH-1.

I-03: BUILDING INTERIOR LEL IS HIGH. SEND HIGH LEL (BUILDING INTERIOR) ALARM NOTIFICATION TO OPERATOR. SHUTDOWN SYSTEM; CLOSE FLOW VALVES FV-0101 AND FV-0102.

I-04: BUILDING FLOOR SUMP HIGH WATER LEVEL. SEND HIGH FLOOR SUMP WATER LEVEL ALARM NOTIFICATION TO OPERATOR. SHUT DOWN SYSTEM.

I-05: TANK T-100 LIQUID LEVEL IS HIGH. CLOSE FLOW VALVE FV 0101 OR FLOW VALVE FV-0102. REOPEN FLOW VALVE FV-0101 OR FV-0102 WHEN WATER LEVEL IN TANK T-100 IS LOWERED TO LSS-0103 (LEVEL SWITCH STOP) IN 10 MINUTES OR LESS; OTHERWISE, INDICATE P-200 WARNING ON HMI SCREEN.

I-06: TANK T-100 HIGH-HIGH LIQUID LEVEL. CLOSE FLOW VALVES FV-0101 AND FV 0102. SIMULTANEOUSLY OPEN MOTOR ACTUATED FLOW VALVE FV-0302 TO >75%. SEND T-100 HHL ALARM NOTIFICATION TO OPERATOR. REOPEN FLOW VALVES FV-0101 AND FV-0102 AND CLOSE ACTUATED FLOW VALVE FV-0302 IF WATER LEVEL IN TANK T-100 IS LOWERED TO LSS-0103 (LEVEL SWITCH STOP) IN 10 MINUTES OR LESS; OTHERWIZE SHUTDOWN SYSTEM. SEND T-100 HHL AND P-200 FAULT ALARM NOTIFICATION TO OPERATOR.

I-07: PUMP P-200 EFFLUENT FLOW RATE IS HIGH. SEND ALARM NOTIFICATION TO OPERATOR.

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Design\169001-003-CALUMET MONTANA
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DATE: 9/30/2020
DESIGNED BY: SWT
APPROVED BY: SWT

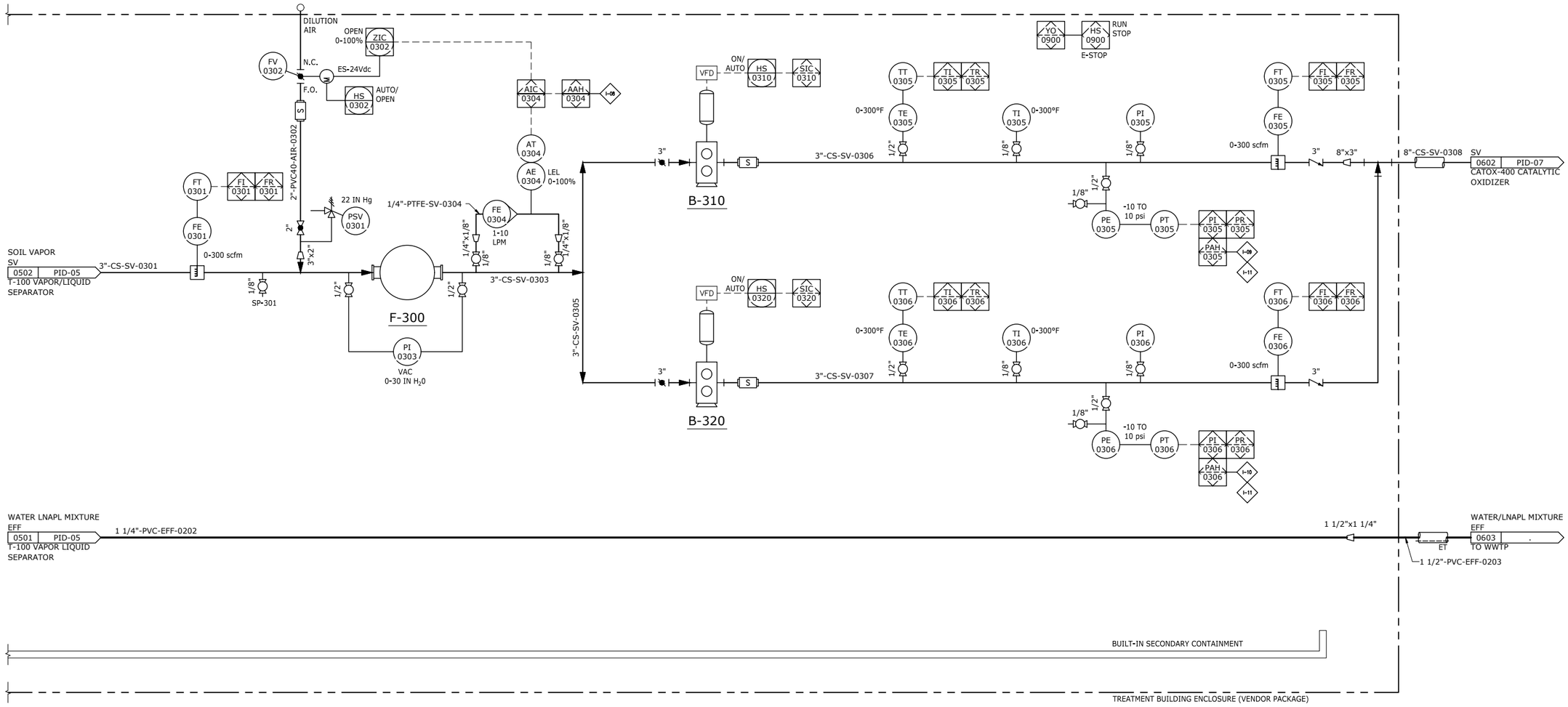
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

DRAWING
PID-05



INTERLOCKS:

I-08: INFLUENT VAPOR LEL IS >25%. OPEN FLOW VALVE FV-0302 AND MODULATE VALVE POSITION SO AIC-0304 IS AT A LEL OF 20%. INDICATE WARNING ON HMI SCREEN.

I-09: BLOWER B-310 DISCHARGE PRESSURE IS HIGH. SHUTDOWN BLOWER B-310. SEND B-310 HIGH PRESSURE ALARM NOTIFICATION TO OPERATOR.

I-10: BLOWER B-320 DISCHARGE PRESSURE IS HIGH. SHUT DOWN BLOWER B-320. SEND B-320 HIGH PRESSURE ALARM NOTIFICATION TO OPERATOR.

I-11: BLOWER B-310 AND BLOWER B-320 DISCHARGE PRESSURE IS HIGH. SHUT DOWN SYSTEM. SEND BLOWER SYSTEM B-310/B 320 HIGH PRESSURE ALARM NOTIFICATION TO OPERATOR.

F-300

INLET FILTER
TYPE: INLET VACUUM PUMP FILTER
OPER. CAP.: BY VENDOR
M.O.C.: BY VENDOR

B-310/320

VACUUM BLOWERS
TYPE: HIGH EFF OIL FREE CONTACTLESS ROTARY CLAW
OPER. CAP: 100 scfm (310 acfm) @ 17 IN Hg (60 hz) 3,300' msl
POWER: 15 HP
M.O.C.: BY VENDOR

FILE LOCATION:
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DESIGNED BY: SWT
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APPROVED BY: SWT
DATE: 9/30/2020

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

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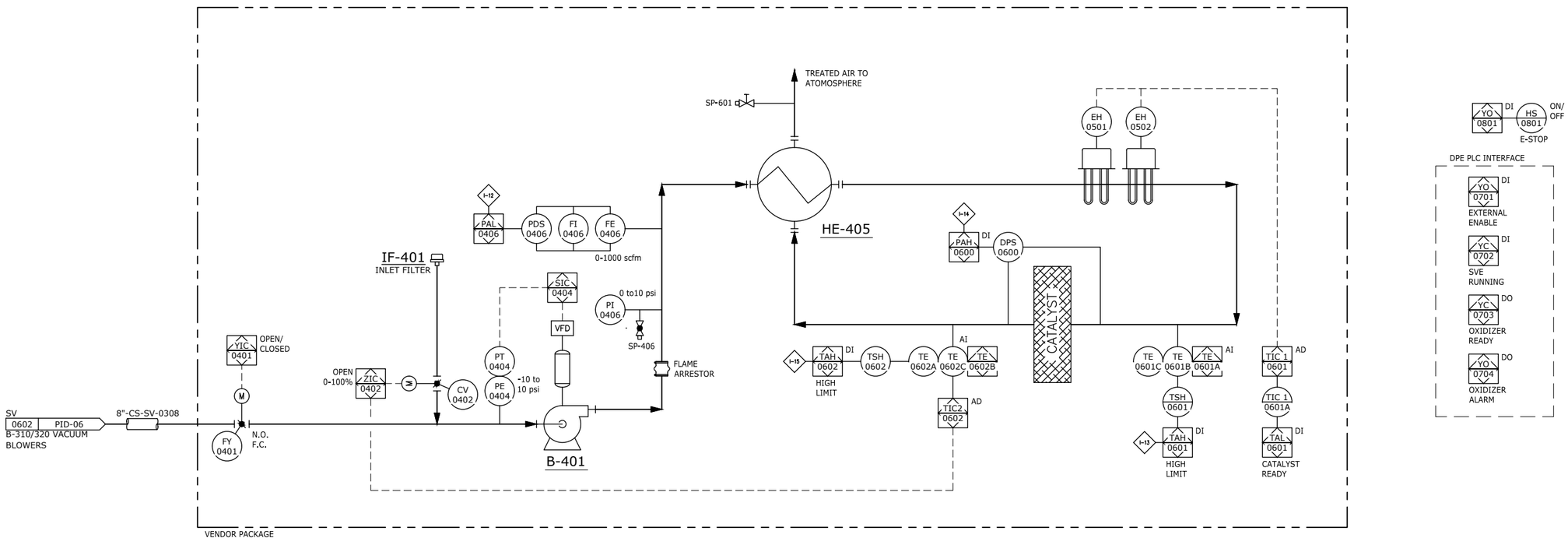

B-401

CATOX SYSTEM BLOWER
TYPE: CENTRIFUGAL
OPER. CAP: 1000 scfm
POWER: X HP
M.O.C.: BY VENDOR

HE-405

CATOX HEAT EXCHANGER
TYPE: BY VENDOR
OPER. CAP.: BY VENDOR
M.O.C.: BY VENDOR

INTERLOCKS:

I-12: OXIDIZER SYSTEM INLET BLOWER B 401 DISCHARGE PRESSURE IS LOW. SHUT DOWN SYSTEM. SEND OXIDIZER SYSTEM INLET PRESSURE LOW ALARM NOTIFICATION TO OPERATOR.

I-13: OXIDIZER HIGH TEMPERATURE ALARM. SHUT DOWN SYSTEM. SEND OXIDIZER ALARM NOTIFICATION TO OPERATOR.

I-14: OXIDIZER CATALYST HIGH PRESSURE ALARM. SHUT DOWN SYSTEM. SEND OXIDIZER ALARM NOTIFICATION TO OPERATOR.

I-15: OXIDIZER HIGH TEMPERATURE ALARM. SHUT DOWN SYSTEM. SEND OXIDIZER ALARM NOTIFICATION TO OPERATOR.

FILE LOCATION:
C:\CAD Support\Calumet Montana Refining LLC\01-AOC-16 DUAL-PHASE EXTRACTION AND MONTANA REFINING_1690014124.dwg

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DATE: 9/30/2020
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APPROVED BY: SWT

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PIPING & INSTRUMENTATION DIAGRAM

PROJECT # 1690014124-003

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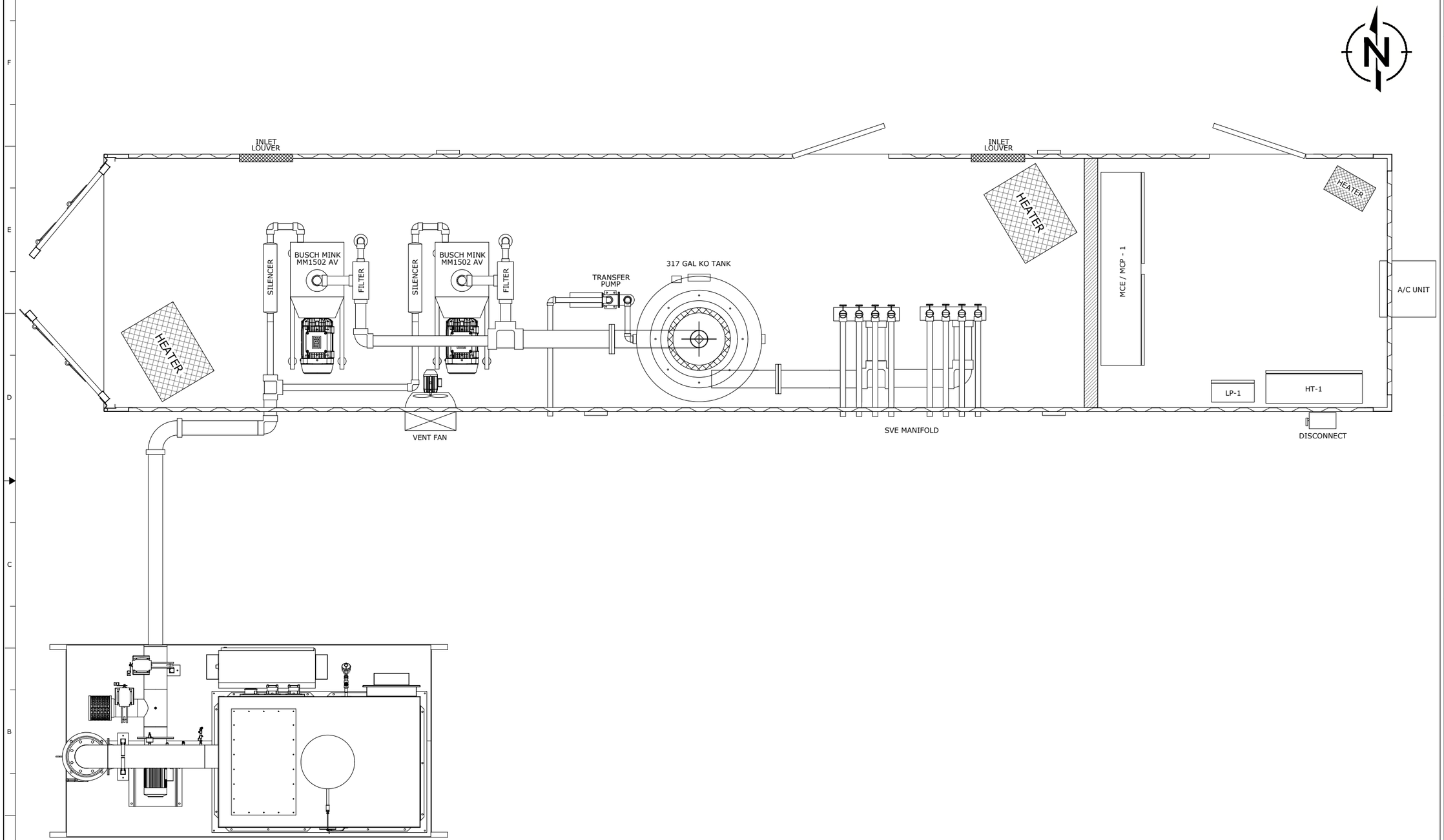
PID-07



FILE LOCATION:
M:\CADV\1690014124-003_Calumet_AOC-16\100% Design\M1 Dual-Phase Extraction System General Arrangement.dwg

DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 9/30/2020

SIGNATURE
DATE

RAMBOLL

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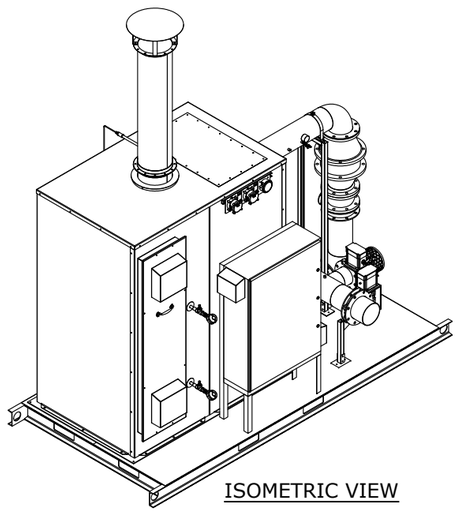
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

DUAL-PHASE EXTRACTION SYSTEM GENERAL ARRANGEMENT

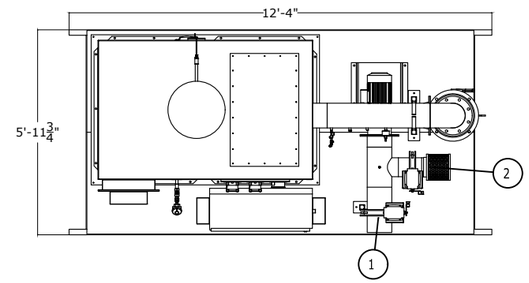
PROJECT # 1690014124-003

DRAWING
M1

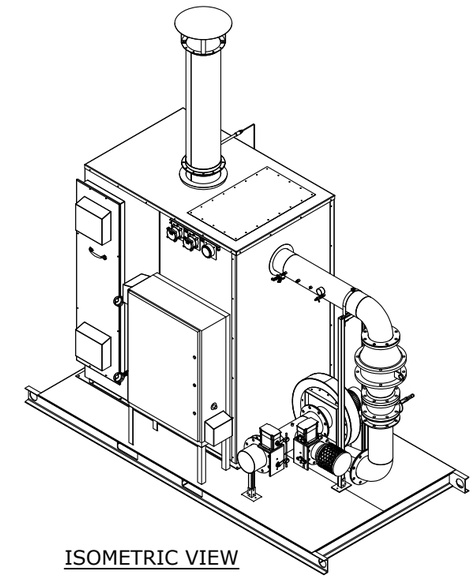


ISOMETRIC VIEW

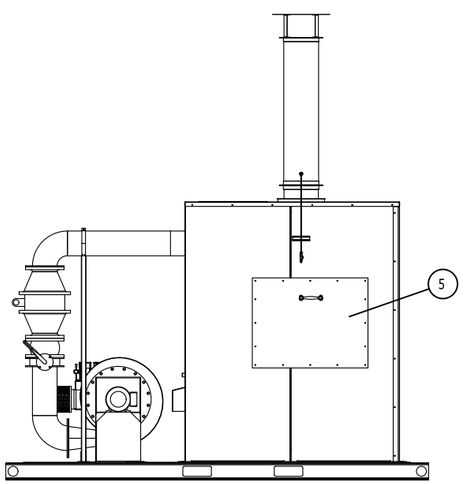
ITEM	DESCRIPTION
1	8" PROCESS INLET
2	AUTO DILLUTION
3	PROCESS FAN
4	HEATER ACCESS
5	CATALYST ACCESS
6	CONTROL PANEL
7	EXHAUST STACK



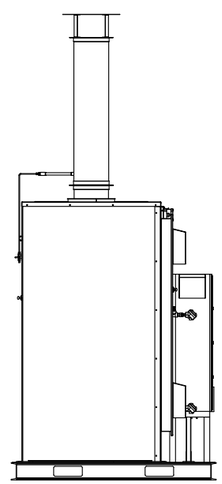
PLAN VIEW



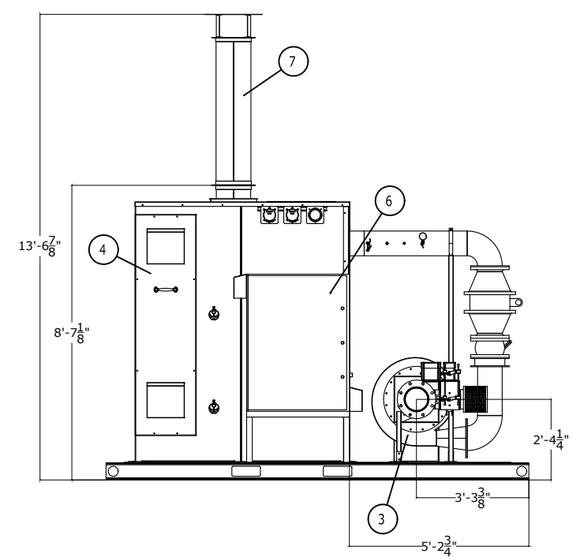
ISOMETRIC VIEW



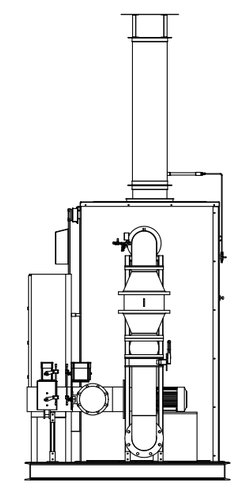
REAR ELEVATION VIEW



SIDE ELEVATION VIEW



FRONT ELEVATION VIEW



SIDE ELEVATION VIEW

FILE LOCATION:
M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\M2-SELF-Recuperative Catalytic Oxidizer General Arrangement.dwg

DESIGNED BY: AS/PL
DRAFTED BY: HJW
APPROVED BY: ST
DATE: 9/30/2020

DATE
SIGNATURE

RAMBOLL

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DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

SELF-RECUPERATIVE CATALYTIC OXIDIZER GENERAL ARRANGEMENT

PROJECT # 1690014124-003

DRAWING
M2

ABBREVIATIONS

A	AMPERE
AC	ALTERNATING CURRENT
A/C	AIR CONDITIONING
AF	AMPERE FRAME, CKT. BKR. RATING
AFF	ABOVE FINISHED FLOOR
AH	AMP HOUR
AHU	AIR HANDLING UNIT
AL	ALUMINUM
AI	ANALOG IN
AIT	CHLORINE RESIDUAL ANALYZER
AM	AMMETER
ANN	ANNUNCIATOR
AMP	AMPERES, AMPERAGE
AO	ANALOG OUT
APC	AMERICAN POWER CORP.
APPD	APPROVED
AS	AMMETER SWITCH
AT	AMPERE TRIP
ATS	AUTOMATIC TRANSFER SWITCH
AUTO	AUTOMATIC
AUX	AUXILIARY
AWG	AMERICAN WIRE GAUGE
B	BLOWER
BATT	BATTERY
BKR	BREAKER
BLDG	BUILDING
C	CONDUIT
CAB	CABINET
CB	CIRCUIT BREAKER
CKT	CIRCUIT
CL	CIRCUIT
CO	CONDUIT ONLY
COM	COMMON
COMPT	COMPARTMENT
COMPR	COMPRESSOR
COND	CONDUIT
CP	CONTROL PANEL
CPT	CONTROL POWER TRANSFORMER
CR	CONTROL RELAY
CT	CURRENT TRANSFORMER
CU	COPPER
DC	DIRECT CURRENT
DH	DATA HIGHWAY
DI	DIGITAL IN
DIO	DIGITAL IN OUTPUT
DISC	DISCONNECT
DISTR	DISTRIBUTION
DPDT	DOUBLE POLE DOUBLE THROW
DWG	DRAWING
(E)	EXISTING
EF	EXHAUST FAN
EHU	ELECTRIC HEATING UNIT
ELEV	ELEVATION
EMERG	EMERGENCY
EMT	ELECTRICAL METALLIC TUBING
ENCL	ENCLOSURE
EQPT	EQUIPMENT
ER	CONDUCTANCE RELAY
EP	EXPLOSION PROOF
ETM	ELAPSED TIME METER
EXH	EXHAUST
EXIST	EXISTING
FDR	FEEDER
FLEX	FLEXIBLE
FLUOR	FLUORESCENT
FUT	FUTURE
FVR	FULL VOLTAGE REVERSING
FVNR	FULL VOLTAGE NON-REVERSING
FWD	FORWARD
GALV	GALVANIZED
GEN	GENERATOR
GND	GROUND
H	HOT CONDUCTOR
HH	HAND HOLE
HID	HIGH INTENSITY DISCHARGE
HG	MERCURY
HMI	HUMAN MACHINE INTERFACE
HOA	HAND-OFF-AUTOMATIC
HP	HORSEPOWER
HPS	HIGH PRESSURE SODIUM
HT TR	HEAT TRACED
HTR	HEATER
HVAC	HEATING, VENTILATING, A/C
HZ	HERTZ - CYCLES PER SECOND
IMC	INTERMEDIATE METAL CONDUIT
INCAND	INCANDESCENT
IND	INDICATION, INDICATING
I/O	INPUT/OUTPUT
INST	INSTANTANEOUS
INSTR	INSTRUMENT
INVT	INVERT
JB	JUNCTION BOX
J BOX	JUNCTION BOX
KVA	KILO VOLT AMPERES
KW	KILOWATTS
KWH	KILOWATT HOUR
KCM	1,000 CIRCULAR MILS
L	LINE
LC	LIGHTING CONTACTOR
LCB	LOCAL CONTROL BOARD
LCP	LOCAL CONTROL PANEL
LOC	LOCAL
LO	LOCKOUT
LOS	LOCKOUT STOP
LS	LEVEL SWITCH
LT	LIGHT
LTG	LIGHTING
LTS	LIGHTS
M	MOTOR CONTACTOR COIL
mA	MILLIAMPS
MAN	MANUAL
MAG	MAGNETIC
MAX	MAXIMUM
MCC	MOTOR CONTROL CENTER
MCB	MAIN CONTROL BOARD
MCP	MOTOR CIRCUIT PROTECTOR
MD	MOTORIZED DAMPER
MDR	MANUFACTURERS DESIGNATION FOR SPECIFIC POWER SUPPLY
MH	MANHOLE
MTG	MOUNTING
MIN	MINIMUM, MINUTES
MLO	MAIN LUGS ONLY
MOV	MOTOR OPERATED VALVE
MS	MOTOR STARTER
MMS	MANUAL MOTOR STARTER
MTD	MOUNTED
MTR	MOTOR
MTS	MANUAL TRANSFER SWITCH
MUX	MULTIPLEXING PANEL
N	NEUTRAL
NA	NON-AUTOMATIC
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
NO	NUMBER
NOS	NUMBERS
NP	NAMEPLATE
(N)	NEW OR PROPOSED
NTS	NOT TO SCALE
O	OPEN
OC	ON CENTER
CC	CENTER TO CENTER
OL	OVERLOAD RELAY
OSC	OSCILLATION
P	POLE
PB	PUSH BUTTON
PCM	PROCESS CONTROL MODULE
PCP	PROCESS CONTROL PANEL
PF	POWER FACTOR
PH, Ø	PHASE
PI	PULSE IN
PIC	POTENTIOMETER
PL	PILOT LIGHT
PLC	PROGRAMMABLE LOGIC CONTROLLER
PNL	PANEL
PNLBD	PANELBOARD
POS	POSITION
PQM	POWER QUALITY MONITOR
POT	POTENTIOMETER
PRI	PRIMARY
P/S	POWER SUPPLY
PS	PRESSURE SWITCH
PT	POTENTIAL TRANSFORMER
PVC	POLYVINYL CHLORIDE
REC	RECEPTACLE
RECPTS	RECEPTACLES
REQ'D	REQUIRED
REV	REVERSE
RGS	RIGID GALVANIZED STEEL
RTU	REMOTE TERMINAL UNIT
RVNR	REDUCED VOLTAGE NON-REVERSING
RVSS	REDUCED VOLTAGE SOLID STATE
S	SOLENOID
SC	SHORT CIRCUIT CURRENT
SCH	SCHEDULE
SEC	SECONDARY, SECONDS
SECT	SECTION
SS	SELECTOR SWITCH
SEQ	SEQUENCE
SHLD	SHIELDED
SHT	SHEET
SIG	SIGNAL
SP	SPARE
SPDT	SINGLE POLE DOUBLE THROW
SPECS	SPECIFICATIONS
SP HTR	SPACE HEATER
SPST	SINGLE POLE SINGLE THROW
SS	SOLID STATE
ST	SHUNT TRIP
STA	STATION
STD	STANDARD
STL	STEEL
STR	STARTER
SOV	SOLENOID OPERATED VALVE
SW	SWITCH
SYS	SYSTEM
SYM	SYMMETRICAL
TB	TERMINAL BOX
TC	TIME CLOCK
TACH	TACHOMETER
TEMP	TEMPERATURE
TERM	TERMINAL
T'STAT	THERMOSTAT
TR	TIMING RELAY
TD	TIME DELAY
TS	TEMPERATURE SWITCH
TSP	TWISTED SHIELDED PAIR
TU	TREATMENT UNIT
TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR
TYP	TYPICAL
UG	UNDERGROUND
UH	UNIT HEATER
UI	UNIVERSAL IN
UON	UNLESS OTHERWISE NOTED
UPS	UNINTERRUPTIBLE POWER SUPPLY
V	VOLTAGE, VOLTS
VAR	VAR METER
VFD	VARIABLE FREQUENCY DRIVE
VP	VAPOR PROOF
VS	VOLTMETER SWITCH, VARIABLE SPEED
W	WATTS, WIRE
WHD	WATTHOUR DEMAND METER
WHM	WATTHOUR METER
WP	WEATHERPROOF

TIME DELAY CONTACTS

OFF DELAY TIMER	INST. CLOSE TIME OPEN
	INST. OPEN TIME CLOSE
ON DELAY TIMER	TIME CLOSE INST. OPEN
	TIME OPEN INST. CLOSE

OPERATORS

	LOCKOUT STOP PUSH BUTTON
	PUSHBUTTON NORMALLY CLOSED
	PUSHBUTTON NORMALLY OPEN
OX	TWO POSITION SELECTOR SWITCH
1 2 3 X00 00X	THREE POSITION SELECTOR SWITCH X DENOTES CLOSED CONTACT IN THAT POSITION
	TOGGLE SWITCH
	PILOT LIGHT - PUSH TO TEST, X DENOTES COLOR

DRAWING LEGEND

	EXISTING EQUIPMENT, WIRING, DEVICES
	NEW WORK
	DEMOLISH OR REMOVE
	CONDUIT TURNING UP
	CONDUIT TURNING DOWN
X	EQUIPMENT OR DEVICE TAG
X	SHEET NOTE TAG
X	HVAC/LIGHTING DESIGNATION
	DUPLEX RECEPTACLE, 20A, 125V, NEMA 5-20R
	DOUBLE DUPLEX RECEPTACLE, 20A, 125V, NEMA 5-20R
	STRIP OR TROFFER TYPE LIGHTING FIXTURE
	EMERGENCY CIRCUIT LIGHTING FIXTURE
	EXTERIOR WALL-PACK LIGHTING FIXTURE
	LED EXIT LIGHT
	LED EXIT LIGHT WITH DUAL LIGHTING HEADS
OS	DUAL TECHNOLOGY OCCUPANCY SENSOR
M	ELECTRIC MOTOR
J	JUNCTION BOX, SIZE PER NEC
	WALL MOUNTED LUMINAIRE
$a	LIGHT SWITCH. SUBSCRIPT "a" INDICATES LUMINAIRE CONTROLLED. MOUNT AT 48".
	3/4" x 8' CU CLAD GROUND ROD.
	UNDERGROUND CONDUIT OR DUCTBANK.
	INSTRUMENTATION DEVICE
	MINI-POWER ZONE (COMBINATION TRANSFORMER & PANELBOARD)
	SHORT HASH MARK INDICATES HOT WIRE INDICATES GROUND CONDUCTOR LONG HASH MARK INDICATES NEUTRAL WIRE

NOTE: NO HASH MARK INDICATES 3/4"C. 2#12+1#12G

ELECTRICAL COMPONENTS

	EARTH GROUND
	CHASSIS GROUND
	GROUNDED RECEPTACLE
	FUSE
	HORN
	TRANSFORMER
	SOLENOID
	OVERLOAD RELAY
	CIRCUIT BREAKER
10	MOTOR (NO. DENOTES HORSEPOWER)
X	COIL
	RELAY CONTACT, N.O.
	RELAY CONTACT, N.C.
	SHIELDED CABLE
	DIODE, SURGE SUPPRESSOR
	SURGE SUPPRESSOR
XX	TERMINAL BLOCK
	SEPARABLE CONNECTOR
	POTENTIOMETER
	CURRENT TRANSFORMER

PRESSURE SWITCHES

	OPEN - CLOSES ON RISING PRESSURE
	CLOSED - CLOSES ON FALLING PRESSURE
	OPEN - OPENS ON RISING PRESSURE
	CLOSED - OPENS ON FALLING PRESSURE

LIMIT SWITCHES

	NORMALLY OPEN
	HELD OPEN
	NORMALLY CLOSED
	HELD CLOSED

LEVEL FLOAT SWITCHES

	CLOSES ON RISING LEVEL
	CLOSES ON FALLING LEVEL
	OPENS ON RISING LEVEL
	OPENS ON FALLING LEVEL

NOTES-GENERAL ELECTRICAL CONSTRUCTION

1. CONTRACTOR IS RESPONSIBLE FOR VERIFYING EXISTING CONDITIONS AND ROUTE CONDUITS WITHOUT DISTURBING EXISTING UTILITIES. IN ADDITION, CONDUIT ROUTING MUST BE APPROVED BY A OWNERS REPRESENTATIVE. FEASIBILITY OF THE PROPOSED LOCATION OF THE EQUIPMENT SHALL BE FIELD VERIFIED. COORDINATE WITH ALL TRADES.
2. VERIFY, LOCATE AND PRESERVE ALL UNDERGROUND UTILITIES. REPAIR ALL UTILITIES DAMAGED DURING CONSTRUCTION TO OWNER'S SATISFACTION.
3. ELECTRICAL CONTRACTOR SHALL VISIT JOB SITE AND VERIFY EXISTING CONDITIONS BEFORE BIDDING AND SHALL INCLUDE IN HIS BID THE NECESSARY COSTS TO CONSTRUCT THIS PROJECT IN ACCORDANCE WITH THE INTENT OF THE ELECTRICAL DRAWINGS, SPECIFICATIONS, AND ALL APPLICABLE CODES.
4. THE ELECTRICAL INSTALLATION SHALL COMPLY WITH ALL LOCAL, STATE, AND NATIONAL CODES, LAWS, AND ORDINANCES APPLICABLE TO ELECTRICAL WORK.
5. ALL ELECTRICAL MATERIALS AND EQUIPMENT SHALL BE LISTED BY UNDERWRITERS LABORATORIES.
6. THE WORD PROVIDE AS USED ON THE DRAWINGS SHALL BE DEFINED AS CONTRACTOR FURNISHED AND INSTALLED.
7. AT LEAST TWO WORKING DAYS PRIOR TO ANY EXCAVATION WORK, THE CONTRACTOR SHALL CALL UNDERGROUND SERVICE ALERT FOR LOCATING AND MARKING UTILITIES IN THE AREA OF THE WORK.
8. ALL UNDERGROUND CONDUITS SHALL BE PVC, SCHEDULE 40 OR BETTER UNLESS OTHERWISE NOTED.
9. THE BUILDING PERMITS REQUIRED FOR THE WORK SHOWN ON THE ELECTRICAL DRAWINGS WILL BE OBTAINED BY THE OWNER. THE ELECTRICAL CONTRACTOR SHALL COORDINATE WITH THE OWNERS REPRESENTATIVE TO ENSURE THE PERMITTED WORK IS INSPECTED BY THE MARINETTE COUNTY PERMIT AND RESOURCE MANAGEMENT DEPARTMENT.

NOTES-RACEWAYS

1. CONDUIT ROUTING SHOWN ON DRAWINGS IS DIAGRAMMATIC TO ILLUSTRATE DESIGN INTENT. CONTRACTOR SHALL FIELD DETERMINE THE MOST SUITABLE ROUTING TO FACILITATE INSTALLATION.
2. ALL CONDUIT RUNS SHALL BE INSTALLED WITH A MINIMUM NUMBER OF BENDS AND OFFSETS. GENERALLY, A RUN OF CONDUIT CONTAINING LOW VOLTAGE (600 VOLT MAXIMUM) WIRE SHALL HAVE A MAXIMUM PULLING DISTANCE OF 300 FEET AND CONTAIN NO MORE THAN THREE AND ONE-HALF QUARTER BENDS (315 DEGREES TOTAL), INCLUDING OFFSETS AND BENDS LOCATED IMMEDIATELY ADJACENT TO THE PULL LOCATION. ON RUNS OVER 300 FEET THIS SHALL BE REDUCED TO TWO QUARTER BENDS (180 DEGREES TOTAL).
3. FOR 600 VOLT CABLES, THE MINIMUM RADIUS OF CONDUIT BENDS SHALL BE SIX TIMES THE DIAMETER OF THE CONDUIT. WHERE BENDS OR OFFSETS ARE REQUIRED, THEY SHALL BE MADE WITH SUITABLE CONDUIT BENDING EQUIPMENT. A UNIFORM CIRCULAR CROSS SECTION OF THE CONDUIT SHALL BE MAINTAINED AT BENDS. NO SINGLE BEND SHALL BE GREATER THAN 90 DEGREES.
4. CONDUIT UNIONS SHALL BE INSTALLED AT REMOVABLE DEVICES SUCH THAT THE DEVICES CAN BE EASILY AND INDEPENDENTLY REMOVED.
5. NOT ALL FITTINGS REQUIRED FOR A COMPLETE CONDUIT SYSTEM ARE SHOWN ON THE DRAWINGS. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO INSTALL THE NUMBER AND TYPE OF FITTINGS REQUIRED FOR A COMPLETE CONDUIT SYSTEM WHICH COMPLIES WITH ALL APPLICABLE CODES AND STANDARDS. THE THREADS OF FITTINGS, INCLUDING COVER SCREWS AND BOLTS, SHALL BE COATED WITH A CONDUCTIVE THREAD LUBRICANT PRIOR TO INSTALLATION TO PROTECT AGAINST CORROSION.
6. ALL CONDUIT FITTINGS AND JUNCTION BOXES SHALL BE INSTALLED SO THAT THEIR COVERS ARE EASILY REMOVED.
7. ALL METALLIC CONDUIT SHALL BE TERMINATED WITH INSULATED BUSHINGS TO PREVENT DAMAGE TO WIRE DURING PULLING OPERATIONS, EXCEPT IN ENCLOSURES WHERE HUB DESIGN IS ADEQUATE TO PREVENT INSULATION DAMAGE. GROUNDING CONNECTIONS SHALL BE PROVIDED ON ALL INSTALLED BUSHINGS FOR GROUND CONTINUITY.
8. CONDUITS SHALL NOT BE SUPPORTED FROM EQUIPMENT OR PIPING. CONDUITS SHALL BE SUPPORTED AT INTERVAL AS REQUIRED BY NEC 344.30, "SECURING AND SUPPORTS" AND TABLE 344.30(B)(2), TO PREVENT NOTICEABLE SAG. NO NOTICEABLE SAG SHALL BE ALLOWED. THE CONTRACTOR SHALL PROVIDE ANY ADDITIONAL SUPPORT REQUIRED TO PREVENT OBJECTIONABLE SAG. IF RIGID ALUMINUM CONDUIT IS USED, THE SUPPORT SYSTEM SHALL BE OF SUITABLE MATERIAL OR CONSTRUCTION TO PREVENT GALVANIC CORROSION.
9. LIQUID-TITE FLEXIBLE CONDUIT WITH PVC JACKET SHALL BE USED WHERE VIBRATION IS PRESENT, WHERE FLEXIBILITY IS REQUIRED, AND AT ALL MOTOR CONDUIT BOXES. TERMINATIONS OF FLEXIBLE METALLIC CONDUIT SHALL BE MADE USING LIQUID-TIGHT CONNECTORS WITH INTEGRAL INSULATED BUSHINGS AND POSITIVE GROUND CONNECTIONS. THE MAXIMUM LENGTH OF FLEXIBLE CONDUIT SHALL BE 24 INCHES FOR INSTRUMENTS AND EQUIPMENT, 36 INCHES FOR MOTORS, AND 48 INCHES FOR LIGHTING.
10. ALL ABOVE GROUND, STRAIGHT CONDUIT RUNS OVER 200 FEET LONG SHALL HAVE EXPANSION FITTINGS, WITH PROVISION FOR 4 INCHES TOTAL EXPANSION. BONDING JUMPERS SHALL BE INSTALLED TO ASSURE GROUNDING CONTINUITY.
11. THREADED JOINTS FOR CONDUITS SHALL BE MADE UP WITH A METAL OXIDE PAINT SUCH AS "T&B" KOPR-SHIELD, BURNDY PENETROX E OR APPROVED EQUAL.
12. PROVIDE ABOVE GRADE CONDUIT SUPPORT AT LEAST EVERY 10 FEET. FASTEN CONDUIT WITHIN 3 FEET OF EACH OUTLET BOX OR FITTING.
13. USE CABLE PULLING LUBRICANT, SUCH AS, POLYWATER OR EQUAL FOR CABLE PULLS IN CONDUIT GREATER THAN 10-FEET.

NOTES-WIRING

1. SINGLE OR MULTICONDUCTOR CABLE MAY BE USED FOR CONTROL, INSTRUMENT, COMMUNICATION AND SIGNAL CIRCUITS. SINGLE-CONDUCTOR SHALL BE #14 AWG MINIMUM; SINGLE PAIRED CABLES SHALL BE #18 AWG MINIMUM; AND MULTICONDUCTOR CABLE SHALL BE #18 AWG MINIMUM. CIRCUITS CLASSIFIED AS CLASS I CIRCUITS BY NEC ARTICLE 725 SHALL BE #18 AWG MINIMUM, 600 VOLT INSULATION CLASS.
2. ALL FIELD POWER, CONTROL AND LIGHTING CONDUCTORS SHALL BE COLOR CODED AS FOLLOWS UNLESS OTHERWISE SPECIFIED.
   - BLACK - ALL UNGROUNDED CONTROL CIRCUIT CONDUCTORS OPERATING AT THE SUPPLY VOLTAGE.
   - RED - UNGROUNDED AC CONTROL CIRCUITS OPERATING AT A VOLTAGE LESS THAN THE SUPPLY VOLTAGE.
   - BLUE - UNGROUNDED DC CONTROL CIRCUITS.
   - YELLOW OR ORANGE - UNGROUNDED CONTROL CIRCUITS OR OTHER WIRING.
   - WHITE - GROUNDED AC CURRENT-CARRYING CONTROL CIRCUIT CONDUCTOR REGARDLESS OF VOLTAGE.
   - GREY - GROUNDED DC CURRENT-CARRYING CONTROL CIRCUIT CONDUCTOR.

   ALL INTERIOR CONTROL PANEL WIRING SHALL BE PER UL 508A, LATEST EDITION.
3. NO MORE THAN TWO CONDUCTORS SHALL BE CONNECTED TO ANY ONE TERMINAL ON A TERMINAL STRIP. IF MORE THAN TWO CONDUCTORS MUST BE TERMINATED AT THE SAME POINT, THE TERMINATIONS SHALL BE MADE ON AS MANY TERMINALS AS NECESSARY AND THE TERMINALS INTERCONNECTED WITH JUMPERS. THE JUMPERS SHALL BE PHYSICALLY SEPARATED FROM THE CONDUCTORS.
4. FOR POWER AND LIGHTING CIRCUITS, 600 VOLTS AND BELOW, THE SMALLEST WIRE SHALL BE #12 AWG. EXCEPT THAT #14 AWG SHALL BE USED FOR CONTROLS. WIRES SHALL BE SINGLE CONDUCTOR, COPPER, STRANDED, 600 VOLT HEAT AND MOISTURE RESISTANT THERMOPLASTIC INSULATED TYPE "THHN/THWN", UNDERGROUND CONDUCTORS MUST BE RHW, UNLESS OTHERWISE NOTED.
5. #10 AWG OR LARGER SHALL BE XHHW UNLESS NOTED OTHERWISE.
6. MOTOR JUNCTION BOX CONNECTIONS SHALL BE CRIMP LUG/BOLTED CONNECTIONS WITH 3M MOTOR SPICE KIT 5300 SERIES INSULATORS.

NOTES-GROUNDING

1. ALL INSULATED GROUNDING CONDUCTORS SHALL BE MADE OF SOFT DRAWN, STRANDED COPPER WIRE, UTILIZING GREEN, FIRE RETARDANT INSULATION. ALL EXPOSED GROUNDING CONDUCTORS SHALL BE MINIMUM #6 AWG (UNLESS OTHERWISE NOTED), RIGIDLY SUPPORTED, AND PROTECTED FROM MECHANICAL INJURY.
2. ALL UN-INSULATED GROUNDING CONDUCTORS (STRANDED OR SOLID) SHALL BE TINNED COPPER.
3. ALL CONNECTIONS SHALL BE COATED WITH A CONDUCTIVE, CORROSION PREVENTIVE COMPOUND BEFORE JOINING.
4. ALL COPPER BUS BARS MUST BE CLEANED PRIOR TO MAKING CONNECTIONS TO REMOVE SURFACE OXIDATION.

NOTES-LABELING

1. PROVIDE LAMINATED PLASTIC EQUIPMENT NAMEPLATE LABELS AT ALL FIELD DEVICES, DENOTING EQUIPMENT NAME, VOLTAGE AND FEEDER ORIGIN. PLASTIC NAMEPLATES SHALL BE WHITE WITH BLACK LETTERS. ALL PANELBOARD CIRCUIT DIRECTORIES SHALL BE UPDATED DENOTING NEW EQUIPMENT LOADS.
2. ALL JUNCTION BOX COVERPLATES SHALL BE LABELED WITH CIRCUIT NUMBERS IT CONTAINS.
3. NAMEPLATES AND TAGS SHALL BE PROVIDED FOR ELECTRICAL EQUIPMENT AND DEVICES, INCLUDING ALL PUSHBUTTONS, SELECTOR SWITCHES, CIRCUIT BREAKERS AND STARTERS. WHERE EQUIPMENT ALSO CAN BE STARTED FROM ANOTHER LOCATION, OR STARTED AUTOMATICALLY, A CAUTION NAMEPLATE SHALL BE PROVIDED.
4. THE NAMEPLATE DESCRIPTION SHALL SHOW THE EQUIPMENT NUMBER AND SERVICE OF THE CONTROLLED EQUIPMENT. ALL PANELBOARDS SHALL HAVE NAMEPLATES STATING THE APPROPRIATE DESIGNATION, VOLTAGE, CONTINUOUS RATING, AND NUMBER OF PHASES. LIGHTING AND POWER PANELS SHALL BE SUPPLIED WITH COMPLETED CIRCUIT DIRECTORIES.
5. ALL WIRING SHALL BE IDENTIFIED AT EACH TERMINATION WITH PERMANENT, PRINTED, HEAT-SHRINKABLE PLASTIC SLEEVES OR WITH CLEAR, HEAT-SHRINKABLE SLEEVES THAT COVER ADHESIVE WRAP-ON MARKERS. CONTRACTOR SHALL USE A "BRADY" OR EQUAL TYPE WIRE MARKER. THE WIRE IDENTIFICATION NUMBER SHALL INCLUDE THE COMPLETE CIRCUIT OR INSTRUMENT NUMBER. THE WIRE IDENTIFICATION SHALL BE THE IDENTIFICATION SHOWN ON THE WIRING DIAGRAM. IF NONE IS SHOWN ON A WIRING DIAGRAM, THE OWNERS REPRESENTATIVE SHALL BE CONSULTED FOR PROPER IDENTIFICATION. ELECTRICAL CABLES SHALL BE LABELED WITH THE CIRCUIT NUMBER AND PHASE DESIGNATION AT EACH END OF CABLE. IF THE CABLE IS IN CONDUIT, THE CONDUIT TAG MAY SERVE AS AN INDICATION OF THE CIRCUIT NUMBER FOR POWER CIRCUITS.

DATE

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FILE LOCATION:
M:\CAD\169001\124-003_Calumet_AOC-16\100% Design\E1_General Notes, Symbols, & Abbreviations.dwg

DRAFTED BY: HJW

DATE: 9/30/2020

DESIGNED BY: AS/PL

APPROVED BY:

RAMBOLL

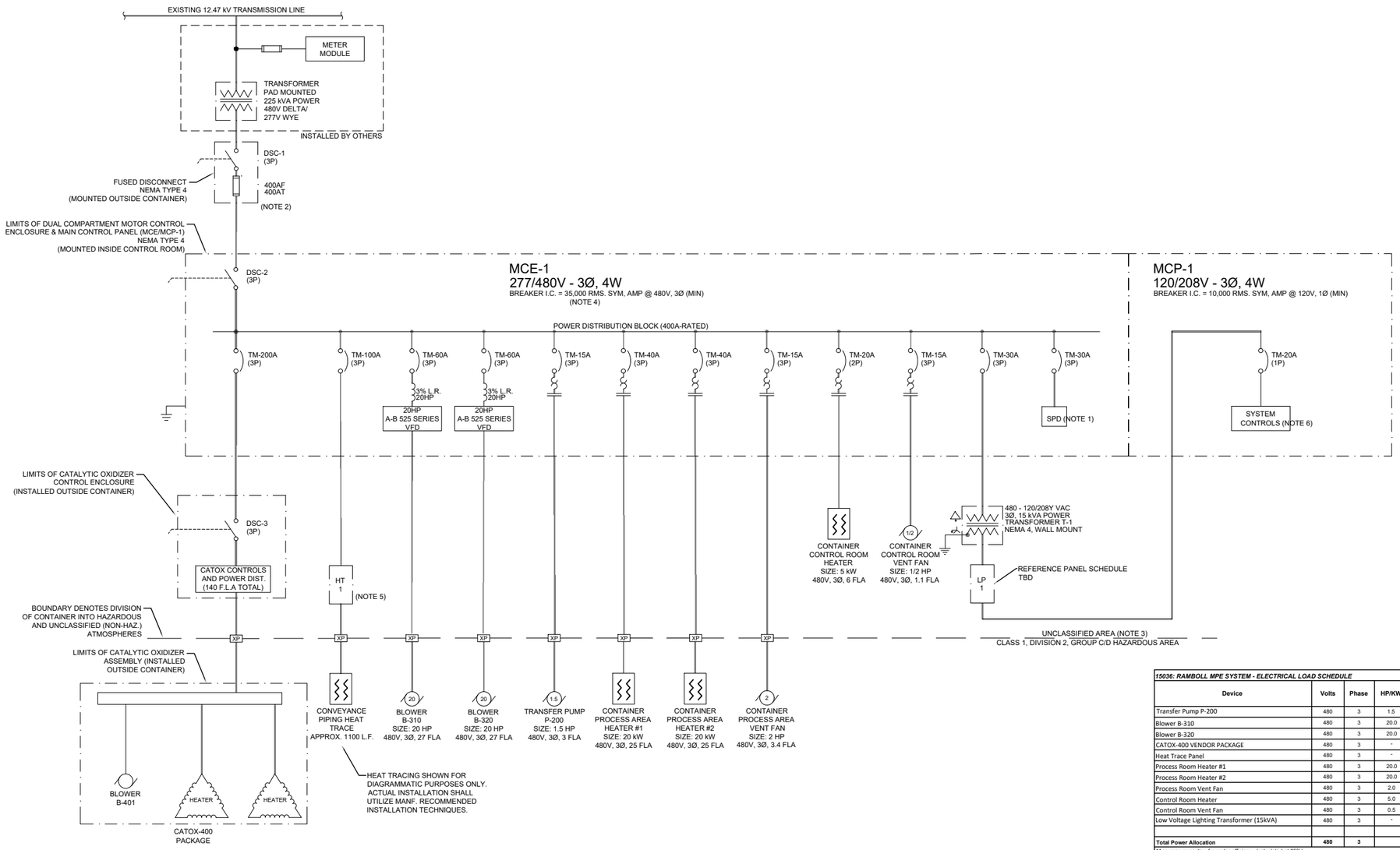
AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

GENERAL NOTES, SYMBOLS, & ABBREVIATIONS

PROJECT# 1690014124-003

DRAWING

E1



ELECTRICAL SINGLE-LINE DIAGRAM

NOT TO SCALE

15036: RAMBOLL MPE SYSTEM - ELECTRICAL LOAD SCHEDULE

Device	Volts	Phase	HP/KW	Power Feed Source	Connected Load - 480V (Amps)**	kVA	KW*	Duty Factor	Comments
Transfer Pump P-200	480	3	1.5	MCE-1	3.0	2.49	2.12	1.00	
Blower B-310	480	3	20.0	MCE-1	27.0	22.45	19.08	1.00	
Blower B-320	480	3	20.0	MCE-1	27.0	22.45	19.08	1.00	
CATOX-400 VENDOR PACKAGE	480	3	-	MCE-1	140.0	116.39	98.93	1.00	
Heat Trace Panel	480	3	-	MCE-1	15.0	12.47	10.60	1.00	
Process Room Heater #1	480	3	20.0	MCE-1	25.0	20.78	17.67	1.00	
Process Room Heater #2	480	3	20.0	MCE-1	25.0	20.78	17.67	1.00	
Process Room Vent Fan	480	3	2.0	MCE-1	3.4	2.83	2.40	1.00	
Control Room Heater	480	3	5.0	MCE-1	6.0	4.99	4.24	1.00	
Control Room Vent Fan	480	3	0.5	MCE-1	1.1	0.91	0.78	1.00	
Low Voltage Lighting Transformer (15kVA)	480	3	-	MCE-1	15.0	12.47	10.60	1.00	
Total Power Allocation	**480**	**3**			**287.5**	**239.0**	**203.2**		

*Assumes correction for motor efficiency (calculated at 85%)
**Values taken from 2017 NEC

SITE LOAD SCHEDULE

NOT TO SCALE

DRAWING NOTES

1. MCE-1 SHALL BE EQUIPPED WITH A SURGE PROTECTION DEVICE (SPD) RATED AT A MINIMUM CAPACITY OF 50 KV. IT SHALL BE INTEGRAL TO MCE-1 & INSTALLED WITHIN 12" OF CABLE CONNECTION WITH NO BENDS IN CONDUIT SYSTEM.
2. DISCONNECT DSC-1 SHALL BE EQUIPPED WITH CURRENT-LIMITING FUSES.
3. HAZARDOUS AREA CLASSIFICATION DEFINED IN NFPA-497A PUBLICATION, 2017 VERSION.
4. CIRCUIT BREAKER INTERRUPT CAPACITY BASED ON ESTIMATES OF EXPECTED UTILITY SHORT CIRCUIT CURRENT RATING COMBINED WITH LAYOUT GEOMETRY OF EQUIPMENT ON SITE.
5. HEAT TRACE PANEL EQUIPPED WITH NECESSARY CONNECTIONS FOR CONVEYANCE PIPING HEAT TRACE.
6. REFERENCE P&ID AND CONTROL PANEL DRAWINGS FOR DETAILS

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FILE LOCATION:
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DUAL-PHASE EXTRACTION AND
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CALUMET MONTANA REFINING, LLC,
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DUAL-PHASE EXTRACTION SYSTEM ELECTRICAL ONE-LINE DIAGRAM

PROJECT# 1690014124-003

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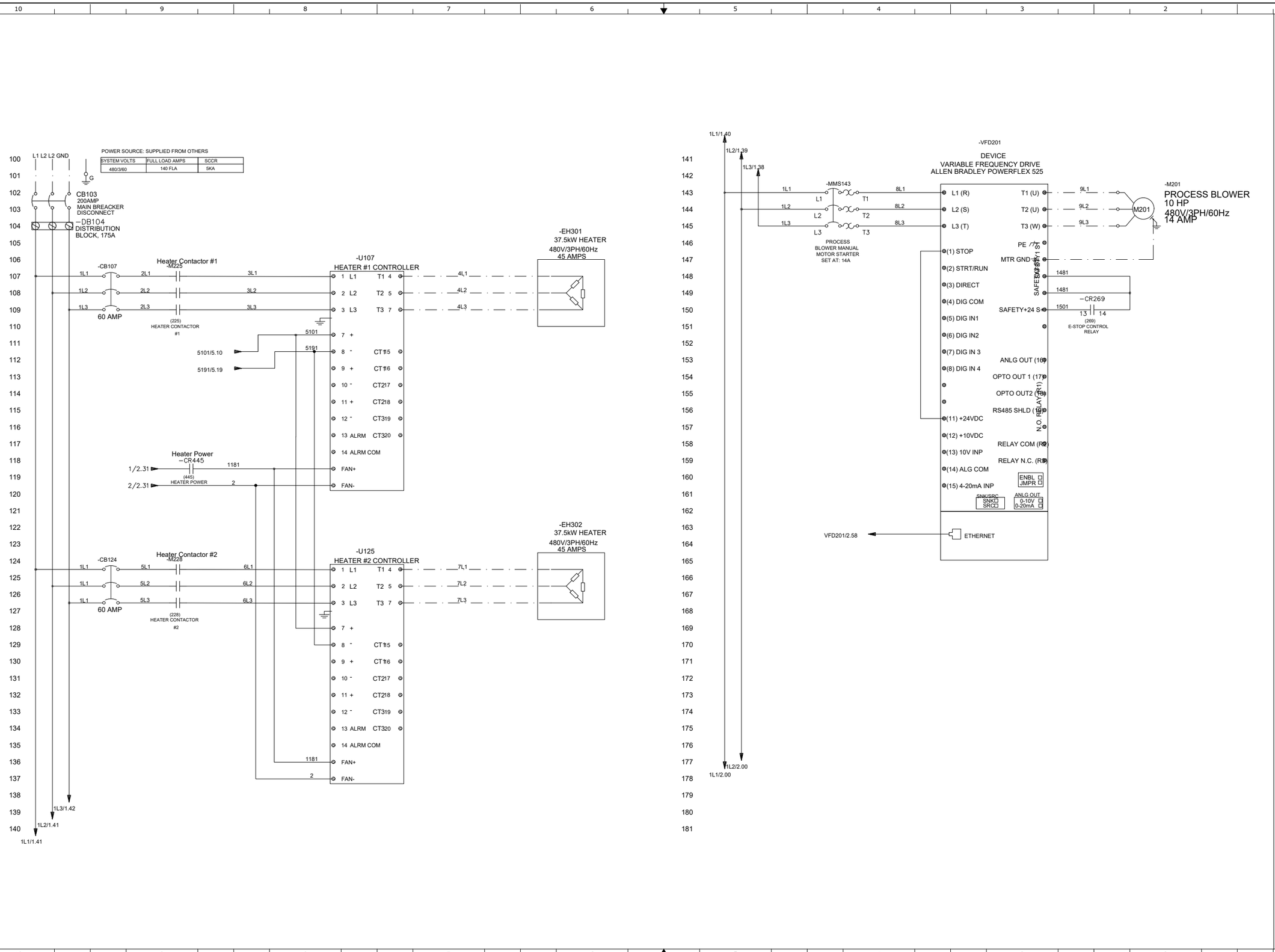

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DUAL-PHASE EXTRACTION AND
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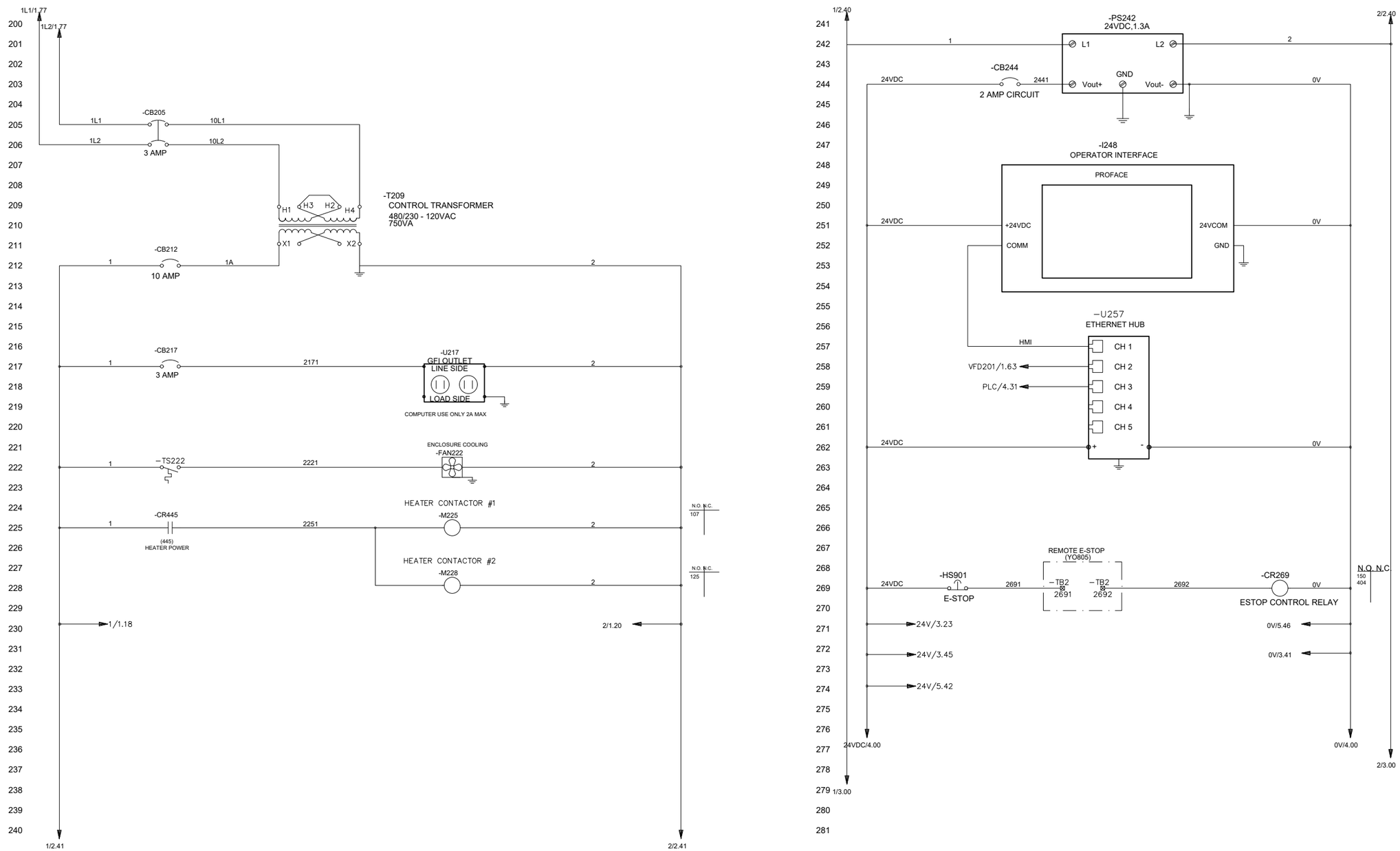
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

PROJECT# 1690014124-003

DRAWING
E3
SHEET 1 OF 7



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DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

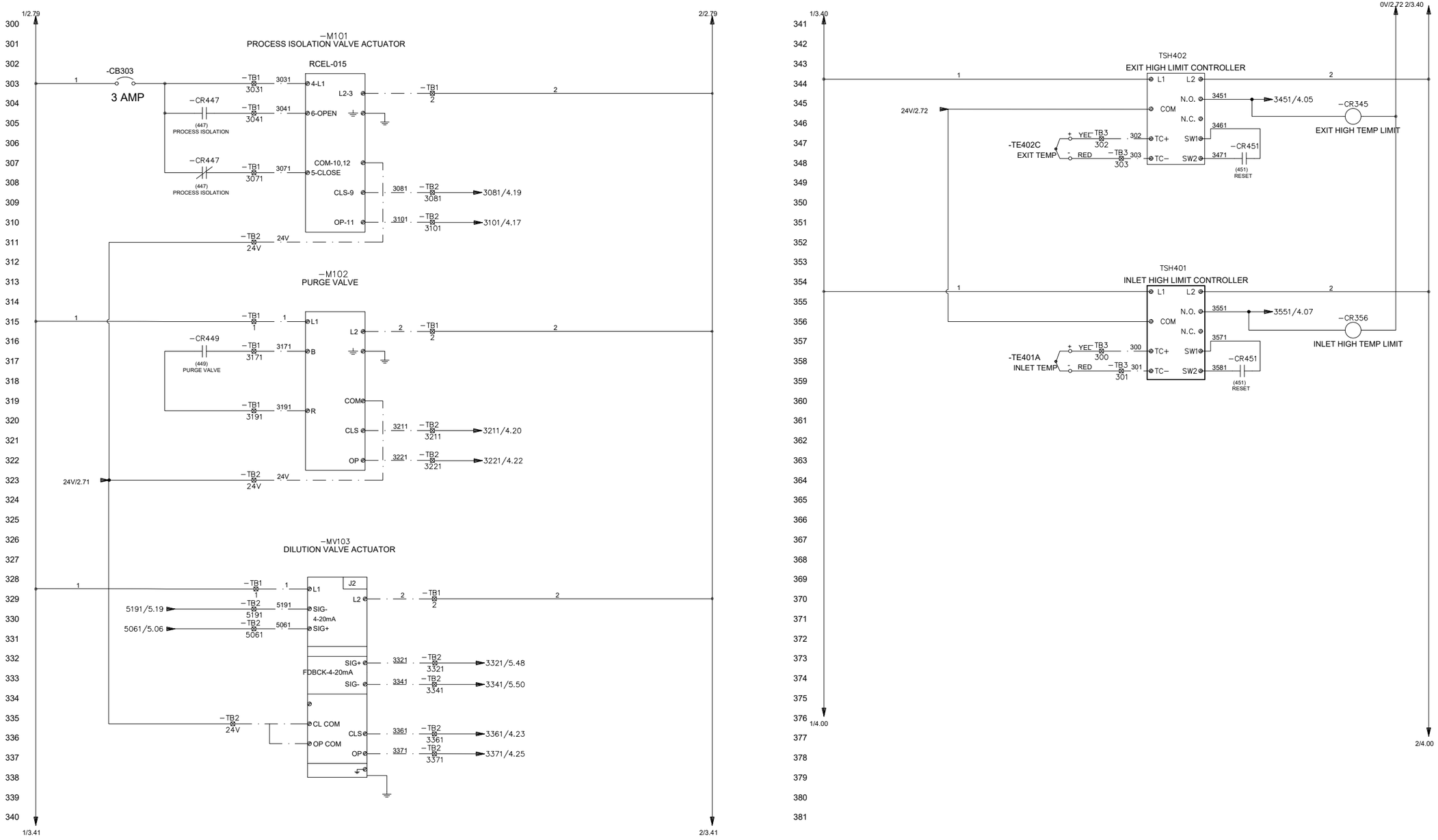
SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

PROJECT # 1690014124-003

DRAWING

E3

SHEET 2 OF 7



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One-Line Diagram (Sheet 3 of 7).dwg

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CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

PROJECT# 1690014124-003

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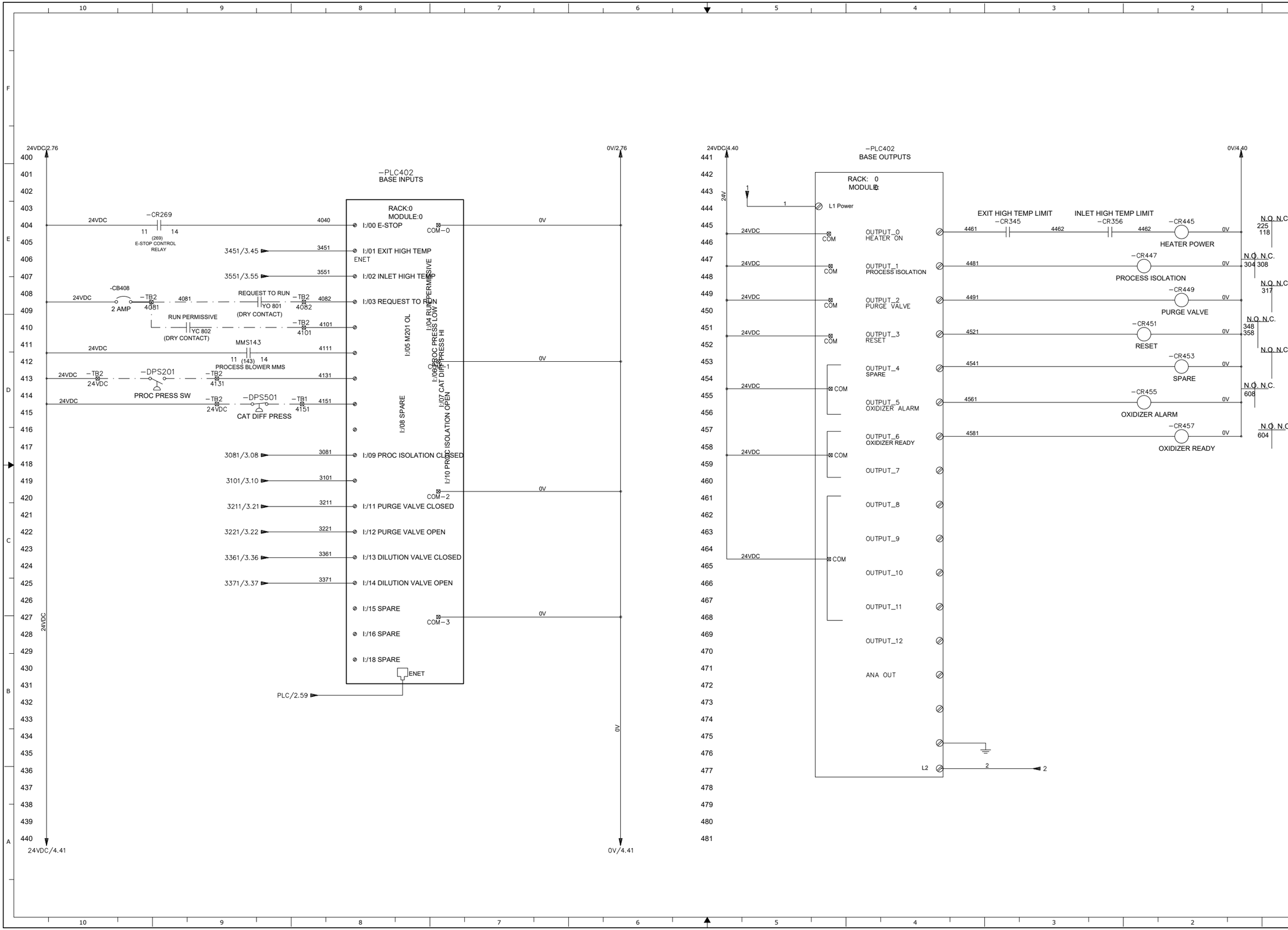
E3
SHEET 3 OF 7



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1900 10TH STREET, GREAT FALLS, MONTANA

SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

PROJECT# 1690014124-003

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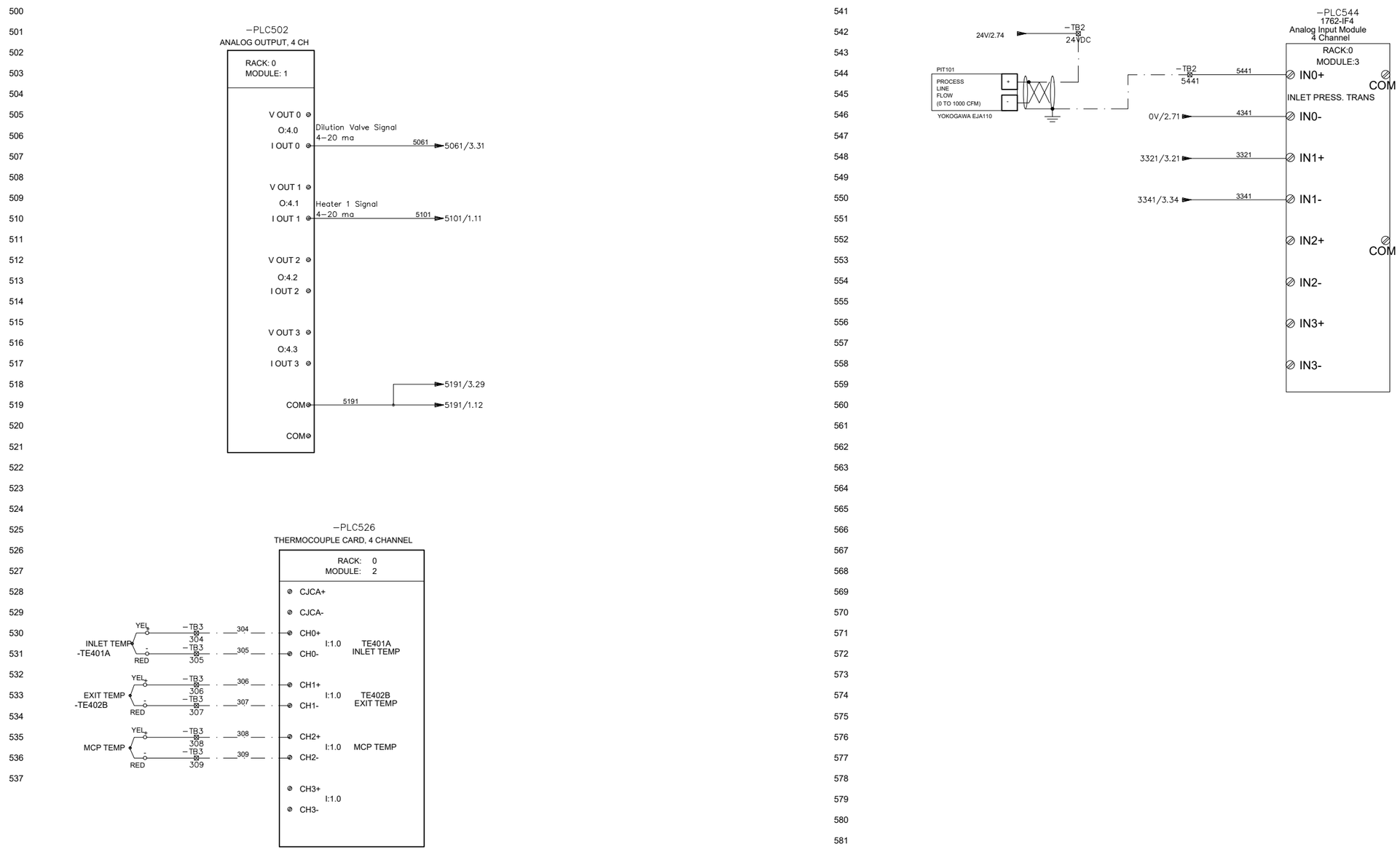
SHEET 4 OF 7



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SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

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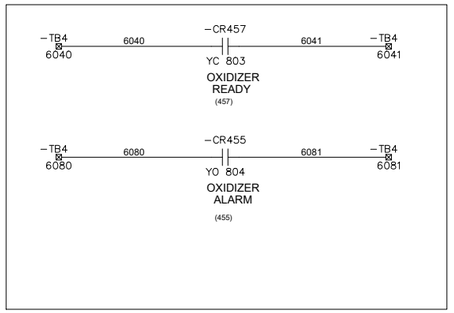
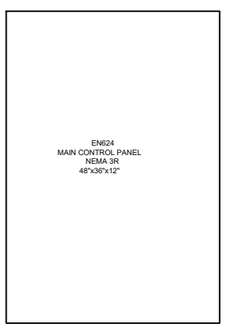
SHEET 5 OF 7

DRY CONTACT INTERLOCKS





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Designs\E3 Self-recuperative Catalytic Oxidizer Electrical
One-Line Diagram (Sheet 6 of 7).dwg

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DUAL-PHASE EXTRACTION AND
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CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

PROJECT # 1690014124-003

DRAWING
E3
SHEET 6 OF 7

OXIDIZER WIRING INFORMATION

PANEL WIRE ASSIGNMENTS

120VAC - RED, 18 AWG, THHN, STRANDED
N (2) - WHITE, 16 AWG, THHN, STRANDED
24VAC - PURPLE, 16 AWG, THHN, STRANDED
24VDC - BLUE, 18 AWG, THHN, STRANDED
0VDC - WHITE w/ BLUE STRIPE, 18 AWG, THHN, STRANDED
THERMOCOUPLE - TYPE-K EXTENSION WIRE, 20AWG
4-20mA - TWISTED PAIR, 20 AWG
EXTERNAL INTERFACE WIRING - YELLOW, 16 AWG, THHN, STRANDED

CONDUIT AND WIRING NOTES

1) NO CONDUIT HOLES IN TOP OF CONTROL PANEL
2) PREVENT FILINGS FROM FALLING ON CONTROL COMPONENTS WHILE DRILLING KNOCKOUT HOLES
3) ENSURE ALL CONDUIT CONNECTIONS INTO CONTROL PANEL ARE TIGHT AND WATERPROOF
4) INSTALL A MINIMUM 1/2" X 8' COPPER GROUNDING ROD TO BE CONNECTED TO CHASIS OF OXIDIZER BASE

INCOMING POWER:

SYSTEM VOLTS	FULL LOAD AMPS	
480/3/60	140	

INCOMING POWER IS SUPPLIED BY OTHERS TO THE MAIN PANEL DISCONNECT SEE SCHEMATIC LINE 101.

WIRE MUST BE SIZED TO ME NEC & LOCAL CODE REQUIREMENTS

TERMINAL DESIGNATION & INTERFACE WIRING

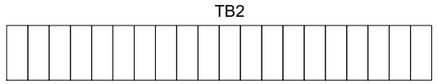
TB3
THERMCOUPLE TERMINALS
TYPE-K

WARNING!!!!!

INCORRECT CONNECTIONS WILL CAUSE PERMANENT SYSTEM DAMAGE!!!

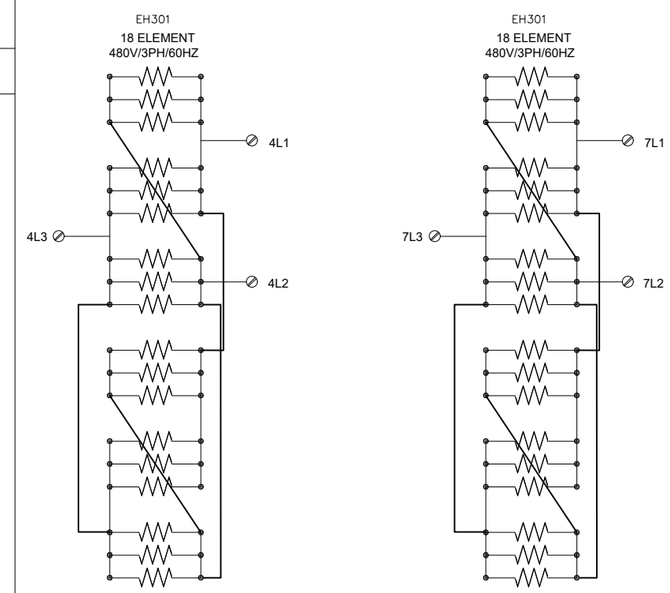
VERIFY INTERCONNECTION WIRING PRIOR TO ENERGIZING SYSTEM

TB2



TB1

OXIDIZER MAIN PANEL	(NOT ALL ARE REQUIRED)	OTHERS PANEL
OXIDIZER READY TB2:6040 OXIDIZER READY TB2:6041	N.O. →	SIGNAL FROM OXIDIZER: CLOSES WHEN OXIDIZER IS READY
OXIDIZER ALARM TB2:6080 OXIDIZER ALARM TB2:6081	N.O. →	SIGNAL FROM OXIDIZER: OPENS WHEN OXIDIZER HAS NO ALARM CONDITION.
RUN PERMISSIVE TB1:4081 RUN PERMISSIVE TB2:4101	←	SIGNAL TO OXIDIZER: CLOSES TO INDICATE THAT SVE IS RUNNING. (CONNECTED TO AUX CONTACTS ON BLOWER)
REQUEST TO RUN TB1:4081 REQUEST TO RUN TB2:4082	← JUMPER INSTALLED IF NOT USED	SIGNAL TO OXIDIZER: OPENS TO REMOTELY SHUTDOWN OXIDIZER.



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CALUMET MONTANA REFINING, LLC,
1900 10TH STREET, GREAT FALLS, MONTANA

SELF-RECUPERATIVE CATALYTIC OXIDIZER ELECTRICAL ONE-LINE DIAGRAM

PROJECT # 1690014124-003

DRAWING
E3
SHEET 7 OF 7

APPENDIX B

PRE-DESIGN INVESTIGATION RESULTS

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APPENDIX B1
GROUNDWATER ANALYTICAL RESULTS TABLE

Table 1
Groundwater Analytical Results
Calumet Montana Refining, LLC - Great Falls, Montana

Location Field Sample ID Lab Sample ID Sample Date Comments	Montana DEQ-7 Human Health Standards - Groundwater	Montana DEQ Tier 1 Groundwater RBSLs	MW-041S CMR-MW41S-200622 VF24007-001 6/22/2020	MW-056S CMR-MW56S-200623 VF24007-006 6/23/2020	MW-059S CMR-MW59S-200622 VF24007-005 6/22/2020	TW-202D CMR-TW202D-200622 VF24007-003 6/22/2020	TW-202S CMR-TW202S-200622 VF24007-004 6/22/2020	TW-203S CMR-TW203S-200622 VF24007-002 6/22/2020
VOC								
Acetone	--	--	220 (40)	U (400)	6.4 J (4)	100 (4)	280 (20)	480 (40)
Benzene	5	5	**1000 (4)**	**5800 (40)**	U (0.4)	3.8 (0.4)	**290 (2)**	**96 (4)**
Bromodichloromethane	10		U (4)	U (40)	U (0.4)	0.96 (0.4)	U (2)	0.81 (0.4)
2-Butanone	--	--	89 J (20)	U (200)	U (2)	19 (2)	87 (10)	290 (2)
Carbon Disulfide	--	--	U (4)	U (40)	U (0.4)	U (0.4)	U (2)	1.1 (0.4)
Chloroform	70		4 J (4)	U (40)	U (0.4)	3.1 (0.4)	4.5 (2)	4.9 (0.4)
Cumene	--	--	10 (4)	61 (40)	U (0.4)	U (0.4)	8.5 (2)	11 (0.4)
Cyclohexane	--	--	24 (4)	320 (40)	U (0.4)	U (0.4)	29 (2)	25 (0.4)
Ethyl Benzene	700	700	370 (4)	**860 (40)**	U (0.4)	2.3 (0.4)	240 (2)	25 (4)
2-Hexanone	--	--	U (20)	U (200)	U (2)	4.4 J (2)	12 J (10)	16 (2)
Methyl tert-butyl ether	30	30	U (4)	U (40)	U (0.4)	0.95 (0.4)	U (2)	U (0.4)
4-Methyl-2-pentanone	--	--	U (20)	U (200)	U (2)	13 (2)	19 J (10)	26 (2)
Methylcyclohexane	--	--	11 J (4)	170 J (40)	U (0.4)	0.82 J (0.4)	16 J (2)	12 (0.4)
Naphthalene	100	100	31 (4)	**160 (40)**	U (0.4)	0.91 (0.4)	16 (2)	3 (0.4)
Toluene	1000	1000	82 (4)	680 (40)	U (0.4)	2.1 (0.4)	9.3 (2)	19 (0.4)
meta-xylene	10000		550 (4)	630 (40)	U (0.4)	9.2 (0.4)	200 (2)	64 (4)
ortho-xylene	10000		67 (4)	150 (40)	U (0.4)	6.3 (0.4)	12 (2)	16 (0.4)
Xylenes (total)	10000	10000	620 (4)	770 (40)	U (0.4)	16 (0.4)	210 (2)	64 (4)
SVOC								
Acenaphthene	70	70	U (0.4)	0.43 J (0.2)	U (0.04)	0.19 J (0.04)	U (0.4)	U (0.04)
bis(2-Ethylhexyl)phthalate	6		**11 BJ (5)**	U (2.5)	2.6 BJ (0.5)	1.1 BJ (0.5)	U (5)	1.4 BJ (0.5)
Diethylphthalate	600		U (5)	U (2.5)	U (0.5)	0.98 (0.5)	U (5)	0.53 J (0.5)
2,4-Dimethylphenol	100		84 (4.8)	27 (2.4)	U (0.48)	U (0.48)	24 (4.8)	74 (4.8)
Di-n-butylphthalate	20		6.1 BJ (5)	U (2.5)	0.83 B (0.5)	1.1 B (0.5)	U (5)	0.77 BJ (0.5)
Fluorene	50	50	U (0.3)	1.4 (0.15)	U (0.03)	0.36 (0.03)	0.85 J (0.3)	U (0.03)
2-Methylnaphthalene	--	36	5.4 (0.4)	37 (0.2)	0.047 J (0.04)	U (0.04)	4.8 (0.4)	0.27 (0.04)
2-Methylphenol	--	--	U (2.1)	8.7 (1.1)	U (0.21)	U (0.21)	U (2.1)	U (0.21)
4-Methylphenol	--	--	U (15)	12 (7.5)	U (1.5)	U (1.5)	U (15)	U (1.5)
Naphthalene	100	100	24 B (0.5)	84 B (0.25)	0.074 BJ (0.05)	U (0.05)	2.2 B (0.5)	U (0.05)
Phenanthrene	--	--	U (0.6)	0.85 J (0.3)	U (0.06)	0.22 (0.06)	U (0.6)	U (0.06)
Phenol	4000		53 (5)	75 (2.5)	U (0.5)	U (0.5)	U (5)	U (0.5)
MTDEQ VPH								
C5-C8 Aliphatics	--	650	680 J (150)	5400 J (1500)	29 J (15)	59 J (15)	760 (75)	530 (75)
C9-C12 Aliphatics	--	1400	1700 (150)	U (1500)	U (15)	120 (15)	630 (75)	880 (75)
C9-C10 Aromatics	--	1100	1100 (50)	1200 J (500)	U (5)	170 (5)	1400 (25)	1000 (25)
Benzene	5	5	**1100 (5.1)**	**5500 (51)**	U (0.51)	3.9 J (0.51)	**290 (2.6)**	**240 (2.6)**
Ethyl Benzene	700	700	410 (6.2)	**780 (62)**	U (0.62)	1.9 J (0.62)	260 (3.1)	110 (3.1)
Naphthalene	100	100	45 J (7)	**160 J (70)**	U (0.7)	6.8 (0.7)	27 (3.5)	6.2 J (3.5)
Petroleum Hydrocarbons (Total)	--	--	5000 (350)	14000 J (3500)	U (35)	370 (35)	3500 (180)	3500 (180)
Toluene	1000	1000	84 (5.3)	710 (53)	U (0.53)	2.7 J (0.53)	14 J (2.7)	11 J (2.7)
meta-xylene	10000		610 (12)	590 (120)	U (1.2)	7.7 (1.2)	220 (6)	590 (6)
ortho-xylene	10000		79 (5.8)	160 J (58)	U (0.58)	6.5 (0.58)	15 J (2.9)	17 J (2.9)
Xylenes (total)	10000	10000	1332 (5.8)	1520 (58)	U (1.2)	22.8 (1.2)	475 (6)	1418 (6)
MTDEQ EPH								
C9-C18 Aliphatics	--	1400	U (320)	740 (330)		U (670)		
C11-C22 Aromatics	--	1100	U (320)	520 (330)		U (670)		
EPH - Total	--	--	4300 (650)	4100 (670)	270 (210)	1900 (1300)		
EPH - Fractionated	--	--	U (320)	1500 (330)		U (670)		

Table 1
Groundwater Analytical Results
Calumet Montana Refining, LLC - Great Falls, Montana

Location Field Sample ID Lab Sample ID Sample Date Comments	Montana DEQ-7 Human Health Standards - Groundwater	Montana DEQ Tier 1 Groundwater RBSLs	MW-041S CMR-MW41S-200622 VF24007-001 6/22/2020	MW-056S CMR-MW56S-200623 VF24007-006 6/23/2020	MW-059S CMR-MW59S-200622 VF24007-005 6/22/2020	TW-202D CMR-TW202D-200622 VF24007-003 6/22/2020	TW-202S CMR-TW202S-200622 VF24007-004 6/22/2020	TW-203S CMR-TW203S-200622 VF24007-002 6/22/2020
INORG								
Antimony	6		0.9 J (0.5)	U (0.5)	1.8 J (0.5)	0.55 J (0.5)	1.1 J (0.5)	1.1 J (0.5)
Arsenic	10		5.2 (1.3)	1.6 J (1.3)	**27 (1.3)**	3.2 (1.3)	1.8 J (1.3)	4.1 (1.3)
Barium	1000	--	290 (1.3)	220 (1.3)	55 (1.3)	320 (13)	190 (1.3)	240 (1.3)
Cadmium	5		0.15 J (0.13)	U (0.13)	0.49 J (0.13)	U (0.13)	U (0.13)	U (0.13)
Cobalt	--	--	U (1.3)	U (1.3)	7.1 (1.3)	U (1.3)	U (1.3)	U (1.3)
Copper	1300	--	5.9 (1.3)	5.5 (1.3)	61 (1.3)	2.5 J (1.3)	3.5 J (1.3)	1.9 J (1.3)
Lead	15		U (0.25)	0.9 J (0.25)	0.5 J (0.25)	U (0.25)	0.36 J (0.25)	U (0.25)
Nickel	100	--	3.7 J (1.3)	U (1.3)	12 (1.3)	1.9 J (1.3)	3 J (1.3)	2.2 J (1.3)
Selenium	50		1.6 J (1.3)	U (1.3)	U (1.3)	2.5 J (1.3)	3.3 J (1.3)	6.8 (1.3)
Vanadium	--	--	3.7 J (2.5)	U (2.5)	U (2.5)	6.7 (2.5)	2.8 J (2.5)	3.7 J (2.5)
Zinc	2000	--	U (2.5)	15 (2.5)	79 (2.5)	U (2.5)	4.8 J (2.5)	U (2.5)

Notes:
1 All concentrations are presented in ug/L (ppb).
2 Only compounds with at least one detection are shown.
3 Concentrations that exceed the Montana DEQ-7 Human Health Standards - Groundwater are **boldfaced**.
4 Concentrations that exceed the Montana DEQ Tier 1 Groundwater RBSLs are underlined.

Abbreviations:
U -- Not Detected.
J -- Estimated Concentration.
B -- Blank Contamination.
( ) -- Sample Quantitation Limit.
-- --No Standard or Not Analyzed.
VOCs -- Volatile Organic Compounds.
SVOCs -- Semi Volatile Organic Compounds.
MT VPH -- Montana Volatile Petroleum Hydrocarbon Method.
MT EPH -- Montana Extractable Petroleum Hydrocarbon Method.
INORG -- Inorganics.

APPENDIX B2
BORING LOGS

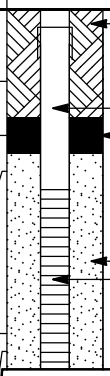
Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID: **MW-105**
BORING NUMBER: **MW-105**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/17/20 **COMPLETED** 6/17/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 10 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 10 ft bgs **SCREEN INTERVAL** 5-10 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						
		5.6				(SC) **SAND**, fine to very fine with clay, gray (10YR 5/1), trace fine gravel, soft, moist, low plasticity, trace rootlets.
		361.5				2.0 (SM) **SILTY SAND**, dusky red (10R 3/3), firm, dry, medium dense, hydrocarbon odor.
		4.7				3.5 (CL) **SANDY CLAY**, little fine sand, pale brown (10YR 6/3), soft, slightly moist, medium plasticity.
5						4.5 (SM) **VERY FINE SAND AND SILT**, dusky red (10R 3/3), gray mottling, hard, dense, dry, weakly laminated, diminishing mottling from 7-9 feet, very dense, hydrocarbon odor.
		5.2				
		209.1				
		343.3				9.0
10		100.3				9.5 (CL) **FINE SANDY CLAY**, dusky red (10R 3/3), gray mottling, soft, wet, medium plasticity, hydrocarbon odor. 10.0 (SM) **VERY FINE SAND AND SILT**, dusky red (10R 3/3), gray mottling, less dense, dry to slightly moist, faint hydrocarbon odor.

Bottom of borehole at 10.0 feet.



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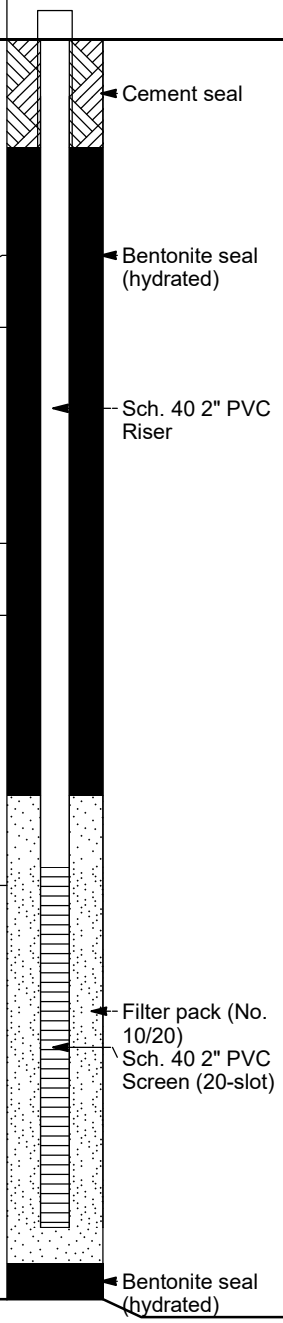
Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID: **MW-41D**
BORING NUMBER: **MW-41D**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/18/20 **COMPLETED** 6/18/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 35 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 33 ft bgs **SCREEN INTERVAL** 23-33 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						(SM) **SILTY FINE SAND (FILL)**, dusky red (10R 3/3) with grayish brown mottling, some clay, moist, medium dense, low plasticity, rootlets throughout.
		14.1				
5						(SP) **FINE TO VERY FINE SAND (FILL)**, pale brown (10YR 6/3), trace fines, soft, moist, loose, hydrocarbon odor increasing in strength with depth toward uderlying sandstone.
		82.8				6.0 **LITHIFIED SAND**, gray (10YR 5/1), competent, thinly bedded.
		390				8.0
		118.7				(SM) **FINE TO VERY FINE SAND AND SILT**, gray (10YR 5/1), brownish yellow mottling, hard to firm, slightly moist, weakly laminated, hydrocarbon odor.
10		322				(SP) **VERY FINE SAND**, little silt, dusky red (10R 3/3), medium dense to dense, dry to slightly moist, hydrocarbon odor dissipating in strength with depth.
		106				
		23				
		1.6				14.0
15		1.7				(SP) **VERY FINE SAND**, gray (10YR 6/1), very hard, dry, dense, strongly cemented, no hydrocarbon odor.
		1.7				16.0
		0.5				(SM) **VERY FINE SAND AND SILT**, dusky red (10R 3/3), dense, dry, weakly laminated.
20		0.6				(ML) **SILT**, dusky red (10R 3/3), trace very fine sand, firm to hard, dry, weakly laminated.
		0.9				(ML) **SAME AS ABOVE**, intermixed with gray (10YR 6/1), dry to slightly moist.
						23.5 (ML) **SILT**, gray (10YR 6/1), trace orangish brown mottling, firm, medium dense.
25		0.6				
		0.5				
30		0.6				
		0.5				
		0.3				
35						

WELL CONSTRUCTION



Bottom of borehole at 35.0 feet.

RAMBOLL BASIC SB & WELL LOG - GINT STD US LAB.GDT - 7/2/20 09:27 - D:\PROJECTS\GINT\PROJECT\CMR - GREAT FALLS, MT\CMR_MW_INSTALL_AOC-16_IMD_JUNE2020.GPJ

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

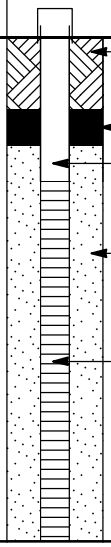
WELL ID: **MW-41S**
BORING NUMBER: **MW-41S**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/18/20 **COMPLETED** 6/18/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 14 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 14 ft bgs **SCREEN INTERVAL** 4-14 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						**See MW-41D for Lithology.**
5			CMR-MW41S-4.0-5.0-200618-ST			
10			CMR-MW41S-9.0-10.0-200618-ST	▼		
			CMR-MW41S-12.0-13.0-200618-ST			

Bottom of borehole at 14.0 feet.

WELL CONSTRUCTION



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1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID: **MW-56S**
BORING NUMBER: **MW-56S**

CLIENT	Calumet Montana Refining, LLC	**PROJECT NAME**	MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER	1690017652; 1690014124-003	**PROJECT LOCATION**	Great Falls, MT
DATE STARTED	6/17/20 **COMPLETED** 6/17/20	**LOGGED BY**	Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR	Cascade	**GROUND ELEVATION**	Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT	Boart Longyear LS250 MiniSonic	**NORTHING**	Not Measured **EASTING** Not Measured
DRILLER	Aaron Bradley	**TOTAL BORING DEPTH**	16 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD	Sonic	**TOTAL WELL DEPTH**	14 ft bgs **SCREEN INTERVAL** 4-14 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						0.3 **ASPHALT**	Cement seal and flushmount well completion
						1.0 **FINE SAND AND CLAY FILL (FILL)**, grayish brown, fine gravel throughout.	
		7.8				2.0 **LITHIFIED SAND**, gray (10YR 5/1), competent.	Bentonite seal (hydrated)
		4.8				(SP) **FINE SAND**, yellowish brown (10YR 5/4), little very fine sand, trace fines, some ~1cm layers of clay, loose, increasing density with depth, dry, slightly moist at depth.	
5		5.1					
		326				(SP) **SAME AS ABOVE**, strong hydrocarbon odor and hydrocarbon staining at 5 ft bgs, 0.25 foot clay layer, yellowish brown (10YR 5/4) with gray mottling, moist to wet, soft, medium plasticity.	
		180.5		▼			
		181.5					
		249.6					Filter pack (No. 10/20)
10		394				(SP) **SAME AS ABOVE** gray (10YR 5/1) from 2 to 5 ft bgs.	Sch. 40 PVC Screen (20-slot)
		218.5					
		20.5					
15						(SP) **VERY FINE SAND WITH SILT**, gray (10YR 6/1), firm, medium dense, dry to slightly moist.	
		6.4				16.0	Bentonite seal (hydrated)

Bottom of borehole at 16.0 feet.

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Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID:
BORING NUMBER: **SB-200**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/15/20 **COMPLETED** 6/15/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 10 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 10 ft bgs **SCREEN INTERVAL** 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						(SP) **FINE SAND**, dark brown (10YR 3/3), trace medium sand, little fines, loose, slightly moist, trace rootlets.	Abandoned with bentonite chips (hydrated)
		139.2				(SP) **SAME AS ABOVE**, some light gray mottling, very firm, dense, hydrocarbon odor.	
		55.5					
5		398.5				5.0	
		337.1	CMR-SB200-6.0-7.0-200615			(SW) **SAND**, black (10YR 2/1), medium to fine sand, soft, loose, moist to wet, strong hydrocarbon odor, hydrocarbon staining.	
						7.0	
						8.0 (CL) **CLAY AND SILT**, dark gray (5Y 6/1), reddish brown and brownish yellow mottling, firm, moist, low to medium plasticity, hydrocarbon odor.	
		402.6					
10		397.8				10.0 (SP) **VERY FINE TO FINE SAND WITH SILT**, gray (5Y 6/1) with trace brownish yellow mottling, stiff, dense, dry, weakly laminated.	

Bottom of borehole at 10.0 feet.

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Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID:
BORING NUMBER: **SB-201**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/15/20 **COMPLETED** 6/15/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 10 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 10 ft bgs **SCREEN INTERVAL** 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							
		220.3				(SP) **FINE SAND**, dark brown (10YR 3/3), trace medium sand, little fines, trace rootlets, moderately loose, slightly moist. (SP) **SAME AS ABOVE**, dark yellowish brown (10YR 4/4), hard, medium dense, hydrocarbon odor.	
						4.0	
5		588.3 433.5	CMR-SB201-6.0-7.0-200615			(SW) **SAND**, medium to fine sand, soft, loose, unconsolidated, moist, increasing density and fines with depth, strong hydrocarbon odor, hydrocarbon staining.	Abandoned with bentonite chips (hydrated)
		434.1 427.2				8.0	
						(SP) **VERY FINE TO FINE SAND WITH SILT**, gray (5Y 6/1), trace brownish yellow mottling, dry with increasing moisture with depth, medium dense to dense, weakly laminated.	
						9.5	
10						10.0	
						SANDSTONE, gray (10YR 5/1).	

Bottom of borehole at 10.0 feet.

RAMBOLL BASIC SB & WELL LOG - GINT STD US LAB.GDT - 7/2/20 09:27 - D:\PROJECTS\GINT\PROJECT\CMR - GREAT FALLS, MT\CMR_MW_INSTALL_AOC-16_IMD_JUNE2020.GPJ

Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID: **TW-202D**
BORING NUMBER: **SB-202D**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/16/20 **COMPLETED** 6/16/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 20 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 17 ft bgs **SCREEN INTERVAL** 12-17 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						(SM) **SILTY SAND (FILL)**, dusky red (10R 3/3) to pale brown (10YR 6/3), little clay, trace rootlets, medium density, slightly moist, hydrocarbon odor, hydrocarbon staining.	Cement seal and flushmount well completion
		265.4					
		81.7				(SP) **FINE SAND AND SILT (FILL)**, gray (10YR 5/1), brownish yellow mottling, firm, dense, moist, weakly laminated.	
						3.5 **LITHIFIED SAND**, gray (10YR 5/1), competent, thinly bedded.	Bentonite seal (hydrated)
5							
		264.5				6.0 (SP-SM) **FINE SAND AND SILT**, gray (10YR 5/1), brownish yellow mottling, grades to weak red (10R 5/2), hard, very dense, hydrocarbon odor.	Sch. 40 1" PVC Riser
		8.2					
		394.8				(SP) **VERY FINE SAND**, dusky red (10R 3/3), some silt, hard, dense, dry, hydrocarbon odor.	
		373.2					
10		43.9				(SP) **SAME AS ABOVE**, little silt, soft to firm, low to medium dense, moist.	
		12.6				12.0 (SP) **VERY FINE SAND**, gray (10YR 6/1), strongly cemented, very hard, dense, dry.	
		6.2					
		7.4					Filter pack (No. 10/20)
15				▼		15.8	Sch. 40 1" PVC Screen (20-slot)
		10.1				16.0 (CL) **CLAY**, dusky red (10R 3/3) with gray mottling, soft, moist, medium plasticity.	
		8.4					
		5.4				18.0 (ML) **SILT**, dusky red (10R 3/3), trace very fine sand, hard, dense, dry.	
20		2.5				20.0 (ML) **SILT WITH FINE SAND**, gray (10YR 6/1) with brownish yellow mottling, firm, medium dense, dry, weakly laminated.	Bentonite seal (hydrated)

Bottom of borehole at 20.0 feet.

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Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID: **TW-202S**
BORING NUMBER: **SB-202S**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/16/20 **COMPLETED** 6/16/20
LOGGED BY Brooks Bailey **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 12 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 12 ft bgs **SCREEN INTERVAL** 7-12 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						**See SB-202D for Lithology.**	Cement seal and flushmount well completion
5							Sch. 40 1" PVC Riser Bentonite seal (hydrated)
10				▼			Filter pack (No. 10/20) Sch. 40 1" PVC Screen (20-slot)

Bottom of borehole at 12.0 feet.

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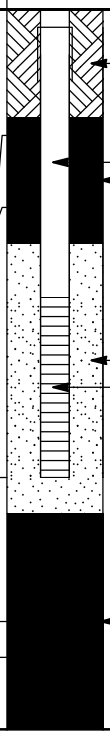
Ramboll
1560 Broadway Suite 1905
Denver, CO 80202
Telephone: 303-382-5460

WELL ID: **TW-203S**
BORING NUMBER: **SB-203**

CLIENT Calumet Montana Refining, LLC
PROJECT NAME MW Install; AOC-16 Interim Measures Design
PROJECT NUMBER 1690017652; 1690014124-003
PROJECT LOCATION Great Falls, MT
DATE STARTED 6/16/20 **COMPLETED** 6/16/20
LOGGED BY Brooks Bailey/Kit Carson **CHECKED BY** Kit Carson
DRILLING CONTRACTOR Cascade
GROUND ELEVATION Not Measured **TOC ELEVATION** Not Measured
DRILLING EQUIPMENT Boart Longyear LS250 MiniSonic
NORTHING Not Measured **EASTING** Not Measured
DRILLER Aaron Bradley
TOTAL BORING DEPTH 20 ft bgs **BOREHOLE SIZE** 4.5 in
DRILLING METHOD Sonic
TOTAL WELL DEPTH 13 ft bgs **SCREEN INTERVAL** 8-13 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							
		32.5					(SM) **SILTY SAND (FILL)**, dusky red (10R 3/3) to pale brown (10YR 6/3), little clay, trace rootlets, medium density, slightly moist.
		9.8					(SP) **FINE TO VERY FINE SAND (FILL)**, pale brown (10YR 6/3), soft, loose, moist.
		8.1				3.5	(SP-SM) **FINE SAND AND SILT (FILL)**, gray (10YR 5/1) with brownish yellow mottling, firm to hard, dense, slightly moist, weakly laminated.
5		7.9				5.5	**LITHIFIED SAND**, gray (10YR 5/1), competent, thinly bedded.
		8.4					(SP-SM) **FINE SAND AND SILT**, gray (10YR 5/1), brownish yellow mottling, grades to weak red (10R 5/2).
		8.3					(SP-SM) **VERY FINE SAND AND SILT**, dusky red (10R 3/3), hard, dense.
		122					(SP) **VERY FINE SAND**, dusky red (10R 3/3), little silt, firm, medium density, moist, hydrocarbon odor, hydrocarbon staining.
10		175					
		113.6		▼		13.0	(SP) **SAME AS ABOVE**, dense, dry to slightly moist, faint hydrocarbon odor.
		7.7					(SP) **VERY FINE SAND**, gray (10YR 6/1), very hard, dense, dry, strongly cemented.
15		21.1				17.0	
		14.9				18.0	(ML) **SILT**, dusky red (10R 3/3), trace very fine sand, dense, dry.
20		12.3				20.0	(ML) **SILT WITH FINE SAND**, gray (10YR 6/1), dusky red and brownish yellow mottling, firm, medium dense, weakly laminated.

WELL CONSTRUCTION



Bottom of borehole at 20.0 feet.

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APPENDIX B3
WELL CONSTRUCTION LOGS

Form No. 603 R2-04

MONTANA WELL LOG REPORT

Well ID# MW-41D

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with Mt. Bureau of Mines & Geology within 60 days of completion of the work.** Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Calumet Montana Refining LLC
Mailing address 1900 10th St NE Great Falls MT 59404

2. WELL LOCATION: List ¼ from smallest to largest
____ ¼ ____ ¼ NE ¼ NE ¼, Section 1
Township 20n N/S Range 3e E/W County Cascade
Lot ____, Tract/Blk ____ Subdivision Name ____
Well Address ____
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☒ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☐ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: Sonic

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 6 in. from 0 ft. to 10 ft.
Dia. 4 in. from 10 ft. to 35 ft.
Dia. ____ in. from ____ ft. to ____ ft.

Casing:
Steel: Wall thickness ____ ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

Plastic: Pressure Rating SCH 40 lbs. ☒ Threaded ☐ Welded
Dia. 2 in. from +3 ft. to 23 ft.

Perforations/Slotted Pipe:
Type of perforator used ____
Size of perforations/slots ____ in. by ____ in.
____ no. of perforations/slots from ____ ft. to ____ ft.
____ no. of perforations/slots from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No
Material PVC
Dia. 2 Slot size .010 from 23 ft. to 33 ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel Packed: ☒ Yes ☐ No
Size of gravel 10x20
Gravel placed from 21 ft. to 33 ft.

Packer: ☐ Yes ☐ No
Type ____ Depth(s) ____

Grout: Material used Bentonite
Depth from 0 ft. to 21 ft. OR ☐ Continuous feed
33 35

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level ____ ft. below top of casing or
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ____
Yellowstone Controlled Groundwater Area - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft. for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	5	Dirt
5	35	Sand Stone Rock

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: June 18 2020

9. REMARKS: ____

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Cascade Drilling LP
Address 1920 97th St East, Tacoma, WA 98445
Signature [signature]
Date Aug 6 2020 License no. 700

Montana Bureau of Mines & Geology
The University of Montana
1300 West Park Street
Butte, MT 59701

MBMG ID#

Form No. 603 R2-04

MONTANA WELL LOG REPORT

Well ID# MW-41S

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with Mt. Bureau of Mines & Geology within 60 days of completion of the work.** Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Calumet Montana Refining LLC
Mailing address 1900 10th St NE Great Falls MT 59404

2. WELL LOCATION: List ¼ from smallest to largest
___ ¼ ___ ¼ NE ¼ NE ¼, Section 1
Township 20n N/S Range 3e E/W County Cascade
Lot ___, Tract/Blk ___ Subdivision Name ___
Well Address ___
GPS ☐ Yes ☐ No
Latitude ___ Longitude ___
Error as reported by GPS locator (± feet) ___
Horizontal datum ☐ NAD27 ☒ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ___

4. TYPE OF WORK:
☐ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: Sonic

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 4 in. from 0 ft. to 14 ft.
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.
Casing:
Steel: Wall thickness ___ ☐ Threaded ☐ Welded
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.
Plastic: Pressure Rating SCH 40 lbs. ☒ Threaded ☐ Welded
Dia. 2 in. from +3 ft. to 4 ft.
Perforations/Slotted Pipe:
Type of perforator used ___
Size of perforations/slots ___ in. by ___ in.
___ no. of perforations/slots from ___ ft. to ___ ft.
___ no. of perforations/slots from ___ ft. to ___ ft.
Screens: ☒ Yes ☐ No
Material PVC
Dia. 2 Slot size .010 from 4 ft. to 14 ft.
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
Gravel Packed: ☒ Yes ☐ No
Size of gravel 10x20
Gravel placed from 4 ft. to 14 ft.
Packer: ☐ Yes ☐ No
Type ___ Depth(s) ___
Grout: Material used Bentonite
Depth from 0 ft. to 4 ft. OR ☐ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level ___ ft. below top of casing or
☐ Closed-in artesian pressure ___ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ___
Yellowstone Controlled Groundwater Area - Water Temperature ___ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
___ gpm with drill stem set at ___ ft. for ___ hours
Time of recovery ___ hrs/min. Recovery water level ___ ft.

OR Bailer test*
___ gpm with ___ ft. of drawdown after ___ hours
Time of recovery ___ hrs/min. Recovery water level ___ ft.

OR Pump test*
Depth pump set for test ___ ft.
___ gpm pump rate with ___ ft. of drawdown after ___ hrs pumping
Time of recovery ___ hrs/min. Recovery water level ___ ft.

OR Flowing Artesian*
___ gpm for ___ hours
Flow controlled by ___

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	5	Dirt
5	14	Sand Stone Rock

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: June 18 2020

9. REMARKS: ___

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Cascade Drilling LP
Address 1920 97th St East, Tacoma, WA 98445
Signature [signature]
Date Aug 6 2020 License no. 700

Montana Bureau of Mines & Geology
The University of Montana
1300 West Park Street
Butte, MT 59701

MBMG ID#

Form No. 603 R2-04

MONTANA WELL LOG REPORT

Well ID# MW-105

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with Mt. Bureau of Mines & Geology within 60 days of completion of the work.** Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Calumet Montana Refining LLC
Mailing address 1900 10th St NE Great Falls MT 59404

2. WELL LOCATION: List ¼ from smallest to largest
___ ¼ ___ ¼ NE ¼ NE ¼, Section 1
Township 20n N/S Range 3e E/W County Cascade
Lot ___, Tract/Blk ___ Subdivision Name ___
Well Address ___
GPS ☐ Yes ☐ No
Latitude ___ Longitude ___
Error as reported by GPS locator (± feet) ___
Horizontal datum ☐ NAD27 ☒ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ___

4. TYPE OF WORK:
☐ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: Sonic

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 4 in. from 0 ft. to 10 ft.
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.
Casing:
Steel: Wall thickness ___ ☐ Threaded ☐ Welded
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.
Plastic: Pressure Rating SCH 40 lbs. ☒ Threaded ☐ Welded
Dia. 2 in. from 0 ft. to 5 ft.
Perforations/Slotted Pipe:
Type of perforator used ___
Size of perforations/slots ___ in. by ___ in.
___ no. of perforations/slots from ___ ft. to ___ ft.
___ no. of perforations/slots from ___ ft. to ___ ft.
Screens: ☒ Yes ☐ No
Material PVC
Dia. 2 Slot size .010 from 5 ft. to 10 ft.
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
Gravel Packed: ☒ Yes ☐ No
Size of gravel 10x20
Gravel placed from 4 ft. to 10 ft.
Packer: ☐ Yes ☐ No
Type ___ Depth(s) ___
Grout: Material used Bentonite
Depth from 0 ft. to 4 ft. OR ☐ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level ___ ft. below top of casing or
☐ Closed-in artesian pressure ___ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ___
Yellowstone Controlled Groundwater Area - Water Temperature ___ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
___ gpm with drill stem set at ___ ft. for ___ hours
Time of recovery ___ hrs/min. Recovery water level ___ ft.

OR Bailer test*
___ gpm with ___ ft. of drawdown after ___ hours
Time of recovery ___ hrs/min. Recovery water level ___ ft.

OR Pump test*
Depth pump set for test ___ ft.
___ gpm pump rate with ___ ft. of drawdown after ___ hrs pumping
Time of recovery ___ hrs/min. Recovery water level ___ ft.

OR Flowing Artesian*
___ gpm for ___ hours
Flow controlled by ___

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	3	Dirt
3	10	Sand Stone Rock

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: June 17 2020

9. REMARKS: ___

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Cascade Drilling LP
Address 1920 97th St East, Tacoma, WA 98445
Signature [signature]
Date Aug 6 2020 License no. 700

Montana Bureau of Mines & Geology
The University of Montana
1300 West Park Street
Butte, MT 59701

MBMG ID#

Form No. 603 R2-04

MONTANA WELL LOG REPORT

Well ID# SB-203

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with Mt. Bureau of Mines & Geology within 60 days of completion of the work.** Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Calumet Montana Refining LLC
Mailing address 1900 10th St NE Great Falls MT 59404

2. WELL LOCATION: List ¼ from smallest to largest
____ ¼ ____ ¼ NE ¼ NE ¼, Section 1
Township 20n N/S Range 3e E/W County Cascade
Lot ____, Tract/Blk ____ Subdivision Name ____
Well Address ____
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☒ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☐ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: Sonic

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 4 in. from 0 ft. to 20 ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Casing:
Steel: Wall thickness ____ ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Plastic: Pressure Rating SCH 40 lbs. ☒ Threaded ☐ Welded
Dia. 1 in. from 0 ft. to 8 ft.
Perforations/Slotted Pipe:
Type of perforator used ____
Size of perforations/slots ____ in. by ____ in.
____ no. of perforations/slots from ____ ft. to ____ ft.
____ no. of perforations/slots from ____ ft. to ____ ft.
Screens: ☒ Yes ☐ No
Material PVC
Dia. 1 Slot size .010 from 8 ft. to 14 ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Gravel Packed: ☒ Yes ☐ No
Size of gravel 10x20
Gravel placed from 7 ft. to 14 ft.
Packer: ☐ Yes ☐ No
Type ____ Depth(s) ____
Grout: Material used Bentonite
Depth from 0 ft. to 7 ft. OR ☐ Continuous feed
14 20

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level ____ ft. below top of casing or
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ____
Yellowstone Controlled Groundwater Area - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft. for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	3	Dirt
3	20	Sand Stone Rock

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: June 16 2020

9. REMARKS: ____

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Cascade Drilling LP
Address 1920 97th St East, Tacoma, WA 98445
Signature [signature]
Date Aug 6 2020 License no. 700

Montana Bureau of Mines & Geology
The University of Montana
1300 West Park Street
Butte, MT 59701

MBMG ID#

Form No. 603 R2-04

MONTANA WELL LOG REPORT

Well ID# TW-202D

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with Mt. Bureau of Mines & Geology within 60 days of completion of the work.** Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Calumet Montana Refining LLC
Mailing address 1900 10th St NE Great Falls MT 59404

2. WELL LOCATION: List ¼ from smallest to largest
____ ¼ ____ ¼ NE ¼ NE ¼, Section 1
Township 20n N/S Range 3e E/W County Cascade
Lot ____, Tract/Blk ____ Subdivision Name ____
Well Address ____
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☒ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☐ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: Sonic

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 4 in. from 0 ft. to 20 ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Casing:
Steel: Wall thickness ____ ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Plastic: Pressure Rating SCH 40 lbs. ☒ Threaded ☐ Welded
Dia. 1 in. from 0 ft. to 12 ft.
Perforations/Slotted Pipe:
Type of perforator used ____
Size of perforations/slots ____ in. by ____ in.
____ no. of perforations/slots from ____ ft. to ____ ft.
____ no. of perforations/slots from ____ ft. to ____ ft.
Screens: ☒ Yes ☐ No
Material PVC
Dia. 1 Slot size .010 from 12 ft. to 17 ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Gravel Packed: ☒ Yes ☐ No
Size of gravel 10x20
Gravel placed from 11 ft. to 18 ft.
Packer: ☐ Yes ☐ No
Type ____ Depth(s) ____
Grout: Material used Bentonite
Depth from 0 ft. to 11 ft. OR ☐ Continuous feed
18 20

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level ____ ft. below top of casing or
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ____
Yellowstone Controlled Groundwater Area - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft. for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	3	Dirt
3	20	Sand Stone Rock

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: June 16 2020

9. REMARKS: ____

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Cascade Drilling LP
Address 1920 97th St East, Tacoma, WA 98445
Signature [signature]
Date Aug 6 2020 License no. 700

Montana Bureau of Mines & Geology
The University of Montana
1300 West Park Street
Butte, MT 59701

MBMG ID#

Form No. 603 R2-04

MONTANA WELL LOG REPORT

Well ID# TW-202S

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with Mt. Bureau of Mines & Geology within 60 days of completion of the work.** Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Calumet Montana Refining LLC
Mailing address 1900 10th St NE Great Falls MT 59404

2. WELL LOCATION: List ¼ from smallest to largest
____ ¼ ____ ¼ NE ¼ NE ¼, Section 1
Township 20n N/S Range 3e E/W County Cascade
Lot ____, Tract/Blk ____ Subdivision Name ____
Well Address ____
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☒ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☐ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: Sonic

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 4 in. from 0 ft. to 12 ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Casing:
Steel: Wall thickness ____ ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Plastic: Pressure Rating SCH 40 lbs. ☒ Threaded ☐ Welded
Dia. 1 in. from 0 ft. to 7 ft.
Perforations/Slotted Pipe:
Type of perforator used ____
Size of perforations/slots ____ in. by ____ in.
____ no. of perforations/slots from ____ ft. to ____ ft.
____ no. of perforations/slots from ____ ft. to ____ ft.
Screens: ☒ Yes ☐ No
Material PVC
Dia. 1 Slot size .010 from 7 ft. to 12 ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Gravel Packed: ☒ Yes ☐ No
Size of gravel 10x20
Gravel placed from 6 ft. to 12 ft.
Packer: ☐ Yes ☐ No
Type ____ Depth(s) ____
Grout: Material used Bentonite
Depth from 0 ft. to 6 ft. OR ☐ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☐ Static water level ____ ft. below top of casing or
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ____
Yellowstone Controlled Groundwater Area - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft. for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	3	Dirt
3	12	Sand Stone Rock

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: June 16 2020

9. REMARKS: ____

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Cascade Drilling LP
Address 1920 97th St East, Tacoma, WA 98445
Signature [signature]
Date Aug 6 2020 License no. 700

Montana Bureau of Mines & Geology
The University of Montana
1300 West Park Street
Butte, MT 59701

MBMG ID#

APPENDIX B4
CORE LABORATORY GEOTECHNICAL REPORT

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

July 16, 2020

Paul Lindquist
Ramboll
333 West Wacker Dr., Suite 2700
Chicago, IL 60606

Subject: AOC-16 Interim Measure Design
Project:1690014124-003
CL File No: 2003743

Dear Mr. Lindquist:

The attached file presents the final physical properties determination results for the soil samples submitted from your Project #1690014124-003.

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. 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 LP

Eva Lopez
Core Analyst

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories assumes no responsibility and makes no warranty or representations, expressed or implied, as to the productivity, proper operations or profitableness, however, of any oil, gas, coal or other mineral, property, well or sand in connection with which such report is used or relied upon for any reason whatsoever.

PHYSICAL PROPERTIES DATA

(Methodology: ASTM D2216, ASTM D2937, ASTM D854, ASTM D4318, API RP 40)

Petroleum Services

Ramboll US Corporation

Core Lab File No.: 2003743

Project Name: AOC-16 Interim Measure Design

Project Number: 1690014124-003

Sample ID.	Depth ft.	Sample Orientation (1)	Moisture Content		Dry Bulk Density g/cc	Specific Gravity	Atterberg Limits (2)		
			% weight	cm^3/cm^3			Liquid Limit LL	Plastic Limit PL	Plasticity Index PI
CMR-MW41S-4.0-5.0-200618-ST	4.0-5.0	V	13.68	0.252	1.84	2.64	18	16	2
CMR-MW41S-9.0-10.0-200618-ST	9.0-10.0	V	12.61	0.239	1.90	2.65		Non Plastic	
CMR-MW41S-12.0-13.0-200618-ST	12.0-13.0	V	14.12	0.260	1.84	2.65		Non Plastic	

(1) Sample Orientation: H = horizontal; V = vertical.

(2) Silt assumed as fine fraction for NON-PLASTIC (NP) samples.

SIEVE and LASER PARTICLE SIZE SUMMARY

(METHODOLOGY: ASTM D422/D4464M)

Petroleum Services

Company: Ramboll US Corporation
Project Name: AOC-16 Interim Measure Design
Project Number: 1690014124-003

CL File No.: 2003743
Date: 7/16/2020

Sample ID	Grain Size Description** (Mean from Folk)	Median Grain Size, mm	Component Percentages								
			Gravel	Sand Size					Silt	Clay	Silt & Clay
				VCoarse	Coarse	Medium	Fine	VFine			
CMR-SB201-6.0-7.0-200615	Very Fine Grain Sand	0.1375	0.00	0.00	2.86	24.18	25.62	12.74	28.03	6.58	34.61
CMR-SB200-6.0-7.0-200615	Very Fine Grain Sand	0.1187	0.82	0.00	3.43	21.64	22.78	14.34	30.02	6.96	36.98

**Wentworth Scale

SIEVE and LASER PARTICLE SIZE SUMMARY

(METHODOLOGY: ASTM D422/D4464M)

Petroleum Services

Company: Ramboll US Corporation
Project Name: AOC-16 Interim Measure Design
Project Number: 1690014124-003

CL File No.: 2003743
Date: 7/16/2020

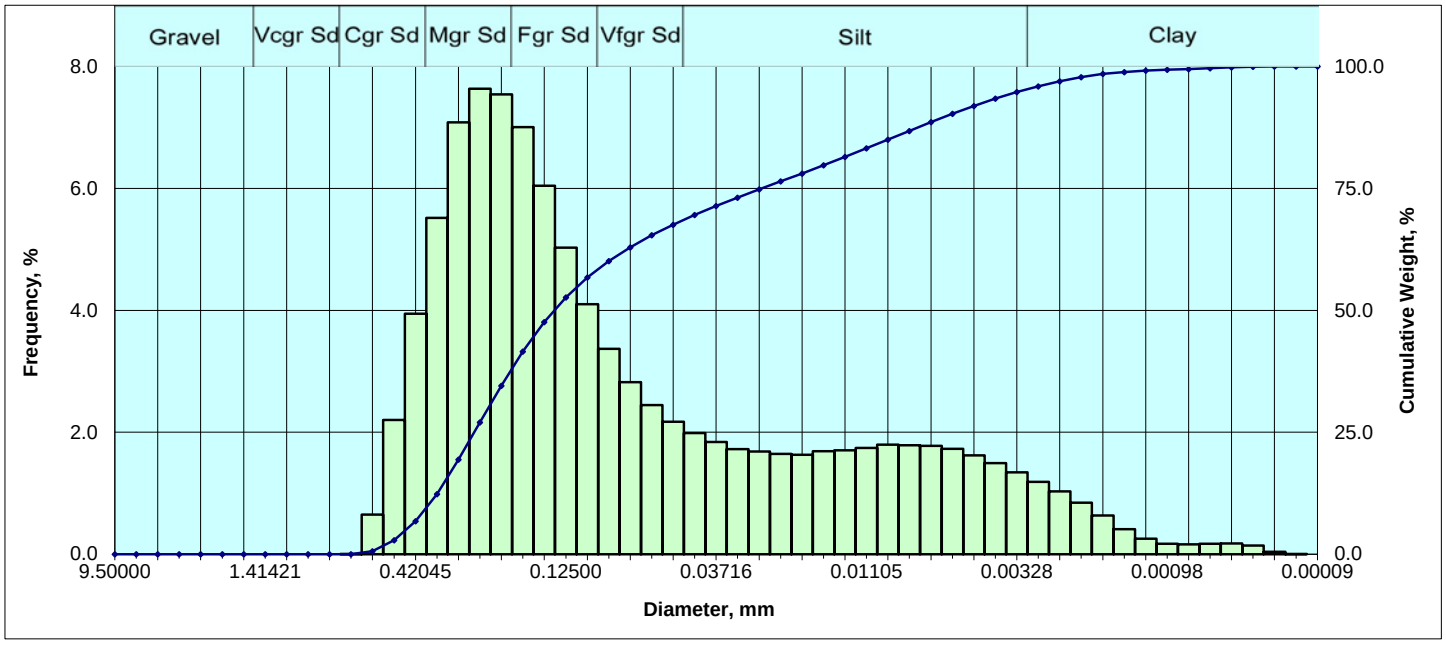
Sample ID	Grain Size Description** (Mean from Trask)	Median Grain Size, mm	Component Percentages				
			Gravel	Sand Sized			Silt & Clay
				Coarse	Medium	Fine	
CMR-SB201-6.0-7.0-200615	Fine Grain Sand	0.1375	0.00	0.00	6.80	56.14	37.06
CMR-SB200-6.0-7.0-200615	Fine Grain Sand	0.1187	0.00	0.82	7.23	51.83	40.11

**USCS Scale

Company: Ramboll US Corporation
Project Name: AOC-16 Interim Measure Design
Project Number: 1690014124-003

CL File No.: 2003743
Sample ID: CMR-SB201-6.0-7.0-200615

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	Diameter [US Mesh]	Diameter [in.]	Diameter [mm]	Diameter [ϕ]	Weight % [Incl.]	Weight % [Cum.]
Gravel	3/8 in.	0.375000	9.50000	-3.25	0.000	0.00
	1/4 in.	0.250000	6.35000	-2.67	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	0.002	0.00
	30	0.023410	0.59460	0.75	0.651	0.65
	35	0.019685	0.50000	1.00	2.205	2.86
Medium Sand	40	0.016553	0.42045	1.25	3.945	6.80
	45	0.013919	0.35355	1.50	5.515	12.32
	50	0.011705	0.29730	1.75	7.084	19.40
	60	0.009843	0.25000	2.00	7.633	27.03
Fine Sand	70	0.008277	0.21022	2.25	7.542	34.58
	80	0.006960	0.17678	2.50	7.005	41.58
	100	0.005852	0.14865	2.75	6.042	47.62
	120	0.004921	0.12500	3.00	5.029	52.65
V. Fine Sand	140	0.004138	0.10511	3.25	4.099	56.75
	170	0.003480	0.08839	3.50	3.367	60.12
	200	0.002926	0.07433	3.75	2.824	62.94
	230	0.002461	0.06250	4.00	2.447	65.39
Silt	270	0.002069	0.05256	4.25	2.171	67.56
	325	0.001740	0.04419	4.50	1.988	69.55
	400	0.001463	0.03716	4.75	1.842	71.39
	450	0.001230	0.03125	5.00	1.724	73.12
	500	0.001035	0.02628	5.25	1.684	74.80
	635	0.000870	0.02210	5.50	1.644	76.44
		0.000732	0.01858	5.75	1.631	78.08
		0.000615	0.01562	6.00	1.689	79.77
		0.000517	0.01314	6.25	1.705	81.47
		0.000435	0.01105	6.50	1.741	83.21
		0.000366	0.00929	6.75	1.795	85.01
		0.000308	0.00781	7.00	1.786	86.79
		0.000259	0.00657	7.25	1.779	88.57
		0.000217	0.00552	7.50	1.731	90.30
		0.000183	0.00465	7.75	1.622	91.92
		0.000154	0.00391	8.00	1.497	93.42
Clay		0.000129	0.00328	8.25	1.343	94.76
		0.000109	0.00276	8.50	1.187	95.95
		0.000091	0.00232	8.75	1.033	96.98
		0.000077	0.00195	9.00	0.846	97.83
		0.000065	0.00164	9.25	0.636	98.47
		0.000054	0.00138	9.50	0.412	98.88
		0.000046	0.00116	9.75	0.257	99.13
		0.000038	0.00098	10.00	0.174	99.31
		0.000032	0.00082	10.25	0.160	99.47
		0.000027	0.00069	10.50	0.172	99.64
		0.000023	0.00058	10.75	0.175	99.82
		0.000019	0.00049	11.00	0.144	99.96
		0.000016	0.00041	11.25	0.040	100.00
		0.000015	0.00038	11.50	0.000	100.00
		0.000003	0.00009	13.50	0.000	100.00

Sorting Statistics (Folk)

Parameter	Trask	Inman	Folk
Median	**Fine sand sized**		
(in)	0.0054	0.0054	0.0054
(mm)	0.1375	0.1375	0.1375
Mean	**Very fine sand sized**		
(in)	0.0057	0.0023	0.0030
(mm)	0.1442	0.0577	0.0771
Sorting	**Very poor**		
	3.192	2.490	2.331
Skewness	**Strongly fine skewed**		
	0.598	0.743	0.510
Kurtosis	**Platykurtic**		
	0.315	0.439	0.877

Component Percentages

Gravel	Sand	Silt	Clay	Silt + Clay
0.00	65.39	28.03	6.58	34.61

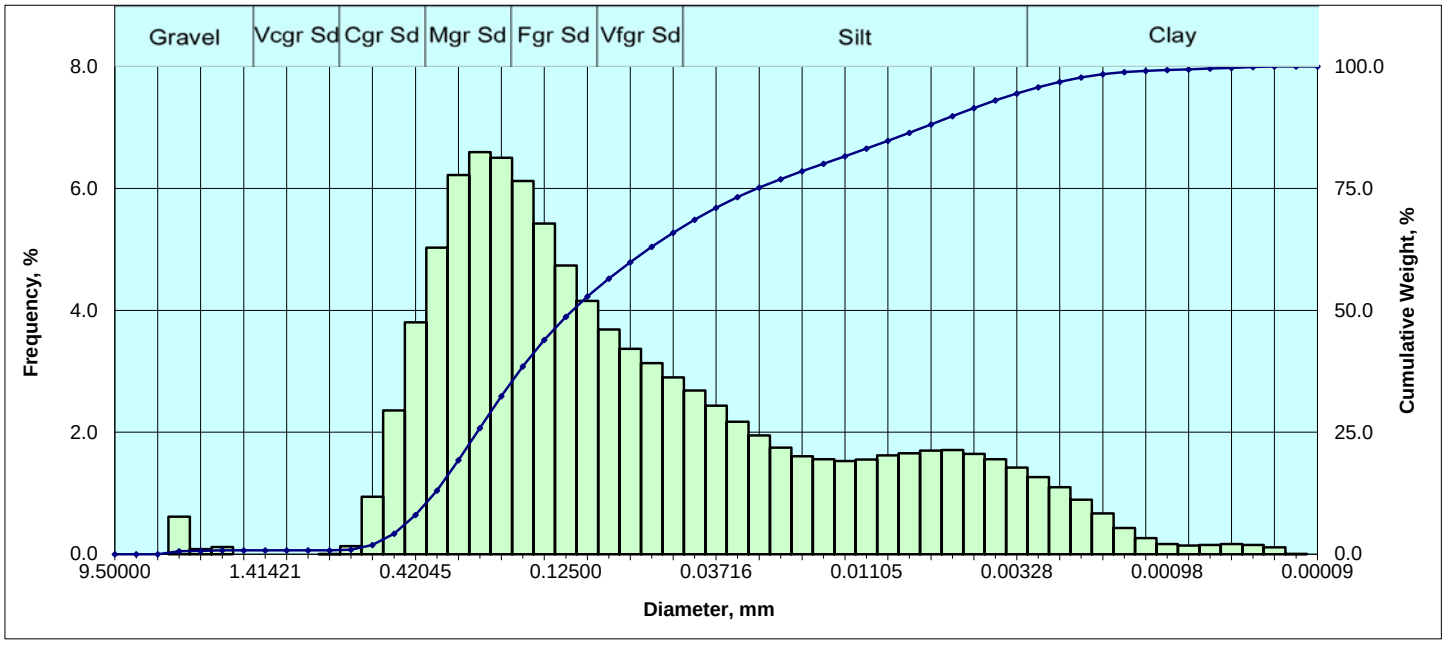
Percentile [Weight, %]	Particle Diameter [in.]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0180	0.4568	1.1303
10	0.0150	0.3817	1.3896
16	0.0128	0.3243	1.6245
25	0.0103	0.2626	1.9290
40	0.0073	0.1843	2.4397
50	0.0054	0.1375	2.8628
70	0.0017	0.0425	4.5572
75	0.0010	0.0258	5.2781
84	0.0004	0.0103	6.6046
90	0.0002	0.0057	7.4531
95	0.0001	0.0032	8.2964

**All Grain Sizes Classed Using Wentworth Scale

Company: Ramboll US Corporation
Project Name: AOC-16 Interim Measure Design
Project Number: 1690014124-003

CL File No.: 2003743
Sample ID: CMR-SB200-6.0-7.0-200615

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	Diameter [US Mesh]	Diameter [in.]	Diameter [mm]	Diameter [ϕ]	Weight % [Incl.]	Weight % [Cum.]
Gravel	3/8 in.	0.375000	9.50000	-3.25	0.000	0.00
	1/4 in.	0.250000	6.35000	-2.67	0.000	0.00
	4	0.187008	4.75000	-2.25	0.000	0.00
	6	0.131890	3.35000	-1.75	0.619	0.62
	8	0.092913	2.36000	-1.25	0.085	0.70
	10	0.078740	2.00000	-1.00	0.118	0.82
V Crse Sand	12	0.066212	1.68179	-0.75	0.000	0.82
	14	0.055678	1.41421	-0.50	0.000	0.82
	16	0.046819	1.18921	-0.25	0.000	0.82
	18	0.039370	1.00000	0.00	0.000	0.82
Coarse Sand	20	0.033106	0.84090	0.25	0.000	0.82
	25	0.027839	0.70711	0.50	0.131	0.95
	30	0.023410	0.59460	0.75	0.943	1.90
	35	0.019685	0.50000	1.00	2.357	4.25
Medium Sand	40	0.016553	0.42045	1.25	3.802	8.05
	45	0.013919	0.35355	1.50	5.026	13.08
	50	0.011705	0.29730	1.75	6.218	19.30
	60	0.009843	0.25000	2.00	6.596	25.89
Fine Sand	70	0.008277	0.21022	2.25	6.500	32.40
	80	0.006960	0.17678	2.50	6.119	38.51
	100	0.005852	0.14865	2.75	5.426	43.94
	120	0.004921	0.12500	3.00	4.737	48.68
V. Fine Sand	140	0.004138	0.10511	3.25	4.154	52.83
	170	0.003480	0.08839	3.50	3.686	56.52
	200	0.002926	0.07433	3.75	3.369	59.89
	230	0.002461	0.06250	4.00	3.134	63.02
Silt	270	0.002069	0.05256	4.25	2.898	65.92
	325	0.001740	0.04419	4.50	2.688	68.61
	400	0.001463	0.03716	4.75	2.436	71.04
	450	0.001230	0.03125	5.00	2.171	73.21
	500	0.001035	0.02628	5.25	1.947	75.16
	635	0.000870	0.02210	5.50	1.748	76.91
		0.000732	0.01858	5.75	1.606	78.51
		0.000615	0.01562	6.00	1.557	80.07
		0.000517	0.01314	6.25	1.527	81.60
		0.000435	0.01105	6.50	1.551	83.15
		0.000366	0.00929	6.75	1.623	84.77
		0.000308	0.00781	7.00	1.654	86.43
		0.000259	0.00657	7.25	1.701	88.13
		0.000217	0.00552	7.50	1.710	89.84
		0.000183	0.00465	7.75	1.647	91.48
		0.000154	0.00391	8.00	1.560	93.04
Clay		0.000129	0.00328	8.25	1.423	94.47
		0.000109	0.00276	8.50	1.267	95.73
		0.000091	0.00232	8.75	1.101	96.84
		0.000077	0.00195	9.00	0.897	97.73
		0.000065	0.00164	9.25	0.670	98.40
		0.000054	0.00138	9.50	0.430	98.83
		0.000046	0.00116	9.75	0.264	99.10
		0.000038	0.00098	10.00	0.168	99.26
		0.000032	0.00082	10.25	0.144	99.41
		0.000027	0.00069	10.50	0.154	99.56
		0.000023	0.00058	10.75	0.165	99.73
		0.000019	0.00049	11.00	0.151	99.88
		0.000016	0.00041	11.25	0.113	99.99
		0.000015	0.00038	11.50	0.008	100.00
		0.000003	0.00009	13.50	0.000	100.00

Sorting Statistics (Folk)

Parameter	Trask	Inman	Folk
Median	**Very fine sand sized**		
(in)	0.0047	0.0047	0.0047
(mm)	0.1187	0.1187	0.1187
Mean	**Very fine sand sized**		
(in)	0.0056	0.0023	0.0029
(mm)	0.1416	0.0576	0.0733
Sorting	**Very poor**		
	3.100	2.507	2.360
Skewness	**Strongly fine skewed**		
	0.697	0.647	0.430
Kurtosis	**Mesokurtic**		
	0.295	0.457	0.917

Component Percentages

Gravel	Sand	Silt	Clay	Silt + Clay
0.82	62.20	30.02	6.96	36.98

Percentile [Weight, %]	Particle Diameter [in.]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0191	0.4843	1.0459
10	0.0155	0.3945	1.3417
16	0.0129	0.3271	1.6120
25	0.0101	0.2564	1.9634
40	0.0067	0.1691	2.5643
50	0.0047	0.1187	3.0750
70	0.0016	0.0402	4.6376
75	0.0011	0.0267	5.2276
84	0.0004	0.0101	6.6257
90	0.0002	0.0054	7.5228
95	0.0001	0.0031	8.3498

**All Grain Sizes Classed Using Wentworth Scale

CHAIN OF CUSTODY RECORD

Company: Ramboll

Address:

Project Manager: Paul Lindquist — Phone: 612-209-8676

Project Name: AOC-16 Interim Measure Design — Fax:

Project No.: 1690014124-003 — Email: plindquist@ramboll.com

Site Location: Great Falls, MT

Sampler Signature: Brady F

PO#:

Turnaround Time: 24 HR ☐ 48 HR ☐ 72 HR ☐ 5 Day ☐ Normal ☑

CL Bid No.:

CL File No.:

ANALYSIS REQUEST

Sample ID	Date	Time	Depth, ft.	Number of Samples	Vadose Zone Group	Saturated Zone Group	Pore Fluid Saturation Group	Moisture Content: ASTM D2216	Porosity: Total, API RP40	Porosity: Effective, ASTM D425M	Bulk Density: API RP40 / ASTM D2937	Hydraulic Conductivity: API RP40	Grain Size Distribution: ASTM D422/D4464M	Atterberg Limits: ASTM D4318	TOC: Walkley-Black		Particle Size Distribution - Water ASTM D4464M		Fluid Properties Group	Viscosity: ASTM D445	Density/Gravity: ASTM D1481 ASTM D854	Pryo-Chromatography (Fingerprinting)	Interfacial Tension - ASTM D971	Reid Vapor Pressure - D5191		Comments
					SOIL														FLUID							
CMR-SB201-6.0-7.0-200615	6.15.20	17:00	6.0-7.0	1									✓													
CMR-SB200-6.0-7.0-200615	6.15.20	17:30	6.0-7.0	1									✓													
CMR-MW41S-4.0-5.0-200618-ST	6.18.20	13:13	4.0-5.0	1				✓			✓			✓							✓					samples
CMR-MW41S-9.0-10.0-200618-ST	6.18.20	13:43	9.0-10.0	1				✓			✓			✓							✓					arrived w/
CMR-MW41S-12.0-13.0-200618-ST	6.18.20	14:12	12.0-13.0	1				✓			✓			✓							✓					plenty of
																										ice

1. Relinquished By:	2. Received By:	2. Relinquished By:	2. Received By:
Brady F			Alowken
Company: Ramboll	Company: FedEx	Company:	Company: CORE Lab
Date: 6.23.2020 Time: 12:00	Date: 6.23.2020 Time: 12:00	Date: Time:	Date: 6/24/20 Time: 2:00pm

Core Lab

CORE LABORATORIES - 3437 Landco Dr. - Bakersfield, CA 93308 • Phone 661-325-5657 • Fax 661-325-5808

APPENDIX B5
ENERGY LABORATORY REPORTS

ANALYTICAL SUMMARY REPORT

June 25, 2020

Calumet Montana Refining, LLC
1807 3rd St NW
Great Falls, MT 59404-1998

Work Order: B20061759

Project Name: Not Indicated

Energy Laboratories Inc Billings MT received the following 1 sample for Calumet Montana Refining, LLC on 6/19/2020 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B20061759-001	CMR-AS3-200618	06/18/20 12:07	06/19/20	Aqueous	Biochemical Oxygen Demand, 5 Day Chemical Oxygen Demand Preparation for COD testing HACH 8000

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative. Any issues encountered during sample receipt are documented in the Work Order Receipt Checklist.

The results as reported relate only to the item(s) submitted for testing. This report shall be used or copied only in its entirety. Energy Laboratories, Inc. is not responsible for the consequences arising from the use of a partial report.

If you have any questions regarding these test results, please contact your Project Manager.

Report Approved By:

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Not Indicated
Lab ID: B20061759-001
Client Sample ID: CMR-AS3-200618

Report Date: 06/25/20
Collection Date: 06/18/20 12:07
DateReceived: 06/19/20
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
AGGREGATE ORGANICS							
Oxygen Demand, Chemical (COD)	79	mg/L		5		E410.4	06/22/20 13:02 / mas
Oxygen Demand, Biochemical (BOD)	<24	mg/L		24		A5210 B	06/19/20 12:28 / ean
No BOD dilution depleted greater than 2.0 mg/L DO.							

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061759 **Report Date:** 06/25/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A5210 B									Batch: 200619_1_BOD5-W	
Lab ID: Dil-H201_200619		Dilution Water Blank				Run: BOD-SP2000_200619A			06/19/20 10:22	
Oxygen Demand, Biochemical (BOD)		0.2	mg/L	0.2		0	0.2			
Lab ID: GGA1_200619		Laboratory Control Sample				Run: BOD-SP2000_200619A			06/19/20 10:32	
Oxygen Demand, Biochemical (BOD)		217	mg/L	79	110	85	115			
Lab ID: B20061744-001ADUP		Sample Duplicate				Run: BOD-SP2000_200619A			06/19/20 12:17	
Oxygen Demand, Biochemical (BOD)		153	mg/L	68				10	15	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061759 **Report Date:** 06/25/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E410.4									Analytical Run: SPEC3_200622A	
Lab ID: CCV		Continuing Calibration Verification Standard							06/22/20 13:02	
Oxygen Demand, Chemical (COD)		49.5	mg/L	5.0	99	90	110			
Lab ID: CCV		Continuing Calibration Verification Standard							06/22/20 13:02	
Oxygen Demand, Chemical (COD)		51.8	mg/L	5.0	104	90	110			
Method: E410.4									Batch: 145791	
Lab ID: MB-145791		Method Blank				Run: SPEC3_200622A			06/22/20 13:02	
Oxygen Demand, Chemical (COD)		ND	mg/L	3						
Lab ID: LCS-145791		Laboratory Control Sample				Run: SPEC3_200622A			06/22/20 13:02	
Oxygen Demand, Chemical (COD)		23.4	mg/L	5.0	96	90	110			
Lab ID: B20061791-001CMS		Sample Matrix Spike				Run: SPEC3_200622A			06/22/20 13:02	
Oxygen Demand, Chemical (COD)		23.5	mg/L	5.0	96	90	110			
Lab ID: B20061791-001CMSD		Sample Matrix Spike Duplicate				Run: SPEC3_200622A			06/22/20 13:02	
Oxygen Demand, Chemical (COD)		23.5	mg/L	5.0	96	90	110	0.0	10	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

Work Order Receipt Checklist

Calumet Montana Refining, LLC

B20061759

Login completed by: Briana G. Sangiuliano
Reviewed by: BL2000\darcy
Reviewed Date: 6/24/2020

Date Received: 6/19/2020
Received by: gda
Carrier name: Return-FedEx Ground

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☐	No ☑	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☑	No ☐	Not Applicable ☐
Container/Temp Blank temperature:	0.9°C On Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☑	No ☐	Not Applicable ☐

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Radiochemical precision results represent a 2-sigma Total Measurement Uncertainty.

Contact and Corrective Action Comments:

None

ENERGY LAB
Trust our People. Trust our Data

Chain of Custody & Analytical Request Record

www.energylab.com

Account Information (Billing information)

Company/Name	Calumet Montana Refining
Contact	Ray Martinich
Phone	406-454-9862
Mailing Address	1900 10th Street NE
City, State, Zip	Great Falls, MT 59404
Email	Ray.Martinich@calumetspecialty.com
Receive Invoice	☐Hard Copy ☐Email
Receive Report	☐Hard Copy ☐Email
Purchase Order	
Quote	
Bottle Order	

Report Information (if different than Account Information)

Company/Name	SAME AS ABOVE
Contact	
Phone	
Mailing Address	
City, State, Zip	
Email	ALSO, plindquist@ramboll.com
Receive Report	☐Hard Copy ☐Email

Special Report/Formats:
☐ LEVEL IV ☐ NELAC ☐ EDD/EDT (contact laboratory) ☐ Other

Comments

Short HOLD!

Project Information

Project Name, PWSID, Permit, etc	
Sampler Name: Brooks Bailey	Sampler Phone: 336-705-8800
Sample Origin State: MT	EPA/State Compliance ☐ Yes ☐ No

MINING CLIENTS, please indicate sample type.
*If ore has been processed or refined, call before sending.
☐ Byproduct 11 (e)2 material ☐ Unprocessed ore (NOT ground or refined)*

Matrix Codes
A - Air
W - Water
S - Soils/Solids
V - Vegetation
B - Bioassay
O - Other
DW - Drinking Water

All turnaround times are standard unless marked as RUSH.
Energy Laboratories MUST be contacted prior to RUSH sample submittal for charges and scheduling – See Instructions Page

	Sample Identification (Name, Location, Interval, etc.)	Collection Date	Collection Time	Number of Containers	Matrix (See Codes Above)	Biochemical Oxygen Demand, 5 day	Chemical Oxygen Demand	See Attached	RUSH TAT	ELI LAB ID (Laboratory Use Only)
1	CMR-AS3-200618	6.18.20	12:07	2	W	✓	✓			B20061759
2										
3										
4										
5										
6										
7										
8										
9										
10										

KC 6-18-20

KC 6-18-20

Custody Record MUST be signed	Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
	Relinquished by (print)	Date/Time	Signature	Received by Laboratory (print): Gabbie Aschim	Date/Time: 6-19-2020 10:00	Signature: Gabbie Aschim

LABORATORY USE ONLY

Shipped By	Cooler ID(s)	Custody Seals	Intact	Receipt Temp	Temp Blank	On Ice	Payment Type	Amount	Receipt Number (cash/check only)
		Y N C B	Y N	°C	Y N	Y N	CC Cash Check	$	

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

ELI-COC 12/16 v 1

ANALYTICAL SUMMARY REPORT

June 30, 2020

Calumet Montana Refining, LLC
1807 3rd St NW
Great Falls, MT 59404-1998

Work Order: B20061767

Project Name: Waste Characterization

Energy Laboratories Inc Billings MT received the following 2 samples for Calumet Montana Refining, LLC on 6/19/2020 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B20061767-001	S527	06/16/20 15:40	06/19/20	Solid	TCLP Zero Headspace Extraction by SW1311 Volatile Organic Compounds, TCLP
B20061767-002	S528	06/16/20 15:50	06/19/20	Solid	Metals by ICP/ICPMS, Total or Soluble Metals by ICP/ICPMS, TCLP Cyanide, Reactive Total Cyanide Cyanide Distillation SW9010 Mercury, TCLP Mercury in Solid By CVAA Moisture Moisture SW3550C Prep pH of Soil and Waste Total Metals Digestion by SW3050B Mercury Digestion by SW7470A Mercury Digestion by SW7471B Reactivity Preparation by SW846 Ch 7 Sulfide, Reactive Soil Sonication SW3550C Extraction Semi-Volatile Organic Compounds TCLP Extraction by SW1311, Non-volatiles TCLP Zero Headspace Extraction by SW1311 TCLP Metals Digestion by SW3010A BNA TCLP Extraction Semi-Volatile Organic Compounds, TCLP Volatile Organic Compounds, TCLP Volatile Organics, Methanol Extraction SW5035 8260-Volatile Organic Compounds - Short List

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative. Any issues encountered during sample receipt are documented in the Work Order Receipt Checklist.

The results as reported relate only to the item(s) submitted for testing. This report shall be used or copied only in its entirety. Energy Laboratories, Inc. is not responsible for the consequences arising from the use of a partial report.

If you have any questions regarding these test results, please contact your Project Manager.

Report Approved By:

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Waste Characterization
Lab ID: B20061767-001
Client Sample ID: S527

Report Date: 06/30/20
Collection Date: 06/16/20 15:40
DateReceived: 06/19/20
Matrix: Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS, TCLP EXTRACTABLE							
Benzene	ND	mg/L		0.10	0.5	SW8260B	06/27/20 02:31 / msc
Carbon tetrachloride	ND	mg/L		0.10	0.5	SW8260B	06/27/20 02:31 / msc
Chlorobenzene	ND	mg/L		0.10	100	SW8260B	06/27/20 02:31 / msc
Chloroform	ND	mg/L		0.10	6	SW8260B	06/27/20 02:31 / msc
1,4-Dichlorobenzene	ND	mg/L		0.10	7.5	SW8260B	06/27/20 02:31 / msc
1,2-Dichloroethane	ND	mg/L		0.10	0.5	SW8260B	06/27/20 02:31 / msc
1,1-Dichloroethene	ND	mg/L		0.10	0.7	SW8260B	06/27/20 02:31 / msc
Methyl ethyl ketone	ND	mg/L		2.0	200	SW8260B	06/27/20 02:31 / msc
Tetrachloroethene	ND	mg/L		0.10	0.7	SW8260B	06/27/20 02:31 / msc
Trichloroethene	ND	mg/L		0.10	0.5	SW8260B	06/27/20 02:31 / msc
Vinyl chloride	ND	mg/L		0.10	0.2	SW8260B	06/27/20 02:31 / msc
Surr: 1,2-Dichloroethane-d4	97.0	%REC		70-130		SW8260B	06/27/20 02:31 / msc
Surr: Dibromofluoromethane	105	%REC		77-126		SW8260B	06/27/20 02:31 / msc
Surr: p-Bromofluorobenzene	79.0	%REC		76-127		SW8260B	06/27/20 02:31 / msc
Surr: Toluene-d8	107	%REC		79-122		SW8260B	06/27/20 02:31 / msc

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Waste Characterization
Lab ID: B20061767-002
Client Sample ID: S528

Report Date: 06/30/20
Collection Date: 06/16/20 15:50
DateReceived: 06/19/20
Matrix: Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	6.6	wt%		0.2		SW3550C	06/25/20 12:13 / amn
CORROSIVITY							
pH	8.9	s.u.		0.1		SW9045D	06/19/20 14:53 / jlw
pH Measurement Temp	18	C				SW9045D	06/19/20 14:53 / jlw
REACTIVITY							
Cyanide, Reactive	ND	mg/kg		0.05	250	SW846 Ch 7	06/22/20 11:42 / mas
Sulfide, Reactive	ND	mg/kg		20	500	SW846 Ch 7	06/19/20 12:44 / gie
METALS, TCLP EXTRACTABLE							
Antimony	ND	mg/L		0.5		SW6020	06/25/20 20:42 / pap
Arsenic	ND	mg/L		0.5	5	SW6010B	06/24/20 22:04 / rlh
Barium	ND	mg/L		10	100	SW6010B	06/24/20 22:04 / rlh
Beryllium	ND	mg/L		0.5		SW6010B	06/24/20 22:04 / rlh
Cadmium	ND	mg/L		0.1	1	SW6010B	06/24/20 22:04 / rlh
Chromium	ND	mg/L		0.5	5	SW6010B	06/24/20 22:04 / rlh
Cobalt	ND	mg/L		0.5		SW6010B	06/24/20 22:04 / rlh
Copper	ND	mg/L		0.5		SW6010B	06/24/20 22:04 / rlh
Lead	ND	mg/L		0.5	5	SW6010B	06/24/20 22:04 / rlh
Mercury	ND	mg/L		0.001	0.2	SW7470A	06/25/20 14:42 / aao
Nickel	ND	mg/L		0.5		SW6010B	06/24/20 22:04 / rlh
Selenium	ND	mg/L		0.1	1	SW6010B	06/24/20 22:04 / rlh
Silver	ND	mg/L		0.5	5	SW6010B	06/24/20 22:04 / rlh
Vanadium	ND	mg/L		0.5		SW6010B	06/24/20 22:04 / rlh
Zinc	ND	mg/L		1		SW6010B	06/24/20 22:04 / rlh
CYANIDE							
Cyanide, Total	2.0	mg/kg		0.2		SW9012B	06/22/20 13:29 / mas
METALS, TOTAL - EPA SW846							
Antimony	ND	mg/kg		1		SW6020	06/25/20 03:28 / pap
Arsenic	3	mg/kg		1		SW6020	06/25/20 03:28 / pap
Barium	257	mg/kg		1		SW6010B	06/24/20 06:58 / rlh
Beryllium	ND	mg/kg		1		SW6010B	06/24/20 06:58 / rlh
Cadmium	ND	mg/kg		1		SW6010B	06/24/20 06:58 / rlh
Chromium	20	mg/kg		1		SW6020	06/25/20 03:28 / pap
Cobalt	7	mg/kg		1		SW6020	06/25/20 03:28 / pap
Copper	20	mg/kg	D	3		SW6020	06/25/20 22:55 / pap
Lead	7	mg/kg		1		SW6020	06/25/20 03:28 / pap
Mercury	ND	mg/kg		0.1		SW7471B	06/24/20 15:40 / aao
Nickel	22	mg/kg		1		SW6020	06/25/20 03:28 / pap
Selenium	ND	mg/kg	D	3		SW6020	06/25/20 03:28 / pap
Silver	ND	mg/kg		1		SW6020	06/25/20 03:28 / pap

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
D - Reporting Limit (RL) increased due to sample matrix
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Waste Characterization
Lab ID: B20061767-002
Client Sample ID: S528

Report Date: 06/30/20
Collection Date: 06/16/20 15:50
DateReceived: 06/19/20
Matrix: Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
METALS, TOTAL - EPA SW846							
Vanadium	41	mg/kg	D	5		SW6010B	06/24/20 06:58 / rlh
Zinc	56	mg/kg		1		SW6010B	06/24/20 06:58 / rlh
VOLATILE ORGANIC COMPOUNDS, TCLP EXTRACTABLE							
Benzene	ND	mg/L		0.10	0.5	SW8260B	06/27/20 03:46 / msc
Carbon tetrachloride	ND	mg/L		0.10	0.5	SW8260B	06/27/20 03:46 / msc
Chlorobenzene	ND	mg/L		0.10	100	SW8260B	06/27/20 03:46 / msc
Chloroform	ND	mg/L		0.10	6	SW8260B	06/27/20 03:46 / msc
1,4-Dichlorobenzene	ND	mg/L		0.10	7.5	SW8260B	06/27/20 03:46 / msc
1,2-Dichloroethane	ND	mg/L		0.10	0.5	SW8260B	06/27/20 03:46 / msc
1,1-Dichloroethene	ND	mg/L		0.10	0.7	SW8260B	06/27/20 03:46 / msc
Methyl ethyl ketone	ND	mg/L		2.0	200	SW8260B	06/27/20 03:46 / msc
Tetrachloroethene	ND	mg/L		0.10	0.7	SW8260B	06/27/20 03:46 / msc
Trichloroethene	ND	mg/L		0.10	0.5	SW8260B	06/27/20 03:46 / msc
Vinyl chloride	ND	mg/L		0.10	0.2	SW8260B	06/27/20 03:46 / msc
Surr: 1,2-Dichloroethane-d4	97.0	%REC		70-130		SW8260B	06/27/20 03:46 / msc
Surr: Dibromofluoromethane	104	%REC		77-126		SW8260B	06/27/20 03:46 / msc
Surr: p-Bromofluorobenzene	78.0	%REC		76-127		SW8260B	06/27/20 03:46 / msc
Surr: Toluene-d8	108	%REC		79-122		SW8260B	06/27/20 03:46 / msc
SEMI-VOLATILE ORGANIC COMPOUNDS, TCLP EXTRACTABLE							
Cresols, Total	ND	mg/L		0.050	200	SW8270C	06/29/20 14:18 / jph
m+p-Cresols	ND	mg/L		0.050		SW8270C	06/29/20 14:18 / jph
o-Cresol	ND	mg/L		0.050		SW8270C	06/29/20 14:18 / jph
Pentachlorophenol	ND	mg/L		0.25	100	SW8270C	06/29/20 14:18 / jph
2,4,5-Trichlorophenol	ND	mg/L		0.050	400	SW8270C	06/29/20 14:18 / jph
2,4,6-Trichlorophenol	ND	mg/L		0.050	2	SW8270C	06/29/20 14:18 / jph
2,4-Dinitrotoluene	ND	mg/L		0.050	0.13	SW8270C	06/29/20 14:18 / jph
Hexachlorobutadiene	ND	mg/L		0.050	0.5	SW8270C	06/29/20 14:18 / jph
Hexachlorobenzene	ND	mg/L		0.050	0.13	SW8270C	06/29/20 14:18 / jph
Hexachloroethane	ND	mg/L		0.050	3	SW8270C	06/29/20 14:18 / jph
Nitrobenzene	ND	mg/L		0.050	2	SW8270C	06/29/20 14:18 / jph
Pyridine	ND	mg/L		0.10	5	SW8270C	06/29/20 14:18 / jph
Surr: 2,4,6-Tribromophenol	77.0	%REC		25-140		SW8270C	06/29/20 14:18 / jph
Surr: 2-Fluorobiphenyl	59.0	%REC		28-107		SW8270C	06/29/20 14:18 / jph
Surr: 2-Fluorophenol	59.0	%REC		10-75		SW8270C	06/29/20 14:18 / jph
Surr: Nitrobenzene-d5	60.0	%REC		32-94		SW8270C	06/29/20 14:18 / jph
Surr: Phenol-d5	63.0	%REC		26-101		SW8270C	06/29/20 14:18 / jph
Surr: Terphenyl-d14	85.0	%REC		32-122		SW8270C	06/29/20 14:18 / jph
VOLATILE ORGANIC COMPOUNDS							
Benzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Bromobenzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Bromochloromethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
D - Reporting Limit (RL) increased due to sample matrix
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Waste Characterization
Lab ID: B20061767-002
Client Sample ID: S528

Report Date: 06/30/20
Collection Date: 06/16/20 15:50
DateReceived: 06/19/20
Matrix: Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
Bromodichloromethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Bromoform	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Bromomethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Carbon tetrachloride	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Chlorobenzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Chloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
2-Chloroethyl vinyl ether	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Chloroform	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Chloromethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
2-Chlorotoluene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
4-Chlorotoluene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Chlorodibromomethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,2-Dibromoethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Dibromomethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,2-Dichlorobenzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,3-Dichlorobenzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,4-Dichlorobenzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Dichlorodifluoromethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1-Dichloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,2-Dichloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
cis-1,2-Dichloroethene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1-Dichloroethene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
trans-1,2-Dichloroethene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,2-Dichloropropane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,3-Dichloropropane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
2,2-Dichloropropane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1-Dichloropropene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
cis-1,3-Dichloropropene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
trans-1,3-Dichloropropene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Ethylbenzene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Methyl tert-butyl ether (MTBE)	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Methylene chloride	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Methyl ethyl ketone	ND	mg/kg		4.0		SW8260B	06/26/20 07:03 / msc
Styrene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1,1,2-Tetrachloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1,2,2-Tetrachloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Tetrachloroethene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Toluene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1,1-Trichloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,1,2-Trichloroethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Trichloroethene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Trichlorofluoromethane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
1,2,3-Trichloropropane	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Waste Characterization
Lab ID: B20061767-002
Client Sample ID: S528

Report Date: 06/30/20
Collection Date: 06/16/20 15:50
DateReceived: 06/19/20
Matrix: Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
Vinyl chloride	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
m+p-Xylenes	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
o-Xylene	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Xylenes, Total	ND	mg/kg		0.20		SW8260B	06/26/20 07:03 / msc
Surr: p-Bromofluorobenzene	108	%REC		78-160		SW8260B	06/26/20 07:03 / msc
Surr: Dibromofluoromethane	96.0	%REC		70-132		SW8260B	06/26/20 07:03 / msc
Surr: 1,2-Dichloroethane-d4	92.0	%REC		60-136		SW8260B	06/26/20 07:03 / msc
Surr: Toluene-d8	98.0	%REC		75-138		SW8260B	06/26/20 07:03 / msc
SEMI-VOLATILE ORGANIC COMPOUNDS							
1,2,4-Trichlorobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
1,2-Dichlorobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
1,3-Dichlorobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
1,4-Dichlorobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
1-Methylnaphthalene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2,4,5-Trichlorophenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2,4,6-Trichlorophenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2,4-Dichlorophenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2,4-Dimethylphenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2,4-Dinitrophenol	ND	mg/kg		1.7		SW8270C	06/28/20 04:17 / dsm
2,4-Dinitrotoluene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2,6-Dinitrotoluene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2-Chloronaphthalene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2-Chlorophenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2-Methylnaphthalene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
2-Nitrophenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
3,3´-Dichlorobenzidine	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
4,6-Dinitro-2-methylphenol	ND	mg/kg		1.7		SW8270C	06/28/20 04:17 / dsm
4-Bromophenyl phenyl ether	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
4-Chloro-3-methylphenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
4-Chlorophenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
4-Chlorophenyl phenyl ether	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
4-Nitrophenol	ND	mg/kg		1.7		SW8270C	06/28/20 04:17 / dsm
Acenaphthene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Acenaphthylene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Anthracene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Azobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Benzidine	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Benzo(a)anthracene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Benzo(a)pyrene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Benzo(b)fluoranthene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Benzo(g,h,i)perylene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Benzo(k)fluoranthene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC
Project: Waste Characterization
Lab ID: B20061767-002
Client Sample ID: S528

Report Date: 06/30/20
Collection Date: 06/16/20 15:50
DateReceived: 06/19/20
Matrix: Solid

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SEMI-VOLATILE ORGANIC COMPOUNDS							
bis(-2-chloroethoxy)Methane	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
bis(-2-chloroethyl)Ether	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
bis(2-chloroisopropyl)Ether	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
bis(2-ethylhexyl)Phthalate	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Butylbenzylphthalate	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Chrysene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Dibenzo(a,h)anthracene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Diethyl phthalate	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Dimethyl phthalate	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Di-n-butyl phthalate	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Di-n-octyl phthalate	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Fluoranthene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Fluorene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Hexachlorobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Hexachlorobutadiene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Hexachlorocyclopentadiene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Hexachloroethane	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Indeno(1,2,3-cd)pyrene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Isophorone	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
m+p-Cresols	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Naphthalene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Nitrobenzene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
n-Nitrosodimethylamine	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
n-Nitroso-di-n-propylamine	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
n-Nitrosodiphenylamine	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
o-Cresol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Pentachlorophenol	ND	mg/kg		1.7		SW8270C	06/28/20 04:17 / dsm
Phenanthrene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Phenol	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Pyrene	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Pyridine	ND	mg/kg		0.33		SW8270C	06/28/20 04:17 / dsm
Surr: 2,4,6-Tribromophenol	91.0	%REC		53-141		SW8270C	06/28/20 04:17 / dsm
Surr: 2-Fluorobiphenyl	69.0	%REC		63-98		SW8270C	06/28/20 04:17 / dsm
Surr: 2-Fluorophenol	65.0	%REC		53-101		SW8270C	06/28/20 04:17 / dsm
Surr: Nitrobenzene-d5	59.0	%REC		53-101		SW8270C	06/28/20 04:17 / dsm
Surr: Phenol-d5	68.0	%REC		55-100		SW8270C	06/28/20 04:17 / dsm
Surr: Terphenyl-d14	93.0	%REC		71-118		SW8270C	06/28/20 04:17 / dsm

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW846 Ch 7										Batch: 145727
Lab ID: B20061683-001A DUP		Sample Duplicate				Run: MISC-WC_200619B				06/19/20 12:44
Sulfide, Reactive		24	mg/kg	20				0.0	10	
Lab ID: LCS-145727		Laboratory Control Sample				Run: MISC-WC_200619B				06/19/20 12:44
Sulfide, Reactive		1860	mg/kg	50	114	70	130			
Lab ID: MB-145727		Method Blank				Run: MISC-WC_200619B				06/19/20 12:44
Sulfide, Reactive		1	mg/kg	1						
Method: SW846 Ch 7										Batch: 145727
Lab ID: MB-145727		Method Blank				Run: SFA-201-B_200622B				06/22/20 11:40
Cyanide, Reactive		ND	mg/kg	0.005						
Lab ID: B20061767-002AMS		Sample Matrix Spike				Run: SFA-201-B_200622B				06/22/20 11:44
Cyanide, Reactive		1.0	mg/kg	0.050	102	80	120			
Lab ID: B20061767-002AMSD		Sample Matrix Spike Duplicate				Run: SFA-201-B_200622B				06/22/20 11:46
Cyanide, Reactive		1.0	mg/kg	0.050	102	80	120	0.3	10	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW9012B										Batch: 145781
Lab ID: MB-145781	Method Blank					Run: SFA-201-B_200622B				06/22/20 13:25
Cyanide, Total		ND	mg/kg	0.07						
Lab ID: LCS-145781	Laboratory Control Sample					Run: SFA-201-B_200622B				06/22/20 13:27
Cyanide, Total		5.23	mg/kg	0.25	106	60	140			
Lab ID: B20061767-002AMS	Sample Matrix Spike					Run: SFA-201-B_200622B				06/22/20 13:31
Cyanide, Total		6.30	mg/kg	0.25	93	50	150			
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate					Run: SFA-201-B_200622B				06/22/20 13:33
Cyanide, Total		6.59	mg/kg	0.25	96	50	150	4.5	30	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW9045D							Analytical Run: ORION 720A HZW_200619A			
Lab ID: ICV	2	Initial Calibration Verification Standard							06/19/20 12:12	
pH		7.91	s.u.	0.10	99	98	102			
pH Measurement Temp		18.7	C			0	0			
Method: SW9045D									Batch: R343926	
Lab ID: B20061660-003ADUP	2	Sample Duplicate				Run: ORION 720A HZW_200619A			06/19/20 12:59	
pH		9.38	s.u.	0.10				0.6	3	
pH Measurement Temp		18.4	C							

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**SW6010B**									Analytical Run: ICP203-B_200623A	
Lab ID:	**QCS**	5	Initial Calibration Verification Standard							06/23/20 09:47	
Barium			0.811	mg/L	0.10	101	90	110			
Beryllium			0.401	mg/L	0.010	100	90	110			
Cadmium			0.389	mg/L	0.010	97	90	110			
Vanadium			0.809	mg/L	0.10	101	90	110			
Zinc			0.788	mg/L	0.020	98	90	110			
Lab ID:	**ICSA**	5	Interference Check Sample A							06/23/20 09:51	
Barium			0.000460	mg/L	0.10						
Beryllium			-0.0000100	mg/L	0.010						
Cadmium			-0.00253	mg/L	0.010						
Vanadium			0.00296	mg/L	0.10						
Zinc			0.00629	mg/L	0.020						
Lab ID:	**ICSAB**	5	Interference Check Sample AB							06/23/20 09:56	
Barium			0.467	mg/L	0.10	93	80	120			
Beryllium			0.458	mg/L	0.010	92	80	120			
Cadmium			0.835	mg/L	0.010	83	80	120			
Vanadium			0.454	mg/L	0.10	91	80	120			
Zinc			0.928	mg/L	0.020	93	80	120			
Method:	**SW6010B**									Batch: 145787	
Lab ID:	**MB-145787**	5	Method Blank				Run: ICP203-B_200623A			06/24/20 05:09	
Barium			ND	mg/kg	0.1						
Beryllium			ND	mg/kg	0.01						
Cadmium			ND	mg/kg	0.03						
Vanadium			ND	mg/kg	0.3						
Zinc			ND	mg/kg	0.4						
Lab ID:	**SRM3-145787**	5	Standard Reference Material				Run: ICP203-B_200623A			06/24/20 05:13	
Barium			366	mg/kg	1.0	107	74	126			
Beryllium			54.0	mg/kg	1.0	104	72	128			
Cadmium			145	mg/kg	1.0	97	80	120			
Vanadium			236	mg/kg	4.9	104	75	125			
Zinc			468	mg/kg	1.9	102	77	123			
Lab ID:	**B20061767-002ADIL**	5	Serial Dilution				Run: ICP203-B_200623A			06/24/20 07:03	
Barium			280	mg/kg	1.0				8.3	10	
Beryllium			0.549	mg/kg	1.0					10	N
Cadmium			ND	mg/kg	3.8					10	
Vanadium			45.0	mg/kg	24				9.0	10	
Zinc			60.4	mg/kg	4.7				7.0	10	
Lab ID:	**B20061767-002APDS**	5	Post Digestion/Distillation Spike				Run: ICP203-B_200623A			06/24/20 07:15	
Barium			297	mg/kg	1.0		75	125			A
Beryllium			21.5	mg/kg	1.0	86	75	125			
Cadmium			19.8	mg/kg	1.0	80	75	125			
Vanadium			83.3	mg/kg	4.9	86	75	125			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

A - Analyte level was greater than four times the spike level - in accordance with the method, percent recovery is not calculated

N - Analyte concentration was not sufficiently high to calculate a Relative Percent Difference (RPD) for the serial dilution test

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: **SW6010B**										Batch: 145787
Lab ID: **B20061767-002APDS**	5	Post Digestion/Distillation Spike				Run: ICP203-B_200623A			06/24/20 07:15	
Zinc		97.8	mg/kg	1.0	85	75	125			
Lab ID: **B20061767-002AMS3**	5	Sample Matrix Spike				Run: ICP203-B_200623A			06/24/20 07:20	
Barium		364	mg/kg	1.0		75	125			A
Beryllium		22.5	mg/kg	1.0	89	75	125			
Cadmium		20.5	mg/kg	1.0	82	75	125			
Vanadium		93.7	mg/kg	4.9	107	75	125			
Zinc		105	mg/kg	1.0	99	75	125			
Lab ID: **B20061767-002AMSD**	5	Sample Matrix Spike Duplicate				Run: ICP203-B_200623A			06/24/20 07:25	
Barium		454	mg/kg	1.0		75	125	22	20	AR
Beryllium		22.6	mg/kg	1.0	90	75	125	0.5	20	
Cadmium		20.4	mg/kg	1.0	83	75	125	0.2	20	
Vanadium		94.3	mg/kg	4.9	109	75	125	0.6	20	
Zinc		107	mg/kg	1.0	105	75	125	2.4	20	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

A - Analyte level was greater than four times the spike level - in accordance with the method, percent recovery is not calculated

R - Relative Percent Difference (RPD) exceeds advisory limit

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Analytical Run: ICP203-B_200624A	
Lab ID: QCS	13	Initial Calibration Verification Standard								06/24/20 10:04
Arsenic		0.825	mg/L	0.20	103	90	110			
Barium		0.784	mg/L	0.10	98	90	110			
Beryllium		0.397	mg/L	0.010	99	90	110			
Cadmium		0.388	mg/L	0.010	97	90	110			
Chromium		0.767	mg/L	0.050	96	90	110			
Cobalt		0.750	mg/L	0.030	94	90	110			
Copper		0.767	mg/L	0.050	96	90	110			
Lead		0.790	mg/L	0.20	99	90	110			
Nickel		0.766	mg/L	0.050	96	90	110			
Selenium		0.777	mg/L	0.30	97	90	110			
Silver		0.389	mg/L	0.050	97	90	110			
Vanadium		0.794	mg/L	0.10	99	90	110			
Zinc		0.785	mg/L	0.020	98	90	110			
Lab ID: ICSA	13	Interference Check Sample A								06/24/20 10:07
Arsenic		-0.00698	mg/L	0.20						
Barium		0.000350	mg/L	0.10						
Beryllium		0.0000300	mg/L	0.010						
Cadmium		-0.00251	mg/L	0.010						
Chromium		-0.000910	mg/L	0.050						
Cobalt		-0.00145	mg/L	0.030						
Copper		-0.00226	mg/L	0.050						
Lead		0.0888	mg/L	0.20						
Nickel		0.00199	mg/L	0.050						
Selenium		0.0646	mg/L	0.30						
Silver		-0.000710	mg/L	0.050						
Vanadium		0.00518	mg/L	0.10						
Zinc		0.00626	mg/L	0.020						
Lab ID: ICSAB	13	Interference Check Sample AB								06/24/20 10:12
Arsenic		0.936	mg/L	0.20	94	80	120			
Barium		0.449	mg/L	0.10	90	80	120			
Beryllium		0.446	mg/L	0.010	89	80	120			
Cadmium		0.826	mg/L	0.010	83	80	120			
Chromium		0.423	mg/L	0.050	85	80	120			
Cobalt		0.416	mg/L	0.030	83	80	120			
Copper		0.456	mg/L	0.050	91	80	120			
Lead		0.990	mg/L	0.20	99	80	120			
Nickel		0.826	mg/L	0.050	83	80	120			
Selenium		0.944	mg/L	0.30	94	80	120			
Silver		0.922	mg/L	0.050	92	80	120			
Vanadium		0.443	mg/L	0.10	89	80	120			
Zinc		0.911	mg/L	0.020	91	80	120			
Method: SW6010B										Batch: 145865

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**SW6010B**									Batch: 145865	
Lab ID:	**MB-145865**	13	Method Blank				Run: ICP203-B_200624A			06/24/20 21:29	
Arsenic			ND	mg/L	0.04						
Barium			0.1	mg/L	0.001						
Beryllium			ND	mg/L	0.0004						
Cadmium			ND	mg/L	0.001						
Chromium			ND	mg/L	0.01						
Cobalt			ND	mg/L	0.009						
Copper			ND	mg/L	0.02						
Lead			ND	mg/L	0.04						
Nickel			ND	mg/L	0.07						
Selenium			ND	mg/L	0.07						
Silver			0.001	mg/L	0.0006						
Vanadium			ND	mg/L	0.02						
Zinc			0.05	mg/L	0.006						
Lab ID:	**LCS3-145865**	13	Laboratory Control Sample				Run: ICP203-B_200624A			06/24/20 21:33	
Arsenic			0.996	mg/L	0.20	100	80	120			
Barium			5.54	mg/L	0.50	92	80	120			
Beryllium			0.448	mg/L	0.010	90	80	120			
Cadmium			0.443	mg/L	0.010	89	80	120			
Chromium			0.897	mg/L	0.10	90	80	120			
Cobalt			0.891	mg/L	0.030	89	80	120			
Copper			0.908	mg/L	0.050	91	80	120			
Lead			0.909	mg/L	0.20	91	80	120			
Nickel			0.872	mg/L	0.050	87	80	120			
Selenium			1.01	mg/L	0.30	101	80	120			
Silver			0.244	mg/L	0.050	81	80	120			
Vanadium			0.934	mg/L	0.10	93	80	120			
Zinc			0.935	mg/L	0.020	93	80	120			
Lab ID:	**B20061589-001ADIL**	13	Serial Dilution				Run: ICP203-B_200624A			06/24/20 21:42	
Arsenic			ND	mg/L	0.20					10	
Barium			1.11	mg/L	0.50				6.5	10	
Beryllium			ND	mg/L	0.010					10	
Cadmium			ND	mg/L	0.010					10	
Chromium			ND	mg/L	0.10					10	
Cobalt			ND	mg/L	0.045					10	
Copper			ND	mg/L	0.10					10	
Lead			0.826	mg/L	0.25					10	N
Nickel			ND	mg/L	0.050					10	
Selenium			ND	mg/L	0.35					10	
Silver			ND	mg/L	0.035					10	
Vanadium			ND	mg/L	0.10					10	
Zinc			0.236	mg/L	0.022				5.7	10	
Lab ID:	**B20061589-001AMS3**	13	Sample Matrix Spike				Run: ICP203-B_200624A			06/24/20 21:46	
Arsenic			0.970	mg/L	0.10	97	75	125			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

N - Analyte concentration was not sufficiently high to calculate a Relative Percent Difference (RPD) for the serial dilution test

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**SW6010B**									Batch: 145865
Lab ID:	**B20061589-001AMS3**	13	Sample Matrix Spike			Run: ICP203-B_200624A			06/24/20 21:46	
Barium		6.30	mg/L	0.50	88	75	125			
Beryllium		0.426	mg/L	0.010	85	75	125			
Cadmium		0.410	mg/L	0.010	81	75	125			
Chromium		0.843	mg/L	0.10	84	75	125			
Cobalt		0.839	mg/L	0.020	83	75	125			
Copper		0.896	mg/L	0.020	90	75	125			
Lead		1.47	mg/L	0.10	82	75	125			
Nickel		0.826	mg/L	0.050	80	75	125			
Selenium		0.959	mg/L	0.10	96	75	125			
Silver		0.244	mg/L	0.020	81	75	125			
Vanadium		0.903	mg/L	0.10	90	75	125			
Zinc		1.11	mg/L	0.010	89	75	125			
Lab ID:	**B20061589-001AMSD**	13	Sample Matrix Spike Duplicate			Run: ICP203-B_200624A			06/24/20 21:50	
Arsenic		0.989	mg/L	0.10	99	75	125	1.9	20	
Barium		6.36	mg/L	0.50	89	75	125	0.9	20	
Beryllium		0.430	mg/L	0.010	86	75	125	0.8	20	
Cadmium		0.412	mg/L	0.010	82	75	125	0.5	20	
Chromium		0.845	mg/L	0.10	84	75	125	0.3	20	
Cobalt		0.847	mg/L	0.020	83	75	125	0.9	20	
Copper		0.908	mg/L	0.020	91	75	125	1.3	20	
Lead		1.44	mg/L	0.10	80	75	125	1.5	20	
Nickel		0.839	mg/L	0.050	81	75	125	1.6	20	
Selenium		0.984	mg/L	0.10	98	75	125	2.6	20	
Silver		0.245	mg/L	0.020	82	75	125	0.6	20	
Vanadium		0.907	mg/L	0.10	91	75	125	0.5	20	
Zinc		1.11	mg/L	0.010	88	75	125	0.2	20	
Lab ID:	**B20061767-002AMS3**	13	Sample Matrix Spike			Run: ICP203-B_200624A			06/24/20 22:09	
Arsenic		0.996	mg/L	0.10	100	75	125			
Barium		7.50	mg/L	0.50	88	75	125			
Beryllium		0.437	mg/L	0.010	87	75	125			
Cadmium		0.428	mg/L	0.010	84	75	125			
Chromium		0.870	mg/L	0.10	87	75	125			
Cobalt		0.892	mg/L	0.020	85	75	125			
Copper		0.901	mg/L	0.020	90	75	125			
Lead		0.901	mg/L	0.10	90	75	125			
Nickel		0.875	mg/L	0.050	83	75	125			
Selenium		1.01	mg/L	0.10	101	75	125			
Silver		0.244	mg/L	0.020	81	75	125			
Vanadium		0.945	mg/L	0.10	91	75	125			
Zinc		1.10	mg/L	0.010	90	75	125			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6020									Analytical Run: ICPMS206-B_200624A	
Lab ID: ICSA	8	Interference Check Sample A								06/24/20 21:53
Antimony		0.000342	mg/L	0.0010						
Arsenic		0.0000870	mg/L	0.0010						
Chromium		0.000841	mg/L	0.0010						
Cobalt		0.000356	mg/L	0.0010						
Lead		0.0000488	mg/L	0.0010						
Nickel		0.000164	mg/L	0.0010						
Selenium		0.000975	mg/L	0.0010						
Silver		4.71E-06	mg/L	0.0010						
Lab ID: ICSAB	8	Interference Check Sample AB								06/24/20 21:59
Antimony		0.0000908	mg/L	0.0010						
Arsenic		0.00912	mg/L	0.0010	91	80	120			
Chromium		0.0206	mg/L	0.0010	103	80	120			
Cobalt		0.0193	mg/L	0.0010	96	80	120			
Lead		0.0000360	mg/L	0.0010						
Nickel		0.0202	mg/L	0.0010	101	80	120			
Selenium		0.0102	mg/L	0.0010	102	80	120			
Silver		0.00429	mg/L	0.0010	86	80	120			
Lab ID: QCS	8	Initial Calibration Verification Standard								06/24/20 12:54
Antimony		0.0482	mg/L	0.0010	96	90	110			
Arsenic		0.0531	mg/L	0.0010	106	90	110			
Chromium		0.0521	mg/L	0.0010	104	90	110			
Cobalt		0.0530	mg/L	0.0010	106	90	110			
Lead		0.0522	mg/L	0.0010	104	90	110			
Nickel		0.0536	mg/L	0.0010	107	90	110			
Selenium		0.0530	mg/L	0.0010	106	90	110			
Silver		0.0252	mg/L	0.0010	101	90	110			
Method: SW6020										Batch: 145787
Lab ID: MB-145787	9	Method Blank				Run: ICPMS206-B_200624A				06/24/20 22:33
Antimony		ND	mg/kg	0.04						
Arsenic		ND	mg/kg	0.3						
Chromium		ND	mg/kg	0.10						
Cobalt		0.02	mg/kg	0.01						
Copper		ND	mg/kg	0.2						
Lead		ND	mg/kg	0.2						
Nickel		ND	mg/kg	0.2						
Selenium		ND	mg/kg	0.5						
Silver		ND	mg/kg	0.04						
Lab ID: SRM3-145787	9	Standard Reference Material				Run: ICPMS206-B_200624A				06/24/20 22:39
Antimony		26.5	mg/kg	7.4	52	0	303			
Arsenic		225	mg/kg	62	111	82	119			
Chromium		227	mg/kg	19	124	71	129			
Cobalt		176	mg/kg	2.7	103	76	123			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**SW6020**									Batch: 145787	
Lab ID:	**SRM3-145787**	9	Standard Reference Material				Run: ICPMS206-B_200624A			06/24/20 22:39	
Copper			275	mg/kg	35	122	74	126			
Lead			345	mg/kg	43	104	73	127			
Nickel			210	mg/kg	31	125	73	127			
Selenium			200	mg/kg	99	118	77	122			
Silver			47.4	mg/kg	8.0	97	75	125			
Lab ID:	**B20061767-002ADIL**	9	Serial Dilution				Run: ICPMS206-B_200624A			06/25/20 03:34	
Antimony			ND	mg/kg	1.0					10	
Arsenic			ND	mg/kg	7.6					10	
Chromium			19.9	mg/kg	2.3					10	N
Cobalt			7.60	mg/kg	1.0				13	10	R
Copper			21.5	mg/kg	4.3					10	N
Lead			8.02	mg/kg	5.2					10	N
Nickel			22.6	mg/kg	3.8					10	N
Selenium			ND	mg/kg	12					10	
Silver			ND	mg/kg	1.0					10	
Lab ID:	**B20061767-002APDS1**	9	Post Digestion/Distillation Spike				Run: ICPMS206-B_200624A			06/25/20 03:40	
Antimony			13.0	mg/kg	1.0	106	75	125			
Arsenic			17.4	mg/kg	1.5	119	75	125			
Chromium			34.0	mg/kg	1.0	117	75	125			
Cobalt			18.4	mg/kg	1.0	98	75	125			
Copper			34.7	mg/kg	1.0	115	75	125			
Lead			20.0	mg/kg	1.1	104	75	125			
Nickel			36.3	mg/kg	1.0	117	75	125			
Selenium			12.7	mg/kg	2.5	105	75	125			
Silver			4.30	mg/kg	1.0	89	75	125			
Lab ID:	**B20061767-002AMS3**	9	Sample Matrix Spike				Run: ICPMS206-B_200624A			06/25/20 03:45	
Antimony			17.3	mg/kg	1.0	35	75	125			S
Arsenic			63.9	mg/kg	6.3	124	75	125			
Chromium			78.0	mg/kg	1.9	118	75	125			
Cobalt			59.2	mg/kg	1.0	107	75	125			
Copper			74.8	mg/kg	3.5	110	75	125			
Lead			59.2	mg/kg	4.3	105	75	125			
Nickel			77.5	mg/kg	3.1	113	75	125			
Selenium			52.1	mg/kg	10	106	75	125			
Silver			22.9	mg/kg	1.0	93	75	125			
Lab ID:	**B20061767-002AMSD**	9	Sample Matrix Spike Duplicate				Run: ICPMS206-B_200624A			06/25/20 03:51	
Antimony			17.0	mg/kg	1.0	34	75	125	1.4	20	S
Arsenic			59.6	mg/kg	6.2	116	75	125	6.9	20	
Chromium			79.2	mg/kg	1.9	122	75	125	1.6	20	
Cobalt			57.0	mg/kg	1.0	103	75	125	3.8	20	
Copper			77.6	mg/kg	3.5	116	75	125	3.6	20	
Lead			58.7	mg/kg	4.3	105	75	125	0.8	20	
Nickel			79.8	mg/kg	3.1	118	75	125	2.9	20	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

N - Analyte concentration was not sufficiently high to calculate a Relative Percent Difference (RPD) for the serial dilution test

R - Relative Percent Difference (RPD) exceeds advisory limit

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**SW6020**										Batch: 145787
Lab ID:	**B20061767-002AMSD**	9	Sample Matrix Spike Duplicate				Run: ICPMS206-B_200624A			06/25/20 03:51	
Selenium			53.3	mg/kg	9.9	109	75	125	2.3	20	
Silver			22.6	mg/kg	1.0	93	75	125	1.3	20	
Method:	**SW6020**										Analytical Run: ICPMS207-B_200625A
Lab ID:	**ICSA**	2	Interference Check Sample A							06/25/20 15:45	
Antimony			0.0000533	mg/L	0.0010						
Copper			0.000137	mg/L	0.0010						
Lab ID:	**ICSAB**	2	Interference Check Sample AB							06/25/20 15:49	
Antimony			0.0000268	mg/L	0.0010						
Copper			0.0194	mg/L	0.0010	97	80	120			
Lab ID:	**QCS**	2	Initial Calibration Verification Standard							06/26/20 00:08	
Antimony			0.0493	mg/L	0.0010	99	90	110			
Copper			0.0528	mg/L	0.0010	105	90	110			
Method:	**SW6020**										Batch: 145787
Lab ID:	**MB-145787**		Method Blank				Run: ICPMS207-B_200625A			06/25/20 22:51	
Copper			ND	mg/kg	0.2						
Method:	**SW6020**										Batch: 145865
Lab ID:	**MB-145865**		Method Blank				Run: ICPMS207-B_200625A			06/25/20 19:53	
Antimony			ND	mg/L	0.002						
Lab ID:	**LCS3-145865**		Laboratory Control Sample				Run: ICPMS207-B_200625A			06/25/20 19:57	
Antimony			1.09	mg/L	0.10	109	80	120			
Lab ID:	**B20061589-001ADIL**		Serial Dilution				Run: ICPMS207-B_200625A			06/25/20 20:09	
Antimony			ND	mg/L	0.10					10	
Lab ID:	**B20061589-001AMS3**		Sample Matrix Spike				Run: ICPMS207-B_200625A			06/25/20 20:30	
Antimony			1.09	mg/L	0.10	109	75	125			
Lab ID:	**B20061589-001AMSD**		Sample Matrix Spike Duplicate				Run: ICPMS207-B_200625A			06/25/20 20:34	
Antimony			1.10	mg/L	0.10	110	75	125	1.0	20	
Lab ID:	**B20061767-002AMS3**		Sample Matrix Spike				Run: ICPMS207-B_200625A			06/25/20 20:47	
Antimony			1.09	mg/L	0.10	109	75	125			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**SW7470A**								Analytical Run: HGCV202-B_200625A		
Lab ID:	**ICV**		Initial Calibration Verification Standard							06/25/20 12:13	
Mercury			0.00181	mg/L	0.00010	90	90	110			
Method:	**SW7470A**									Batch: 145885	
Lab ID:	**MB-145885**		Method Blank				Run: HGCV202-B_200625A			06/25/20 14:29	
Mercury			ND	mg/L	0.0001						
Lab ID:	**LCS-145885**		Laboratory Control Sample				Run: HGCV202-B_200625A			06/25/20 14:31	
Mercury			0.00188	mg/L	0.0010	94	80	120			
Lab ID:	**B20061767-002AMS**		Sample Matrix Spike				Run: HGCV202-B_200625A			06/25/20 14:44	
Mercury			0.00928	mg/L	0.0010	93	75	125			
Lab ID:	**B20061834-002ADIL**		Serial Dilution				Run: HGCV202-B_200625A			06/25/20 14:57	
Mercury			ND	mg/L	0.0025					10	
Lab ID:	**B20061834-002AMS**		Sample Matrix Spike				Run: HGCV202-B_200625A			06/25/20 14:59	
Mercury			0.00952	mg/L	0.0010	95	75	125			
Lab ID:	**B20061834-002AMSD**		Sample Matrix Spike Duplicate				Run: HGCV202-B_200625A			06/25/20 15:00	
Mercury			0.00927	mg/L	0.0010	93	75	125	2.6	20	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/29/20

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: **SW7471B**									Analytical Run: HGCV202-B_200624A	
Lab ID: **ICV**		Initial Calibration Verification Standard							06/24/20 14:54	
Mercury		0.00215	mg/kg	0.10	107	90	110			
Method: **SW7471B**									Batch: 145789	
Lab ID: **MB-145789**		Method Blank				Run: HGCV202-B_200624A			06/24/20 14:59	
Mercury		ND	mg/kg	0.005						
Lab ID: **LCS3-145789**		Laboratory Control Sample				Run: HGCV202-B_200624A			06/24/20 15:01	
Mercury		0.221	mg/kg	0.10	111	80	120			
Lab ID: **B20061761-001ADIL**		Serial Dilution				Run: HGCV202-B_200624A			06/24/20 15:53	
Mercury		1.62	mg/kg-dry	0.35				40	10	R
Lab ID: **B20061761-001AMS3**		Sample Matrix Spike				Run: HGCV202-B_200624A			06/24/20 15:54	
Mercury		1.49	mg/kg-dry	0.10		80	120			A
Lab ID: **B20061761-001AMSD**		Sample Matrix Spike Duplicate				Run: HGCV202-B_200624A			06/24/20 15:56	
Mercury		1.46	mg/kg-dry	0.10		80	120	2.2	20	A

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

A - Analyte level was greater than four times the spike level - in accordance with the method, percent recovery is not calculated

R - Relative Percent Difference (RPD) exceeds advisory limit

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145815
Lab ID: LCS062620a	Laboratory Control Sample				Run: SV5972.I_200626B				06/26/20 23:53
Benzene	0.00461	mg/L	0.0010	92	71	133			
Carbon tetrachloride	0.00423	mg/L	0.0010	85	61	144			
Chlorobenzene	0.00563	mg/L	0.0010	113	78	136			
Chloroform	0.00421	mg/L	0.0010	84	69	133			
1,4-Dichlorobenzene	0.00486	mg/L	0.0010	97	78	132			
1,2-Dichloroethane	0.00440	mg/L	0.0010	88	57	146			
1,1-Dichloroethene	0.00468	mg/L	0.0010	94	66	142			
Methyl ethyl ketone	0.0687	mg/L	0.020	137	55	145			
Tetrachloroethene	0.00524	mg/L	0.0010	105	78	137			
Trichloroethene	0.00508	mg/L	0.0010	102	75	138			
Vinyl chloride	0.00415	mg/L	0.0010	83	66	140			
Surr: 1,2-Dichloroethane-d4			0.0010	101	70	130			
Surr: Dibromofluoromethane			0.0010	105	77	126			
Surr: p-Bromofluorobenzene			0.0010	78	76	127			
Surr: Toluene-d8			0.0010	106	79	122			
Lab ID: MB-145815	Method Blank				Run: SV5972.I_200626B				06/27/20 01:53
Benzene	ND	mg/L	0.010						
Carbon tetrachloride	ND	mg/L	0.010						
Chlorobenzene	ND	mg/L	0.010						
Chloroform	ND	mg/L	0.010						
1,4-Dichlorobenzene	ND	mg/L	0.010						
1,2-Dichloroethane	ND	mg/L	0.010						
1,1-Dichloroethene	ND	mg/L	0.010						
Methyl ethyl ketone	ND	mg/L	0.20						
Tetrachloroethene	ND	mg/L	0.010						
Trichloroethene	ND	mg/L	0.010						
Vinyl chloride	ND	mg/L	0.010						
Surr: 1,2-Dichloroethane-d4			0.010	98	70	130			
Surr: Dibromofluoromethane			0.010	106	77	126			
Surr: p-Bromofluorobenzene			0.010	77	76	127			
Surr: Toluene-d8			0.010	107	79	122			
Lab ID: B20061767-001AMS	Sample Matrix Spike				Run: SV5972.I_200626B				06/27/20 03:09
Benzene	0.533	mg/L	0.10	107	71	133			
Carbon tetrachloride	0.419	mg/L	0.10	84	61	144			
Chlorobenzene	0.579	mg/L	0.10	116	78	136			
Chloroform	0.437	mg/L	0.10	87	69	133			
1,4-Dichlorobenzene	0.508	mg/L	0.10	102	78	132			
1,2-Dichloroethane	0.469	mg/L	0.10	94	57	146			
1,1-Dichloroethene	0.494	mg/L	0.10	99	66	142			
Methyl ethyl ketone	6.75	mg/L	2.0	135	55	145			
Tetrachloroethene	0.545	mg/L	0.10	109	78	137			
Trichloroethene	0.508	mg/L	0.10	102	75	138			
Vinyl chloride	0.457	mg/L	0.10	91	66	140			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145815
Lab ID: B20061767-001AMS	Sample Matrix Spike				Run: SV5972.I_200626B				06/27/20 03:09
Surr: 1,2-Dichloroethane-d4			0.10	98	70	130			
Surr: Dibromofluoromethane			0.10	105	77	126			
Surr: p-Bromofluorobenzene			0.10	77	76	127			
Surr: Toluene-d8			0.10	106	79	122			
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: SV5972.I_200626B				06/27/20 04:23
Benzene	0.467	mg/L	0.10	93	71	133			
Carbon tetrachloride	0.407	mg/L	0.10	81	61	144			
Chlorobenzene	0.564	mg/L	0.10	113	78	136			
Chloroform	0.419	mg/L	0.10	84	69	133			
1,4-Dichlorobenzene	0.496	mg/L	0.10	99	78	132			
1,2-Dichloroethane	0.444	mg/L	0.10	89	57	146			
1,1-Dichloroethene	0.469	mg/L	0.10	94	66	142			
Methyl ethyl ketone	6.47	mg/L	2.0	129	55	145			
Tetrachloroethene	0.537	mg/L	0.10	107	78	137			
Trichloroethene	0.505	mg/L	0.10	101	75	138			
Vinyl chloride	0.449	mg/L	0.10	90	66	140			
Surr: 1,2-Dichloroethane-d4			0.10	95	70	130			
Surr: Dibromofluoromethane			0.10	105	77	126			
Surr: p-Bromofluorobenzene			0.10	78	76	127			
Surr: Toluene-d8			0.10	107	79	122			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145914
Lab ID: LCS-145914	Laboratory Control Sample				Run: 5971A.I_200625B				06/26/20 05:40
Benzene	1.07	mg/kg	0.10	107	70	127			
Bromobenzene	1.04	mg/kg	0.10	104	70	135			
Bromochloromethane	1.12	mg/kg	0.10	112	60	130			
Bromodichloromethane	1.05	mg/kg	0.10	106	56	136			
Bromoform	1.13	mg/kg	0.10	113	59	132			
Bromomethane	0.434	mg/kg	0.10	43	18	134			
Carbon tetrachloride	1.12	mg/kg	0.10	112	60	140			
Chlorobenzene	1.02	mg/kg	0.10	102	75	132			
Chlorodibromomethane	1.09	mg/kg	0.10	110	62	133			
Chloroethane	0.435	mg/kg	0.10	44	12	80			
Chloroform	1.06	mg/kg	0.10	106	62	132			
Chloromethane	0.982	mg/kg	0.10	98	41	138			
2-Chloroethyl vinyl ether	1.08	mg/kg	0.10	108	41	149			
1,2-Dibromoethane	1.10	mg/kg	0.10	110	60	135			
2-Chlorotoluene	1.12	mg/kg	0.10	112	74	135			
Dibromomethane	1.04	mg/kg	0.10	105	60	135			
1,2-Dichlorobenzene	1.06	mg/kg	0.10	106	70	130			
4-Chlorotoluene	1.09	mg/kg	0.10	109	75	136			
1,3-Dichlorobenzene	1.03	mg/kg	0.10	104	71	132			
1,4-Dichlorobenzene	0.973	mg/kg	0.10	97	71	131			
Dichlorodifluoromethane	0.956	mg/kg	0.10	96	31	123			
1,1-Dichloroethane	1.08	mg/kg	0.10	109	66	130			
1,2-Dichloroethane	1.10	mg/kg	0.10	110	51	140			
1,1-Dichloroethene	1.13	mg/kg	0.10	113	64	133			
cis-1,2-Dichloroethene	1.14	mg/kg	0.10	114	63	131			
trans-1,2-Dichloroethene	1.15	mg/kg	0.10	115	66	133			
1,2-Dichloropropane	1.07	mg/kg	0.10	107	60	130			
1,3-Dichloropropane	1.06	mg/kg	0.10	107	59	135			
2,2-Dichloropropane	0.926	mg/kg	0.10	93	39	157			
1,1-Dichloropropene	1.05	mg/kg	0.10	106	65	132			
cis-1,3-Dichloropropene	1.08	mg/kg	0.10	108	55	134			
trans-1,3-Dichloropropene	1.04	mg/kg	0.10	105	58	146			
Ethylbenzene	0.974	mg/kg	0.10	98	74	136			
Methyl tert-butyl ether (MTBE)	0.915	mg/kg	0.10	92	43	152			
Methyl ethyl ketone	11.1	mg/kg	2.0	112	43	148			
Methylene chloride	1.05	mg/kg	0.10	105	51	134			
Styrene	1.04	mg/kg	0.10	104	70	135			
1,1,1,2-Tetrachloroethane	1.07	mg/kg	0.10	108	35	156			
1,1,2,2-Tetrachloroethane	1.13	mg/kg	0.10	113	59	135			
Tetrachloroethene	0.996	mg/kg	0.10	100	64	139			
Toluene	1.06	mg/kg	0.10	106	73	137			
1,1,1-Trichloroethane	1.12	mg/kg	0.10	113	63	134			
1,1,2-Trichloroethane	1.03	mg/kg	0.10	103	56	136			
Trichloroethene	1.05	mg/kg	0.10	105	65	134			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145914
Lab ID: LCS-145914	Laboratory Control Sample				Run: 5971A.I_200625B				06/26/20 05:40
Trichlorofluoromethane	0.931	mg/kg	0.10	93	48	140			
1,2,3-Trichloropropane	1.12	mg/kg	0.10	112	56	142			
Vinyl chloride	1.06	mg/kg	0.10	107	32	136			
m+p-Xylenes	2.06	mg/kg	0.20	103	75	136			
o-Xylene	1.02	mg/kg	0.10	102	72	134			
Xylenes, Total	3.08	mg/kg	0.10	103	72	136			
Surr: 1,2-Dichloroethane-d4			0.10	87	60	136			
Surr: Dibromofluoromethane			0.10	90	70	132			
Surr: p-Bromofluorobenzene			0.10	101	78	160			
Surr: Toluene-d8			0.10	90	75	138			
Lab ID: MB-145914	Method Blank				Run: 5971A.I_200625B				06/26/20 06:35
Benzene	ND	mg/kg	0.10						
Bromobenzene	ND	mg/kg	0.10						
Bromochloromethane	ND	mg/kg	0.10						
Bromodichloromethane	ND	mg/kg	0.10						
Bromoform	ND	mg/kg	0.10						
Bromomethane	ND	mg/kg	0.10						
Carbon tetrachloride	ND	mg/kg	0.10						
Chlorobenzene	ND	mg/kg	0.10						
Chlorodibromomethane	ND	mg/kg	0.10						
Chloroethane	ND	mg/kg	0.10						
Chloroform	ND	mg/kg	0.10						
Chloromethane	ND	mg/kg	0.10						
2-Chloroethyl vinyl ether	ND	mg/kg	0.10						
1,2-Dibromoethane	ND	mg/kg	0.10						
2-Chlorotoluene	ND	mg/kg	0.10						
Dibromomethane	ND	mg/kg	0.10						
1,2-Dichlorobenzene	ND	mg/kg	0.10						
4-Chlorotoluene	ND	mg/kg	0.10						
1,3-Dichlorobenzene	ND	mg/kg	0.10						
1,4-Dichlorobenzene	ND	mg/kg	0.10						
Dichlorodifluoromethane	ND	mg/kg	0.10						
1,1-Dichloroethane	ND	mg/kg	0.10						
1,2-Dichloroethane	ND	mg/kg	0.10						
1,1-Dichloroethene	ND	mg/kg	0.10						
cis-1,2-Dichloroethene	ND	mg/kg	0.10						
trans-1,2-Dichloroethene	ND	mg/kg	0.10						
1,2-Dichloropropane	ND	mg/kg	0.10						
1,3-Dichloropropane	ND	mg/kg	0.10						
2,2-Dichloropropane	ND	mg/kg	0.10						
1,1-Dichloropropene	ND	mg/kg	0.10						
cis-1,3-Dichloropropene	ND	mg/kg	0.10						
trans-1,3-Dichloropropene	ND	mg/kg	0.10						

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145914
Lab ID: MB-145914	Method Blank				Run: 5971A.I_200625B				06/26/20 06:35
Ethylbenzene	ND	mg/kg	0.10						
Methyl tert-butyl ether (MTBE)	ND	mg/kg	0.10						
Methyl ethyl ketone	ND	mg/kg	2.0						
Methylene chloride	ND	mg/kg	0.10						
Styrene	ND	mg/kg	0.10						
1,1,1,2-Tetrachloroethane	ND	mg/kg	0.10						
1,1,2,2-Tetrachloroethane	ND	mg/kg	0.10						
Tetrachloroethene	ND	mg/kg	0.10						
Toluene	ND	mg/kg	0.10						
1,1,1-Trichloroethane	ND	mg/kg	0.10						
1,1,2-Trichloroethane	ND	mg/kg	0.10						
Trichloroethene	ND	mg/kg	0.10						
Trichlorofluoromethane	ND	mg/kg	0.10						
1,2,3-Trichloropropane	ND	mg/kg	0.10						
Vinyl chloride	ND	mg/kg	0.10						
m+p-Xylenes	ND	mg/kg	0.20						
o-Xylene	ND	mg/kg	0.10						
Xylenes, Total	ND	mg/kg	0.10						
Surr: 1,2-Dichloroethane-d4			0.10	111	60	136			
Surr: Dibromofluoromethane			0.10	114	70	132			
Surr: p-Bromofluorobenzene			0.10	112	78	160			
Surr: Toluene-d8			0.10	116	75	138			
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: 5971A.I_200625B				06/26/20 12:35
Benzene	1.28	mg/kg	0.10	128	70	127			S
Bromobenzene	1.20	mg/kg	0.10	120	70	135			
Bromochloromethane	1.24	mg/kg	0.10	124	60	130			
Bromodichloromethane	1.24	mg/kg	0.10	124	56	136			
Bromoform	1.21	mg/kg	0.10	121	59	132			
Bromomethane	0.391	mg/kg	0.10	39	18	134			
Carbon tetrachloride	1.34	mg/kg	0.10	134	60	140			
Chlorobenzene	1.25	mg/kg	0.10	125	75	132			
Chlorodibromomethane	1.29	mg/kg	0.10	129	62	133			
Chloroethane	0.493	mg/kg	0.10	49	12	80			
Chloroform	1.23	mg/kg	0.10	123	62	132			
Chloromethane	1.08	mg/kg	0.10	108	41	138			
2-Chloroethyl vinyl ether	1.34	mg/kg	0.10	134	41	149			
1,2-Dibromoethane	1.27	mg/kg	0.10	127	60	135			
2-Chlorotoluene	1.19	mg/kg	0.10	119	74	135			
Dibromomethane	1.23	mg/kg	0.10	123	60	135			
1,2-Dichlorobenzene	1.14	mg/kg	0.10	114	70	130			
4-Chlorotoluene	1.13	mg/kg	0.10	113	75	136			
1,3-Dichlorobenzene	1.21	mg/kg	0.10	121	71	132			
1,4-Dichlorobenzene	1.13	mg/kg	0.10	113	71	131			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145914
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: 5971A.I_200625B				06/26/20 12:35
Dichlorodifluoromethane	1.01	mg/kg	0.10	101	31	123			
1,1-Dichloroethane	1.29	mg/kg	0.10	129	66	130			
1,2-Dichloroethane	1.29	mg/kg	0.10	129	51	140			
1,1-Dichloroethene	1.29	mg/kg	0.10	129	64	133			
cis-1,2-Dichloroethene	1.32	mg/kg	0.10	132	63	131			S
trans-1,2-Dichloroethene	1.31	mg/kg	0.10	131	66	133			
1,2-Dichloropropane	1.27	mg/kg	0.10	127	60	130			
1,3-Dichloropropane	1.25	mg/kg	0.10	125	59	135			
2,2-Dichloropropane	0.933	mg/kg	0.10	93	39	157			
1,1-Dichloropropene	1.25	mg/kg	0.10	124	65	132			
cis-1,3-Dichloropropene	1.25	mg/kg	0.10	124	55	134			
trans-1,3-Dichloropropene	1.18	mg/kg	0.10	118	58	146			
Ethylbenzene	1.25	mg/kg	0.10	125	74	136			
Methyl tert-butyl ether (MTBE)	1.08	mg/kg	0.10	108	43	152			
Methyl ethyl ketone	12.6	mg/kg	2.0	126	43	148			
Methylene chloride	1.23	mg/kg	0.10	123	51	134			
Styrene	1.27	mg/kg	0.10	127	70	135			
1,1,1,2-Tetrachloroethane	1.35	mg/kg	0.10	135	35	156			
1,1,2,2-Tetrachloroethane	1.29	mg/kg	0.10	129	59	135			
Tetrachloroethene	1.24	mg/kg	0.10	124	64	139			
Toluene	1.26	mg/kg	0.10	126	73	137			
1,1,1-Trichloroethane	1.33	mg/kg	0.10	132	63	134			
1,1,2-Trichloroethane	1.25	mg/kg	0.10	125	56	136			
Trichloroethene	1.22	mg/kg	0.10	122	65	134			
Trichlorofluoromethane	0.996	mg/kg	0.10	100	48	140			
1,2,3-Trichloropropane	1.24	mg/kg	0.10	124	56	142			
Vinyl chloride	1.16	mg/kg	0.10	116	32	136			
m+p-Xylenes	2.55	mg/kg	0.20	128	75	136			
o-Xylene	1.26	mg/kg	0.10	126	72	134			
Xylenes, Total	3.81	mg/kg	0.10	127	72	136			
Surr: 1,2-Dichloroethane-d4			0.10	90	60	136			
Surr: Dibromofluoromethane			0.10	95	70	132			
Surr: p-Bromofluorobenzene			0.10	100	78	160			
Surr: Toluene-d8			0.10	95	75	138			
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate				Run: 5971A.I_200625B				06/26/20 13:02
Benzene	1.28	mg/kg	0.10	129	70	127	0.5	20	S
Bromobenzene	1.13	mg/kg	0.10	113	70	135	5.3	20	
Bromochloromethane	1.31	mg/kg	0.10	131	60	130	5.5	20	S
Bromodichloromethane	1.19	mg/kg	0.10	119	56	136	4.4	20	
Bromoform	1.20	mg/kg	0.10	120	59	132	0.5	20	
Bromomethane	0.549	mg/kg	0.10	55	18	134	34	20	R
Carbon tetrachloride	1.31	mg/kg	0.10	132	60	140	2.0	20	
Chlorobenzene	1.22	mg/kg	0.10	122	75	132	2.0	20	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

R - Relative Percent Difference (RPD) exceeds advisory limit

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B								Batch: 145914	
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate				Run: 5971A.I_200625B			06/26/20 13:02	
Chlorodibromomethane	1.29	mg/kg	0.10	129	62	133	0.4	20	
Chloroethane	0.454	mg/kg	0.10	45	12	80	8.3	20	
Chloroform	1.22	mg/kg	0.10	122	62	132	0.2	20	
Chloromethane	1.12	mg/kg	0.10	112	41	138	3.6	20	
2-Chloroethyl vinyl ether	1.35	mg/kg	0.10	135	41	149	1.0	20	
1,2-Dibromoethane	1.28	mg/kg	0.10	128	60	135	0.9	20	
2-Chlorotoluene	1.14	mg/kg	0.10	114	74	135	4.3	20	
Dibromomethane	1.25	mg/kg	0.10	126	60	135	2.0	20	
1,2-Dichlorobenzene	1.16	mg/kg	0.10	116	70	130	1.8	20	
4-Chlorotoluene	1.17	mg/kg	0.10	117	75	136	4.2	20	
1,3-Dichlorobenzene	1.19	mg/kg	0.10	119	71	132	1.9	20	
1,4-Dichlorobenzene	1.09	mg/kg	0.10	109	71	131	3.8	20	
Dichlorodifluoromethane	1.03	mg/kg	0.10	103	31	123	2.4	20	
1,1-Dichloroethane	1.26	mg/kg	0.10	126	66	130	2.3	20	
1,2-Dichloroethane	1.29	mg/kg	0.10	129	51	140	0.2	20	
1,1-Dichloroethene	1.26	mg/kg	0.10	126	64	133	2.4	20	
cis-1,2-Dichloroethene	1.33	mg/kg	0.10	133	63	131	1.2	20	S
trans-1,2-Dichloroethene	1.31	mg/kg	0.10	132	66	133	0.4	20	
1,2-Dichloropropane	1.23	mg/kg	0.10	123	60	130	3.4	20	
1,3-Dichloropropane	1.23	mg/kg	0.10	123	59	135	1.4	20	
2,2-Dichloropropane	0.907	mg/kg	0.10	91	39	157	2.8	20	
1,1-Dichloropropene	1.23	mg/kg	0.10	123	65	132	1.1	20	
cis-1,3-Dichloropropene	1.24	mg/kg	0.10	124	55	134	0.4	20	
trans-1,3-Dichloropropene	1.13	mg/kg	0.10	113	58	146	3.9	20	
Ethylbenzene	1.24	mg/kg	0.10	124	74	136	0.4	20	
Methyl tert-butyl ether (MTBE)	1.13	mg/kg	0.10	113	43	152	4.8	20	
Methyl ethyl ketone	13.2	mg/kg	2.0	132	43	148	4.1	20	
Methylene chloride	1.25	mg/kg	0.10	125	51	134	1.7	20	
Styrene	1.24	mg/kg	0.10	124	70	135	1.9	20	
1,1,1,2-Tetrachloroethane	1.36	mg/kg	0.10	135	35	156	0.2	20	
1,1,2,2-Tetrachloroethane	1.25	mg/kg	0.10	125	59	135	3.1	20	
Tetrachloroethene	1.23	mg/kg	0.10	123	64	139	0.8	20	
Toluene	1.22	mg/kg	0.10	122	73	137	3.6	20	
1,1,1-Trichloroethane	1.31	mg/kg	0.10	131	63	134	0.9	20	
1,1,2-Trichloroethane	1.25	mg/kg	0.10	125	56	136	0.6	20	
Trichloroethene	1.22	mg/kg	0.10	122	65	134	0.2	20	
Trichlorofluoromethane	1.14	mg/kg	0.10	114	48	140	13	20	
1,2,3-Trichloropropane	1.19	mg/kg	0.10	119	56	142	4.0	20	
Vinyl chloride	1.21	mg/kg	0.10	121	32	136	4.9	20	
m+p-Xylenes	2.48	mg/kg	0.20	124	75	136	2.9	20	
o-Xylene	1.27	mg/kg	0.10	127	72	134	0.8	20	
Xylenes, Total	3.75	mg/kg	0.10	125	72	136	1.6	20	
Surr: 1,2-Dichloroethane-d4			0.10	102	60	136			
Surr: Dibromofluoromethane			0.10	108	70	132			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8260B									Batch: 145914
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate				Run: 5971A.I_200625B				06/26/20 13:02
Surr: p-Bromofluorobenzene			0.10	112	78	160			
Surr: Toluene-d8			0.10	107	75	138			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145894
Lab ID: MB-145894	Method Blank				Run: SV5973N2.I_200627A				06/29/20 12:14
m+p-Cresols	ND	mg/L	0.050						
o-Cresol	ND	mg/L	0.050						
Pentachlorophenol	ND	mg/L	0.25						
2,4,5-Trichlorophenol	ND	mg/L	0.050						
2,4,6-Trichlorophenol	ND	mg/L	0.050						
2,4-Dinitrotoluene	ND	mg/L	0.050						
Hexachlorobutadiene	ND	mg/L	0.050						
Hexachlorobenzene	ND	mg/L	0.050						
Hexachloroethane	ND	mg/L	0.050						
Nitrobenzene	ND	mg/L	0.050						
Pyridine	ND	mg/L	0.10						
Cresols, Total	ND	mg/L	0.050						
Surr: 2,4,6-Tribromophenol			0.050	70	25	140			
Surr: 2-Fluorobiphenyl			0.050	66	28	107			
Surr: 2-Fluorophenol			0.050	61	10	75			
Surr: Nitrobenzene-d5			0.050	63	32	94			
Surr: Phenol-d5			0.050	65	26	101			
Surr: Terphenyl-d14			0.050	87	32	122			
Lab ID: LCS-145894	Laboratory Control Sample				Run: SV5973N2.I_200627A				06/29/20 12:45
m+p-Cresols	0.619	mg/L	0.050	62	34	104			
o-Cresol	0.378	mg/L	0.050	76	37	110			
Pentachlorophenol	0.462	mg/L	0.25	92	37	129			
2,4,5-Trichlorophenol	0.378	mg/L	0.050	76	52	114			
2,4,6-Trichlorophenol	0.386	mg/L	0.050	77	42	108			
2,4-Dinitrotoluene	0.388	mg/L	0.050	78	36	111			
Hexachlorobutadiene	0.327	mg/L	0.050	65	34	107			
Hexachlorobenzene	0.314	mg/L	0.050	63	40	112			
Hexachloroethane	0.335	mg/L	0.050	67	26	108			
Nitrobenzene	0.433	mg/L	0.050	87	43	115			
Pyridine	0.194	mg/L	0.10	39	10	122			
Surr: 2,4,6-Tribromophenol			0.050	78	25	140			
Surr: 2-Fluorobiphenyl			0.050	66	28	107			
Surr: 2-Fluorophenol			0.050	62	10	75			
Surr: Nitrobenzene-d5			0.050	66	32	94			
Surr: Phenol-d5			0.050	66	26	101			
Surr: Terphenyl-d14			0.050	84	32	122			
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: SV5973N2.I_200627A				06/29/20 14:49
m+p-Cresols	0.616	mg/L	0.050	62	34	104			
o-Cresol	0.383	mg/L	0.050	77	37	110			
Pentachlorophenol	0.442	mg/L	0.25	88	37	129			
2,4,5-Trichlorophenol	0.379	mg/L	0.050	76	52	114			
2,4,6-Trichlorophenol	0.369	mg/L	0.050	74	42	108			
2,4-Dinitrotoluene	0.379	mg/L	0.050	76	36	111			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145894
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: SV5973N2.I_200627A				06/29/20 14:49
Hexachlorobutadiene	0.312	mg/L	0.050	62	34	107			
Hexachlorobenzene	0.315	mg/L	0.050	63	40	112			
Hexachloroethane	0.335	mg/L	0.050	67	26	108			
Nitrobenzene	0.443	mg/L	0.050	89	43	115			
Pyridine	0.118	mg/L	0.10	24	10	122			
Surr: 2,4,6-Tribromophenol			0.050	75	25	140			
Surr: 2-Fluorobiphenyl			0.050	65	28	107			
Surr: 2-Fluorophenol			0.050	61	10	75			
Surr: Nitrobenzene-d5			0.050	67	32	94			
Surr: Phenol-d5			0.050	66	26	101			
Surr: Terphenyl-d14			0.050	85	32	122			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: MB-145958	Method Blank				Run: SV5973N.I_200626D				06/28/20 03:14
1,2,4-Trichlorobenzene	ND	mg/kg	0.33						
1,2-Dichlorobenzene	ND	mg/kg	0.33						
1,3-Dichlorobenzene	ND	mg/kg	0.33						
1,4-Dichlorobenzene	ND	mg/kg	0.33						
1-Methylnaphthalene	ND	mg/kg	0.33						
2,4,5-Trichlorophenol	ND	mg/kg	0.33						
2,4,6-Trichlorophenol	ND	mg/kg	0.33						
2,4-Dichlorophenol	ND	mg/kg	0.33						
2,4-Dimethylphenol	ND	mg/kg	0.33						
2,4-Dinitrophenol	ND	mg/kg	1.7						
2,4-Dinitrotoluene	ND	mg/kg	0.33						
2,6-Dinitrotoluene	ND	mg/kg	0.33						
2-Chloronaphthalene	ND	mg/kg	0.33						
2-Chlorophenol	ND	mg/kg	0.33						
2-Methylnaphthalene	ND	mg/kg	0.33						
2-Nitrophenol	ND	mg/kg	0.33						
3,3´-Dichlorobenzidine	ND	mg/kg	0.33						
4,6-Dinitro-2-methylphenol	ND	mg/kg	1.7						
4-Bromophenyl phenyl ether	ND	mg/kg	0.33						
4-Chloro-3-methylphenol	ND	mg/kg	0.33						
4-Chlorophenol	ND	mg/kg	0.33						
4-Chlorophenyl phenyl ether	ND	mg/kg	0.33						
4-Nitrophenol	ND	mg/kg	1.7						
Acenaphthene	ND	mg/kg	0.33						
Acenaphthylene	ND	mg/kg	0.33						
Anthracene	ND	mg/kg	0.33						
Azobenzene	ND	mg/kg	0.33						
Benzidine	ND	mg/kg	0.33						
Benzo(a)anthracene	ND	mg/kg	0.33						
Benzo(a)pyrene	ND	mg/kg	0.33						
Benzo(b)fluoranthene	ND	mg/kg	0.33						
Benzo(g,h,i)perylene	ND	mg/kg	0.33						
Benzo(k)fluoranthene	ND	mg/kg	0.33						
bis(-2-chloroethoxy)Methane	ND	mg/kg	0.33						
bis(-2-chloroethyl)Ether	ND	mg/kg	0.33						
bis(2-chloroisopropyl)Ether	ND	mg/kg	0.33						
bis(2-ethylhexyl)Phthalate	ND	mg/kg	0.33						
Butylbenzylphthalate	ND	mg/kg	0.33						
Chrysene	ND	mg/kg	0.33						
Dibenzo(a,h)anthracene	ND	mg/kg	0.33						
Diethyl phthalate	ND	mg/kg	0.33						
Dimethyl phthalate	ND	mg/kg	0.33						
Di-n-butyl phthalate	ND	mg/kg	0.33						
Di-n-octyl phthalate	ND	mg/kg	0.33						

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: MB-145958	Method Blank				Run: SV5973N.I_200626D				06/28/20 03:14
Fluoranthene	ND	mg/kg	0.33						
Fluorene	ND	mg/kg	0.33						
Hexachlorobenzene	ND	mg/kg	0.33						
Hexachlorobutadiene	ND	mg/kg	0.33						
Hexachlorocyclopentadiene	ND	mg/kg	0.33						
Hexachloroethane	ND	mg/kg	0.33						
Indeno(1,2,3-cd)pyrene	ND	mg/kg	0.33						
Isophorone	ND	mg/kg	0.33						
m+p-Cresols	ND	mg/kg	0.33						
Naphthalene	ND	mg/kg	0.33						
Nitrobenzene	ND	mg/kg	0.33						
n-Nitrosodimethylamine	ND	mg/kg	0.33						
n-Nitroso-di-n-propylamine	ND	mg/kg	0.33						
n-Nitrosodiphenylamine	ND	mg/kg	0.33						
o-Cresol	ND	mg/kg	0.33						
Pentachlorophenol	ND	mg/kg	1.7						
Phenanthrene	ND	mg/kg	0.33						
Phenol	ND	mg/kg	0.33						
Pyrene	ND	mg/kg	0.33						
Pyridine	ND	mg/kg	0.33						
Surr: 2,4,6-Tribromophenol			0.33	79	53	141			
Surr: 2-Fluorobiphenyl			0.33	73	63	98			
Surr: 2-Fluorophenol			0.33	75	53	101			
Surr: Nitrobenzene-d5			0.33	61	53	101			
Surr: Phenol-d5			0.33	70	55	100			
Surr: Terphenyl-d14			0.33	95	71	118			
Lab ID: LCS-145958	Laboratory Control Sample				Run: SV5973N.I_200626D				06/28/20 03:46
1,2,4-Trichlorobenzene	2.51	mg/kg	0.33	75	63	93			
1,2-Dichlorobenzene	2.40	mg/kg	0.33	72	59	85			
1,3-Dichlorobenzene	2.35	mg/kg	0.33	70	57	83			
1,4-Dichlorobenzene	2.36	mg/kg	0.33	71	58	83			
1-Methylnaphthalene	2.51	mg/kg	0.33	75	63	97			
2,4,5-Trichlorophenol	2.92	mg/kg	0.33	88	68	120			
2,4,6-Trichlorophenol	3.05	mg/kg	0.33	92	65	117			
2,4-Dichlorophenol	2.75	mg/kg	0.33	83	61	110			
2,4-Dimethylphenol	2.70	mg/kg	0.33	81	62	100			
2,4-Dinitrophenol	2.36	mg/kg	1.7	71	47	115			
2,4-Dinitrotoluene	3.38	mg/kg	0.33	101	72	122			
2,6-Dinitrotoluene	3.51	mg/kg	0.33	105	60	126			
2-Chloronaphthalene	2.72	mg/kg	0.33	82	63	106			
2-Chlorophenol	2.58	mg/kg	0.33	77	61	103			
2-Methylnaphthalene	2.59	mg/kg	0.33	78	68	103			
2-Nitrophenol	2.71	mg/kg	0.33	81	58	102			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: LCS-145958	Laboratory Control Sample				Run: SV5973N.I_200626D				06/28/20 03:46
3,3´-Dichlorobenzidine	2.37	mg/kg	0.33	71	35	117			
4,6-Dinitro-2-methylphenol	2.97	mg/kg	1.7	89	55	121			
4-Bromophenyl phenyl ether	2.90	mg/kg	0.33	87	72	113			
4-Chloro-3-methylphenol	2.77	mg/kg	0.33	83	68	107			
4-Chlorophenol	2.71	mg/kg	0.33	81	61	109			
4-Chlorophenyl phenyl ether	2.94	mg/kg	0.33	88	71	110			
4-Nitrophenol	2.75	mg/kg	1.7	83	62	118			
Acenaphthene	2.94	mg/kg	0.33	88	73	104			
Acenaphthylene	2.70	mg/kg	0.33	81	64	101			
Anthracene	3.02	mg/kg	0.33	91	72	110			
Azobenzene	2.65	mg/kg	0.33	80	68	108			
Benzidine	0.352	mg/kg	0.33	11	10	80			
Benzo(a)anthracene	3.12	mg/kg	0.33	94	75	112			
Benzo(a)pyrene	3.07	mg/kg	0.33	92	71	106			
Benzo(b)fluoranthene	3.09	mg/kg	0.33	93	65	121			
Benzo(g,h,i)perylene	2.98	mg/kg	0.33	89	79	117			
Benzo(k)fluoranthene	2.92	mg/kg	0.33	88	64	118			
bis(-2-chloroethoxy)Methane	2.62	mg/kg	0.33	79	63	104			
bis(-2-chloroethyl)Ether	2.43	mg/kg	0.33	73	56	94			
bis(2-chloroisopropyl)Ether	2.16	mg/kg	0.33	65	51	84			
bis(2-ethylhexyl)Phthalate	3.08	mg/kg	0.33	92	65	132			
Butylbenzylphthalate	3.08	mg/kg	0.33	92	68	131			
Chrysene	3.07	mg/kg	0.33	92	76	109			
Dibenzo(a,h)anthracene	3.12	mg/kg	0.33	94	75	111			
Diethyl phthalate	2.89	mg/kg	0.33	87	70	119			
Dimethyl phthalate	2.92	mg/kg	0.33	88	70	118			
Di-n-butyl phthalate	3.07	mg/kg	0.33	92	72	126			
Di-n-octyl phthalate	3.03	mg/kg	0.33	91	68	127			
Fluoranthene	2.95	mg/kg	0.33	89	76	109			
Fluorene	3.00	mg/kg	0.33	90	67	108			
Hexachlorobenzene	2.77	mg/kg	0.33	83	71	107			
Hexachlorobutadiene	2.61	mg/kg	0.33	78	62	91			
Hexachlorocyclopentadiene	2.09	mg/kg	0.33	63	56	108			
Hexachloroethane	2.30	mg/kg	0.33	69	54	95			
Indeno(1,2,3-cd)pyrene	3.06	mg/kg	0.33	92	63	112			
Isophorone	2.84	mg/kg	0.33	85	63	95			
m+p-Cresols	2.52	mg/kg	0.33	76	64	109			
Naphthalene	2.51	mg/kg	0.33	75	60	99			
Nitrobenzene	2.59	mg/kg	0.33	78	57	110			
n-Nitrosodimethylamine	2.47	mg/kg	0.33	74	43	106			
n-Nitroso-di-n-propylamine	2.57	mg/kg	0.33	77	61	107			
n-Nitrosodiphenylamine	2.89	mg/kg	0.33	87	71	119			
o-Cresol	2.64	mg/kg	0.33	79	65	111			
Pentachlorophenol	2.79	mg/kg	1.7	84	60	121			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: LCS-145958	Laboratory Control Sample				Run: SV5973N.I_200626D				06/28/20 03:46
Phenanthrene	3.08	mg/kg	0.33	92	73	104			
Phenol	2.50	mg/kg	0.33	75	57	99			
Pyrene	2.91	mg/kg	0.33	87	77	111			
Pyridine	1.16	mg/kg	0.33	35	18	76			
Surr: 2,4,6-Tribromophenol			0.33	95	64	125			
Surr: 2-Fluorobiphenyl			0.33	72	68	96			
Surr: 2-Fluorophenol			0.33	79	59	102			
Surr: Nitrobenzene-d5			0.33	73	65	92			
Surr: Phenol-d5			0.33	75	67	96			
Surr: Terphenyl-d14			0.33	91	46	147			
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: SV5973N.I_200626D				06/28/20 04:49
1,2,4-Trichlorobenzene	2.27	mg/kg	0.33	68	63	93			
1,2-Dichlorobenzene	2.17	mg/kg	0.33	65	59	85			
1,3-Dichlorobenzene	2.12	mg/kg	0.33	64	57	83			
1,4-Dichlorobenzene	2.10	mg/kg	0.33	63	58	83			
1-Methylnaphthalene	2.41	mg/kg	0.33	72	63	97			
2,4,5-Trichlorophenol	2.56	mg/kg	0.33	77	68	120			
2,4,6-Trichlorophenol	2.71	mg/kg	0.33	82	65	117			
2,4-Dichlorophenol	2.61	mg/kg	0.33	78	61	110			
2,4-Dimethylphenol	2.58	mg/kg	0.33	77	62	100			
2,4-Dinitrophenol	1.47	mg/kg	1.7	44	47	115			S
2,4-Dinitrotoluene	2.91	mg/kg	0.33	87	72	122			
2,6-Dinitrotoluene	3.09	mg/kg	0.33	93	60	126			
2-Chloronaphthalene	2.48	mg/kg	0.33	74	63	106			
2-Chlorophenol	2.48	mg/kg	0.33	75	61	103			
2-Methylnaphthalene	2.59	mg/kg	0.33	78	68	103			
2-Nitrophenol	2.55	mg/kg	0.33	77	58	102			
3,3´-Dichlorobenzidine	2.64	mg/kg	0.33	79	35	117			
4,6-Dinitro-2-methylphenol	2.67	mg/kg	1.7	80	55	121			
4-Bromophenyl phenyl ether	2.87	mg/kg	0.33	86	72	113			
4-Chloro-3-methylphenol	2.70	mg/kg	0.33	81	68	107			
4-Chlorophenol	2.56	mg/kg	0.33	77	61	109			
4-Chlorophenyl phenyl ether	2.60	mg/kg	0.33	78	71	110			
4-Nitrophenol	2.68	mg/kg	1.7	81	62	118			
Acenaphthene	2.72	mg/kg	0.33	82	73	104			
Acenaphthylene	2.43	mg/kg	0.33	73	64	101			
Anthracene	3.00	mg/kg	0.33	90	72	110			
Azobenzene	2.63	mg/kg	0.33	79	68	108			
Benzidine	1.43	mg/kg	0.33	43	10	80			
Benzo(a)anthracene	3.06	mg/kg	0.33	92	75	112			
Benzo(a)pyrene	2.90	mg/kg	0.33	87	71	106			
Benzo(b)fluoranthene	2.87	mg/kg	0.33	86	65	121			
Benzo(g,h,i)perylene	2.81	mg/kg	0.33	84	79	117			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: B20061767-002AMS	Sample Matrix Spike				Run: SV5973N.I_200626D				06/28/20 04:49
Benzo(k)fluoranthene	2.75	mg/kg	0.33	83	64	118			
bis(-2-chloroethoxy)Methane	2.46	mg/kg	0.33	74	63	104			
bis(-2-chloroethyl)Ether	2.27	mg/kg	0.33	68	56	94			
bis(2-chloroisopropyl)Ether	2.03	mg/kg	0.33	61	51	84			
bis(2-ethylhexyl)Phthalate	2.92	mg/kg	0.33	88	65	132			
Butylbenzylphthalate	2.93	mg/kg	0.33	88	68	131			
Chrysene	2.88	mg/kg	0.33	86	76	109			
Dibenzo(a,h)anthracene	2.88	mg/kg	0.33	86	75	111			
Diethyl phthalate	2.61	mg/kg	0.33	78	70	119			
Dimethyl phthalate	2.54	mg/kg	0.33	76	70	118			
Di-n-butyl phthalate	2.94	mg/kg	0.33	88	72	126			
Di-n-octyl phthalate	2.84	mg/kg	0.33	85	68	127			
Fluoranthene	2.94	mg/kg	0.33	88	76	109			
Fluorene	2.74	mg/kg	0.33	82	67	108			
Hexachlorobenzene	2.79	mg/kg	0.33	84	71	107			
Hexachlorobutadiene	2.40	mg/kg	0.33	72	62	91			
Hexachlorocyclopentadiene	2.27	mg/kg	0.33	68	56	108			
Hexachloroethane	2.16	mg/kg	0.33	65	54	95			
Indeno(1,2,3-cd)pyrene	2.83	mg/kg	0.33	85	63	112			
Isophorone	2.74	mg/kg	0.33	82	63	95			
m+p-Cresols	2.46	mg/kg	0.33	74	64	109			
Naphthalene	2.36	mg/kg	0.33	71	60	99			
Nitrobenzene	2.61	mg/kg	0.33	78	57	110			
n-Nitrosodimethylamine	2.24	mg/kg	0.33	67	43	106			
n-Nitroso-di-n-propylamine	2.40	mg/kg	0.33	72	61	107			
n-Nitrosodiphenylamine	2.91	mg/kg	0.33	87	71	119			
o-Cresol	2.55	mg/kg	0.33	77	65	111			
Pentachlorophenol	2.65	mg/kg	1.7	79	60	121			
Phenanthrene	3.12	mg/kg	0.33	94	73	104			
Phenol	2.38	mg/kg	0.33	71	57	99			
Pyrene	2.80	mg/kg	0.33	84	77	111			
Pyridine	1.21	mg/kg	0.33	36	18	76			
Surr: 2,4,6-Tribromophenol			0.33	90	64	125			
Surr: 2-Fluorobiphenyl			0.33	66	68	96			S
Surr: 2-Fluorophenol			0.33	75	59	102			
Surr: Nitrobenzene-d5			0.33	72	65	92			
Surr: Phenol-d5			0.33	75	67	96			
Surr: Terphenyl-d14			0.33	91	46	147			
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate				Run: SV5973N.I_200626D				06/28/20 05:21
1,2,4-Trichlorobenzene	2.40	mg/kg	0.33	72	63	93	5.2	40	
1,2-Dichlorobenzene	2.24	mg/kg	0.33	68	59	85	3.3	40	
1,3-Dichlorobenzene	2.18	mg/kg	0.33	66	57	83	2.5	40	
1,4-Dichlorobenzene	2.21	mg/kg	0.33	67	58	83	4.8	40	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate				Run: SV5973N.I_200626D			06/28/20 05:21	
1-Methylnaphthalene	2.53	mg/kg	0.33	76	63	97	4.9	40	
2,4,5-Trichlorophenol	2.70	mg/kg	0.33	82	68	120	5.6	40	
2,4,6-Trichlorophenol	2.69	mg/kg	0.33	81	65	117	1.0	40	
2,4-Dichlorophenol	2.60	mg/kg	0.33	78	61	110	0.3	40	
2,4-Dimethylphenol	2.65	mg/kg	0.33	80	62	100	2.6	40	
2,4-Dinitrophenol	1.24	mg/kg	1.7	37	47	115		40	S
2,4-Dinitrotoluene	3.08	mg/kg	0.33	93	72	122	5.6	40	
2,6-Dinitrotoluene	3.13	mg/kg	0.33	94	60	126	1.4	40	
2-Chloronaphthalene	2.54	mg/kg	0.33	77	63	106	2.3	40	
2-Chlorophenol	2.57	mg/kg	0.33	77	61	103	3.3	40	
2-Methylnaphthalene	2.60	mg/kg	0.33	78	68	103	0.3	40	
2-Nitrophenol	2.59	mg/kg	0.33	78	58	102	1.3	40	
3,3´-Dichlorobenzidine	2.75	mg/kg	0.33	83	35	117	3.9	40	
4,6-Dinitro-2-methylphenol	2.62	mg/kg	1.7	79	55	121	1.8	40	
4-Bromophenyl phenyl ether	2.88	mg/kg	0.33	87	72	113	0.1	40	
4-Chloro-3-methylphenol	2.75	mg/kg	0.33	83	68	107	1.9	40	
4-Chlorophenol	2.67	mg/kg	0.33	80	61	109	4.1	40	
4-Chlorophenyl phenyl ether	2.77	mg/kg	0.33	83	71	110	6.2	40	
4-Nitrophenol	2.85	mg/kg	1.7	86	62	118	6.1	40	
Acenaphthene	2.83	mg/kg	0.33	85	73	104	4.1	40	
Acenaphthylene	2.46	mg/kg	0.33	74	64	101	1.0	40	
Anthracene	2.99	mg/kg	0.33	90	72	110	0.2	40	
Azobenzene	2.85	mg/kg	0.33	86	68	108	8.1	40	
Benzidine	1.42	mg/kg	0.33	43	10	80	1.0	40	
Benzo(a)anthracene	3.08	mg/kg	0.33	93	75	112	0.9	40	
Benzo(a)pyrene	3.03	mg/kg	0.33	91	71	106	4.6	40	
Benzo(b)fluoranthene	3.02	mg/kg	0.33	91	65	121	5.3	40	
Benzo(g,h,i)perylene	3.02	mg/kg	0.33	91	79	117	7.4	40	
Benzo(k)fluoranthene	2.98	mg/kg	0.33	90	64	118	7.8	40	
bis(-2-chloroethoxy)Methane	2.42	mg/kg	0.33	73	63	104	1.7	40	
bis(-2-chloroethyl)Ether	2.36	mg/kg	0.33	71	56	94	3.5	40	
bis(2-chloroisopropyl)Ether	2.13	mg/kg	0.33	64	51	84	5.2	40	
bis(2-ethylhexyl)Phthalate	3.05	mg/kg	0.33	92	65	132	4.3	40	
Butylbenzylphthalate	3.01	mg/kg	0.33	91	68	131	2.4	40	
Chrysene	2.93	mg/kg	0.33	88	76	109	1.7	40	
Dibenzo(a,h)anthracene	3.00	mg/kg	0.33	90	75	111	4.2	40	
Diethyl phthalate	2.73	mg/kg	0.33	82	70	119	4.3	40	
Dimethyl phthalate	2.66	mg/kg	0.33	80	70	118	4.5	40	
Di-n-butyl phthalate	3.11	mg/kg	0.33	94	72	126	5.4	40	
Di-n-octyl phthalate	3.06	mg/kg	0.33	92	68	127	7.3	40	
Fluoranthene	2.92	mg/kg	0.33	88	76	109	1.0	40	
Fluorene	2.79	mg/kg	0.33	84	67	108	1.9	40	
Hexachlorobenzene	2.85	mg/kg	0.33	86	71	107	2.3	40	
Hexachlorobutadiene	2.43	mg/kg	0.33	73	62	91	1.4	40	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

S - Spike recovery outside of advisory limits

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Calumet Montana Refining, LLC **Work Order:** B20061767 **Report Date:** 06/30/20

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8270C									Batch: 145958
Lab ID: B20061767-002AMSD	Sample Matrix Spike Duplicate				Run: SV5973N.I_200626D			06/28/20 05:21	
Hexachlorocyclopentadiene	2.35	mg/kg	0.33	71	56	108	3.4	40	
Hexachloroethane	2.26	mg/kg	0.33	68	54	95	4.8	40	
Indeno(1,2,3-cd)pyrene	3.10	mg/kg	0.33	93	63	112	9.0	40	
Isophorone	2.73	mg/kg	0.33	82	63	95	0.2	40	
m+p-Cresols	2.52	mg/kg	0.33	76	64	109	2.3	40	
Naphthalene	2.44	mg/kg	0.33	74	60	99	3.6	40	
Nitrobenzene	2.64	mg/kg	0.33	80	57	110	0.9	40	
n-Nitrosodimethylamine	2.50	mg/kg	0.33	75	43	106	11	40	
n-Nitroso-di-n-propylamine	2.58	mg/kg	0.33	78	61	107	7.4	40	
n-Nitrosodiphenylamine	3.11	mg/kg	0.33	94	71	119	6.7	40	
o-Cresol	2.67	mg/kg	0.33	81	65	111	4.7	40	
Pentachlorophenol	2.67	mg/kg	1.7	80	60	121	0.8	40	
Phenanthrene	3.18	mg/kg	0.33	96	73	104	1.8	40	
Phenol	2.41	mg/kg	0.33	73	57	99	1.3	40	
Pyrene	2.83	mg/kg	0.33	85	77	111	1.1	40	
Pyridine	1.16	mg/kg	0.33	35	18	76	3.9	40	
Surr: 2,4,6-Tribromophenol			0.33	94	64	125			
Surr: 2-Fluorobiphenyl			0.33	68	68	96			
Surr: 2-Fluorophenol			0.33	77	59	102			
Surr: Nitrobenzene-d5			0.33	76	65	92			
Surr: Phenol-d5			0.33	74	67	96			
Surr: Terphenyl-d14			0.33	94	46	147			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

Work Order Receipt Checklist

Calumet Montana Refining, LLC

B20061767

Login completed by: Briana G. Sangiuliano
Reviewed by: BL2000\darcy
Reviewed Date: 6/24/2020

Date Received: 6/19/2020
Received by: gda
Carrier name: Return-FedEx Ground N/C

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☑	No ☐	Not Applicable ☐
Container/Temp Blank temperature:	0.9°C On Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Radiochemical precision results represent a 2-sigma Total Measurement Uncertainty.

Contact and Corrective Action Comments:

None

Chain of Custody and Analytical Request Record

ENERGY LABORATORIES

PLEASE PRINT- Provide as much information as possible.

Company Name: CALUMET MONTANA REFINING	Project Name, ~~PWS, Permit, Etc.~~ ~~Quarterly Cooling Tower~~ Waste Characterization	Sample Origin State: MT	EPA/State Compliance Yes X☐ No ☐
Report Mail Address: 1900 10TH STREET NE Great Falls, MT 59404	Contact Name: ~~SHANNON CHOUINARD~~ ~~406-454-9857~~ Phone/Fax: Ray Martinich 406-454-9862	Email Shannon.chouinard@calumetspecialty com	Sampler (Please Print) Brooks Bailey
Invoice Address. SAME AS ABOVE	Invoice Contact & Phone ~~Shannon Chouinard 406-454-9857~~ Ray Martinich 406-454-9862 ~~shannon.chouinard@calumetspecialty.com~~ ray martinich@calumetspecialty.com	Purchase Order 2143148 (ALSO)	Quote/Bottle Order plindquist@ramboll.com

Special Report/Formats – ELI must be notified prior to sample submittal for the following:

☐ DW ☐ A2LA
☐ GSA ☐ EDD/EDT(Electronic Data)
☐ POTW/WWTP Format:_____
☐ State: _____ ☐ LEVEL IV
☐ Other: _____ ☐ NELAC

ANALYSIS REQUESTED

Number of Containers
Sample Type: A W S V B O
Air Water Soils/Solids Vegetation Bioassay Other

RUSH: Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

** metals. antimony, arsenic, barium, beryllium, cadmium chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, vanadium, and zinc

Shipped by:
Cooler ID(s):
Receipt Temp _____ °C
On Ice: Yes No
Custody Seal Y N
Intact Y N
Signature Match Y N

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	~~TCLP~~ ~~8260 + n-Hexane~~	TCLP VOCs	TCLP Metals **	PH	Reactive Cyanide	Reactive Sulfide	Total VOCs	Total SVOCs	Total Metals ** ~~PH~~	Total cyanide SEE ATTACHED	Normal Turnaround (TAT)	RUSH	Notes	Receipt Temp
1 ~~Cooling Tower~~			~~2 W~~	X										X			
2 S527	6-16-20	15.40	S	X										X			B20061767
3 S528	6-16-20	15.50	S	X	X	X	X	X	X	X	X	X	X	X			
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Custody Record MUST be Signed

Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
[illegible]	6 18 20 14 15	[illegible]			
Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
Sample Disposal: Return to Client _____	Lab Disposal: _____		Received by Laboratory: Gabbie ASchim	Date/Time 6-19-2020/10:05	Signature Gabbie Aschim

In certain circumstances, samples submitted to Energy Laboratories, Inc may be subcontracted to other certified laboratories in order to complete the analysis requested
This serves as notice of this possibility All sub-contract data will be clearly notated on your analytical report
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links

APPENDIX B6
PACE ANALYTICAL LABORATORY REPORTS

Report of Analysis

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

Project Name: Calumet (CMR) ACC-16 Interim Measure Design

Project Number: 1690014124-003

Lot Number:**VF24007**

Date Completed:07/17/2020

07/20/2020 7:04 AM
Approved and released by:
Project Manager II: **Kelly M. Nance**

The electronic signature above is the equivalent of a handwritten signature.
This report shall not be reproduced, except in its entirety, without the written approval of Pace Analytical Services, LLC.

Pace Analytical Services, LLC (*formerly Shealy Environmental Services, Inc.*)
106 Vantage Point Drive West Columbia, SC 29172
Tel: 803-791-9700 Fax: 803-791-9111 www.pacelabs.com

Case Narrative
Ramboll US Corporation
Lot Number: VF24007

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 Pace Analytical Services, LLC ("Pace") Quality Assurance Management Plan (QAMP), standard operating procedures (SOPs), and Pace 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 Pace Project Manager listed on the cover page.

Sample Receiving
Samples -001, -002, -003, -004, and -006 was received with low sample volume. Samples were poured up and preserved for analysis, as per client request.

Volatiles
The laboratory control sample (LCS) associated with batch 58271 had 1,4-dioxane recovered above the acceptance limits. This could potentially result in a high bias on analytical results. There were no detections for this compound in the samples associated with this batch; therefore, data quality is not impacted.

The matrix spike/matrix spike duplicate (MS/MSD) associated with sample -001 had multiple compounds and two surrogates recovered outside of the acceptance limits. Additionally, a number of RPDs exceeded the acceptance limit. The MS/MSD was re-analyzed and chloromethane, dichlorodifluoromethane and vinyl chloride recovered outside of the acceptance limits. The laboratory control sample (LCS) were recovered within the required acceptance limits; therefore, this likely demonstrates a matrix effect.

Semivolatiles
The method blank associated with batch 58369 had di-n-butyl phthalate, bis(2-ethylhexyl)phthalate and naphthalene detected at a concentration that was below the LOQ. All samples associated with this method blank that have detections for these compounds have been flagged with a “B” qualifier.

The laboratory control sample (LCS) associated with batch 58389 had 3,3’-dichlorobenzidine and 3-nitroaniline recovered below the acceptance limits. This could potentially result in a low bias on analytical results. All samples were re-extracted and re-analyzed outside of the 7-day holding time. Both sets of data are reported.

The MS/MS associated with sample -001 had multiple compounds recovered outside of the acceptance limits. Additionally, a number of RPDs exceeded the acceptance limit. The LCS was recovered within the required acceptance limits; therefore, this likely demonstrates a matrix effect.

MT VPH
Samples -001, -002, -003, -004 and -006 had naphthalene detected in the VPH analysis and confirmed via dual detector analysis (FID/PID). However, additional compounds elute at approximately the same

times as naphthalene and MTBE, making it difficult for analysts to distinguish the target compounds from non-target compounds. Second method confirmation was performed via GC/MS analysis. The results via dual detection (FID/PID) were not compared to or adjusted based on results via 8260B GC/MS.

Sample -013 was not preserved to a pH<2, although samples were received in the correct sample containers and preservative.

Sample Summary
Ramboll US Corporation
Lot Number: VF24007

Sample Number	Sample ID	Matrix	Date Sampled	Date Received
001	CMR-MW41S-200622	Aqueous	06/22/2020 1118	06/24/2020
002	CMR-TW203S-200622	Aqueous	06/22/2020 1221	06/24/2020
003	CMR-TW202D-200622	Aqueous	06/22/2020 1317	06/24/2020
004	CMR-TW202S-200622	Aqueous	06/22/2020 1356	06/24/2020
005	CMR-MW59S-200622	Aqueous	06/22/2020 1508	06/24/2020
006	CMR-MW56S-200623	Aqueous	06/23/2020 0920	06/24/2020
007	CMR-TB01-200623	Aqueous	06/23/2020	06/24/2020

(7 samples)

Detection Summary
Ramboll US Corporation
Lot Number: VF24007

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	CMR-MW41S-200622	Aqueous	Acetone	8260D	220		ug/L	10
001	CMR-MW41S-200622	Aqueous	Benzene	8260D	1000		ug/L	10
001	CMR-MW41S-200622	Aqueous	2-Butanone (MEK)	8260D	89	J	ug/L	10
001	CMR-MW41S-200622	Aqueous	Chloroform	8260D	4.0	J	ug/L	10
001	CMR-MW41S-200622	Aqueous	Cyclohexane	8260D	24		ug/L	10
001	CMR-MW41S-200622	Aqueous	Ethylbenzene	8260D	370		ug/L	10
001	CMR-MW41S-200622	Aqueous	Isopropylbenzene	8260D	10		ug/L	10
001	CMR-MW41S-200622	Aqueous	Methylcyclohexane	8260D	11	J	ug/L	10
001	CMR-MW41S-200622	Aqueous	Naphthalene	8260D	31		ug/L	10
001	CMR-MW41S-200622	Aqueous	Toluene	8260D	82		ug/L	10
001	CMR-MW41S-200622	Aqueous	Xylenes (total)	8260D	620		ug/L	11
001	CMR-MW41S-200622	Aqueous	m+p - Xylenes	8260D	550		ug/L	11
001	CMR-MW41S-200622	Aqueous	o - Xylenes	8260D	67		ug/L	11
001	CMR-MW41S-200622	Aqueous	2,4-Dimethylphenol	8270E	84		ug/L	12
001	CMR-MW41S-200622	Aqueous	Di-n-butyl phthalate	8270E	6.1	BJ	ug/L	12
001	CMR-MW41S-200622	Aqueous	bis(2-Ethylhexyl)phthalate	8270E	11	BJ	ug/L	12
001	CMR-MW41S-200622	Aqueous	2-Methylnaphthalene	8270E	5.4		ug/L	13
001	CMR-MW41S-200622	Aqueous	Naphthalene	8270E	24	B	ug/L	13
001	CMR-MW41S-200622	Aqueous	Phenol	8270E	53		ug/L	13
001	CMR-MW41S-200622	Aqueous	TEH	Montana EPH	4300		ug/L	16
001	CMR-MW41S-200622	Aqueous	C5 - C8 Aliphatics,	Montana VPH	680	J	ug/L	19
001	CMR-MW41S-200622	Aqueous	C9 - C12 Aliphatics,	Montana VPH	1700		ug/L	19
001	CMR-MW41S-200622	Aqueous	Benzene	Montana VPH	1100		ug/L	20
001	CMR-MW41S-200622	Aqueous	C9 - C10 Aromatics	Montana VPH	1100		ug/L	20
001	CMR-MW41S-200622	Aqueous	Ethylbenzene	Montana VPH	410		ug/L	20
001	CMR-MW41S-200622	Aqueous	Naphthalene	Montana VPH	45	J	ug/L	20
001	CMR-MW41S-200622	Aqueous	Toluene	Montana VPH	84		ug/L	20
001	CMR-MW41S-200622	Aqueous	m+p - Xylenes	Montana VPH	610		ug/L	20
001	CMR-MW41S-200622	Aqueous	o - Xylenes	Montana VPH	79		ug/L	20
001	CMR-MW41S-200622	Aqueous	TPH	Montana VPH	5000		ug/L	21
001	CMR-MW41S-200622	Aqueous	Antimony	6020B	0.90	J	ug/L	22
001	CMR-MW41S-200622	Aqueous	Arsenic	6020B	5.2		ug/L	22
001	CMR-MW41S-200622	Aqueous	Barium	6020B	290		ug/L	22
001	CMR-MW41S-200622	Aqueous	Cadmium	6020B	0.15	J	ug/L	22
001	CMR-MW41S-200622	Aqueous	Copper	6020B	5.9		ug/L	22
001	CMR-MW41S-200622	Aqueous	Nickel	6020B	3.7	J	ug/L	22
001	CMR-MW41S-200622	Aqueous	Selenium	6020B	1.6	J	ug/L	22
001	CMR-MW41S-200622	Aqueous	Vanadium	6020B	3.7	J	ug/L	22
002	CMR-TW203S-200622	Aqueous	Acetone	8260D	480		ug/L	23
002	CMR-TW203S-200622	Aqueous	Benzene	8260D	96		ug/L	23
002	CMR-TW203S-200622	Aqueous	Bromodichloromethane	8260D	0.81		ug/L	23
002	CMR-TW203S-200622	Aqueous	2-Butanone (MEK)	8260D	290		ug/L	23
002	CMR-TW203S-200622	Aqueous	Carbon disulfide	8260D	1.1		ug/L	23
002	CMR-TW203S-200622	Aqueous	Chloroform	8260D	4.9		ug/L	23
002	CMR-TW203S-200622	Aqueous	Cyclohexane	8260D	25		ug/L	23

Detection Summary (Continued)

Lot Number: VF24007

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
002	CMR-TW203S-200622	Aqueous	Ethylbenzene	8260D	25		ug/L	23
002	CMR-TW203S-200622	Aqueous	2-Hexanone	8260D	16		ug/L	23
002	CMR-TW203S-200622	Aqueous	Isopropylbenzene	8260D	11		ug/L	23
002	CMR-TW203S-200622	Aqueous	4-Methyl-2-pentanone	8260D	26		ug/L	23
002	CMR-TW203S-200622	Aqueous	Methylcyclohexane	8260D	12		ug/L	23
002	CMR-TW203S-200622	Aqueous	Naphthalene	8260D	3.0		ug/L	23
002	CMR-TW203S-200622	Aqueous	Toluene	8260D	19		ug/L	23
002	CMR-TW203S-200622	Aqueous	Xylenes (total)	8260D	64		ug/L	24
002	CMR-TW203S-200622	Aqueous	m+p - Xylenes	8260D	64		ug/L	24
002	CMR-TW203S-200622	Aqueous	o - Xylenes	8260D	16		ug/L	24
002	CMR-TW203S-200622	Aqueous	Diethylphthalate	8270E	0.53	J	ug/L	25
002	CMR-TW203S-200622	Aqueous	2,4-Dimethylphenol	8270E	74		ug/L	25
002	CMR-TW203S-200622	Aqueous	Di-n-butyl phthalate	8270E	0.77	BJ	ug/L	25
002	CMR-TW203S-200622	Aqueous	bis(2-Ethylhexyl)phthalate	8270E	1.4	BJ	ug/L	25
002	CMR-TW203S-200622	Aqueous	2-Methylnaphthalene	8270E	0.27		ug/L	26
002	CMR-TW203S-200622	Aqueous	C5 - C8 Aliphatics,	Montana VPH	530		ug/L	29
002	CMR-TW203S-200622	Aqueous	C9 - C12 Aliphatics,	Montana VPH	880		ug/L	29
002	CMR-TW203S-200622	Aqueous	Benzene	Montana VPH	240		ug/L	30
002	CMR-TW203S-200622	Aqueous	C9 - C10 Aromatics	Montana VPH	1000		ug/L	30
002	CMR-TW203S-200622	Aqueous	Ethylbenzene	Montana VPH	110		ug/L	30
002	CMR-TW203S-200622	Aqueous	Naphthalene	Montana VPH	6.2	J	ug/L	30
002	CMR-TW203S-200622	Aqueous	Toluene	Montana VPH	11	J	ug/L	30
002	CMR-TW203S-200622	Aqueous	m+p - Xylenes	Montana VPH	590		ug/L	30
002	CMR-TW203S-200622	Aqueous	o - Xylenes	Montana VPH	17	J	ug/L	30
002	CMR-TW203S-200622	Aqueous	TPH	Montana VPH	3500		ug/L	31
002	CMR-TW203S-200622	Aqueous	Dissolved Antimony	6020B	1.1	J	ug/L	33
002	CMR-TW203S-200622	Aqueous	Dissolved Arsenic	6020B	4.1		ug/L	33
002	CMR-TW203S-200622	Aqueous	Dissolved Barium	6020B	240		ug/L	33
002	CMR-TW203S-200622	Aqueous	Dissolved Copper	6020B	1.9	J	ug/L	33
002	CMR-TW203S-200622	Aqueous	Dissolved Nickel	6020B	2.2	J	ug/L	33
002	CMR-TW203S-200622	Aqueous	Dissolved Selenium	6020B	6.8		ug/L	33
002	CMR-TW203S-200622	Aqueous	Dissolved Vanadium	6020B	3.7	J	ug/L	33
003	CMR-TW202D-200622	Aqueous	Acetone	8260D	100		ug/L	34
003	CMR-TW202D-200622	Aqueous	Benzene	8260D	3.8		ug/L	34
003	CMR-TW202D-200622	Aqueous	Bromodichloromethane	8260D	0.96		ug/L	34
003	CMR-TW202D-200622	Aqueous	2-Butanone (MEK)	8260D	19		ug/L	34
003	CMR-TW202D-200622	Aqueous	Chloroform	8260D	3.1		ug/L	34
003	CMR-TW202D-200622	Aqueous	Ethylbenzene	8260D	2.3		ug/L	34
003	CMR-TW202D-200622	Aqueous	2-Hexanone	8260D	4.4	J	ug/L	34
003	CMR-TW202D-200622	Aqueous	Methyl tertiary butyl ether	8260D	0.95		ug/L	34
003	CMR-TW202D-200622	Aqueous	4-Methyl-2-pentanone	8260D	13		ug/L	34
003	CMR-TW202D-200622	Aqueous	Methylcyclohexane	8260D	0.82	J	ug/L	34
003	CMR-TW202D-200622	Aqueous	Naphthalene	8260D	0.91		ug/L	34
003	CMR-TW202D-200622	Aqueous	Toluene	8260D	2.1		ug/L	34
003	CMR-TW202D-200622	Aqueous	Xylenes (total)	8260D	16		ug/L	35
003	CMR-TW202D-200622	Aqueous	m+p - Xylenes	8260D	9.2		ug/L	35
003	CMR-TW202D-200622	Aqueous	o - Xylenes	8260D	6.3		ug/L	35
003	CMR-TW202D-200622	Aqueous	Acenaphthene	8270E	0.19	J	ug/L	36

Detection Summary (Continued)

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Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
003	CMR-TW202D-200622	Aqueous	Diethylphthalate	8270E	0.98		ug/L	36
003	CMR-TW202D-200622	Aqueous	Di-n-butyl phthalate	8270E	1.1	B	ug/L	36
003	CMR-TW202D-200622	Aqueous	bis(2-Ethylhexyl)phthalate	8270E	1.1	BJ	ug/L	36
003	CMR-TW202D-200622	Aqueous	Fluorene	8270E	0.36		ug/L	36
003	CMR-TW202D-200622	Aqueous	Phenanthrene	8270E	0.22		ug/L	37
003	CMR-TW202D-200622	Aqueous	TEH	Montana EPH	1900		ug/L	40
003	CMR-TW202D-200622	Aqueous	C5 - C8 Aliphatics,	Montana VPH	59	J	ug/L	43
003	CMR-TW202D-200622	Aqueous	C9 - C12 Aliphatics,	Montana VPH	120		ug/L	43
003	CMR-TW202D-200622	Aqueous	Benzene	Montana VPH	3.9	J	ug/L	44
003	CMR-TW202D-200622	Aqueous	C9 - C10 Aromatics	Montana VPH	170		ug/L	44
003	CMR-TW202D-200622	Aqueous	Ethylbenzene	Montana VPH	1.9	J	ug/L	44
003	CMR-TW202D-200622	Aqueous	Naphthalene	Montana VPH	6.8		ug/L	44
003	CMR-TW202D-200622	Aqueous	Toluene	Montana VPH	2.7	J	ug/L	44
003	CMR-TW202D-200622	Aqueous	m+p - Xylenes	Montana VPH	7.7		ug/L	44
003	CMR-TW202D-200622	Aqueous	o - Xylenes	Montana VPH	6.5		ug/L	44
003	CMR-TW202D-200622	Aqueous	TPH	Montana VPH	370		ug/L	45
003	CMR-TW202D-200622	Aqueous	Antimony	6020B	0.55	J	ug/L	46
003	CMR-TW202D-200622	Aqueous	Arsenic	6020B	3.2		ug/L	46
003	CMR-TW202D-200622	Aqueous	Barium	6020B	320		ug/L	46
003	CMR-TW202D-200622	Aqueous	Copper	6020B	2.5	J	ug/L	46
003	CMR-TW202D-200622	Aqueous	Nickel	6020B	1.9	J	ug/L	46
003	CMR-TW202D-200622	Aqueous	Selenium	6020B	2.5	J	ug/L	46
003	CMR-TW202D-200622	Aqueous	Vanadium	6020B	6.7		ug/L	46
004	CMR-TW202S-200622	Aqueous	Acetone	8260D	280		ug/L	47
004	CMR-TW202S-200622	Aqueous	Benzene	8260D	290		ug/L	47
004	CMR-TW202S-200622	Aqueous	2-Butanone (MEK)	8260D	87		ug/L	47
004	CMR-TW202S-200622	Aqueous	Chloroform	8260D	4.5		ug/L	47
004	CMR-TW202S-200622	Aqueous	Cyclohexane	8260D	29		ug/L	47
004	CMR-TW202S-200622	Aqueous	Ethylbenzene	8260D	240		ug/L	47
004	CMR-TW202S-200622	Aqueous	2-Hexanone	8260D	12	J	ug/L	47
004	CMR-TW202S-200622	Aqueous	Isopropylbenzene	8260D	8.5		ug/L	47
004	CMR-TW202S-200622	Aqueous	4-Methyl-2-pentanone	8260D	19	J	ug/L	47
004	CMR-TW202S-200622	Aqueous	Methylcyclohexane	8260D	16	J	ug/L	47
004	CMR-TW202S-200622	Aqueous	Naphthalene	8260D	16		ug/L	47
004	CMR-TW202S-200622	Aqueous	Toluene	8260D	9.3		ug/L	47
004	CMR-TW202S-200622	Aqueous	Xylenes (total)	8260D	210		ug/L	48
004	CMR-TW202S-200622	Aqueous	m+p - Xylenes	8260D	200		ug/L	48
004	CMR-TW202S-200622	Aqueous	o - Xylenes	8260D	12		ug/L	48
004	CMR-TW202S-200622	Aqueous	2,4-Dimethylphenol	8270E	24		ug/L	49
004	CMR-TW202S-200622	Aqueous	Fluorene	8270E	0.85	J	ug/L	49
004	CMR-TW202S-200622	Aqueous	2-Methylnaphthalene	8270E	4.8		ug/L	50
004	CMR-TW202S-200622	Aqueous	Naphthalene	8270E	2.2	B	ug/L	50
004	CMR-TW202S-200622	Aqueous	C5 - C8 Aliphatics,	Montana VPH	760		ug/L	53
004	CMR-TW202S-200622	Aqueous	C9 - C12 Aliphatics,	Montana VPH	630		ug/L	53
004	CMR-TW202S-200622	Aqueous	Benzene	Montana VPH	290		ug/L	54
004	CMR-TW202S-200622	Aqueous	C9 - C10 Aromatics	Montana VPH	1400		ug/L	54
004	CMR-TW202S-200622	Aqueous	Ethylbenzene	Montana VPH	260		ug/L	54
004	CMR-TW202S-200622	Aqueous	Naphthalene	Montana VPH	27		ug/L	54

Detection Summary (Continued)

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Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
004	CMR-TW202S-200622	Aqueous	Toluene	Montana VPH	14	J	ug/L	54
004	CMR-TW202S-200622	Aqueous	m+p - Xylenes	Montana VPH	220		ug/L	54
004	CMR-TW202S-200622	Aqueous	o - Xylenes	Montana VPH	15	J	ug/L	54
004	CMR-TW202S-200622	Aqueous	TPH	Montana VPH	3500		ug/L	55
004	CMR-TW202S-200622	Aqueous	Dissolved Antimony	6020B	1.1	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Arsenic	6020B	1.8	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Barium	6020B	190		ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Copper	6020B	3.5	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Lead	6020B	0.36	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Nickel	6020B	3.0	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Selenium	6020B	3.3	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Vanadium	6020B	2.8	J	ug/L	57
004	CMR-TW202S-200622	Aqueous	Dissolved Zinc	6020B	4.8	J	ug/L	57
005	CMR-MW59S-200622	Aqueous	Acetone	8260D	6.4	J	ug/L	58
005	CMR-MW59S-200622	Aqueous	Di-n-butyl phthalate	8270E	0.83	B	ug/L	60
005	CMR-MW59S-200622	Aqueous	bis(2-Ethylhexyl)phthalate	8270E	2.6	BJ	ug/L	60
005	CMR-MW59S-200622	Aqueous	2-Methylnaphthalene	8270E	0.047	J	ug/L	61
005	CMR-MW59S-200622	Aqueous	Naphthalene	8270E	0.074	BJ	ug/L	61
005	CMR-MW59S-200622	Aqueous	TEH	Montana EPH	270		ug/L	64
005	CMR-MW59S-200622	Aqueous	C5 - C8 Aliphatics,	Montana VPH	29	J	ug/L	65
005	CMR-MW59S-200622	Aqueous	Antimony	6020B	1.8	J	ug/L	68
005	CMR-MW59S-200622	Aqueous	Arsenic	6020B	27		ug/L	68
005	CMR-MW59S-200622	Aqueous	Barium	6020B	55		ug/L	68
005	CMR-MW59S-200622	Aqueous	Cadmium	6020B	0.49	J	ug/L	68
005	CMR-MW59S-200622	Aqueous	Cobalt	6020B	7.1		ug/L	68
005	CMR-MW59S-200622	Aqueous	Copper	6020B	61		ug/L	68
005	CMR-MW59S-200622	Aqueous	Lead	6020B	0.50	J	ug/L	68
005	CMR-MW59S-200622	Aqueous	Nickel	6020B	12		ug/L	68
005	CMR-MW59S-200622	Aqueous	Zinc	6020B	79		ug/L	68
006	CMR-MW56S-200623	Aqueous	Benzene	8260D	5800		ug/L	69
006	CMR-MW56S-200623	Aqueous	Cyclohexane	8260D	320		ug/L	69
006	CMR-MW56S-200623	Aqueous	Ethylbenzene	8260D	860		ug/L	69
006	CMR-MW56S-200623	Aqueous	Isopropylbenzene	8260D	61		ug/L	69
006	CMR-MW56S-200623	Aqueous	Methylcyclohexane	8260D	170	J	ug/L	69
006	CMR-MW56S-200623	Aqueous	Naphthalene	8260D	160		ug/L	69
006	CMR-MW56S-200623	Aqueous	Toluene	8260D	680		ug/L	69
006	CMR-MW56S-200623	Aqueous	Xylenes (total)	8260D	770		ug/L	70
006	CMR-MW56S-200623	Aqueous	m+p - Xylenes	8260D	630		ug/L	70
006	CMR-MW56S-200623	Aqueous	o - Xylenes	8260D	150		ug/L	70
006	CMR-MW56S-200623	Aqueous	Acenaphthene	8270E	0.43	J	ug/L	71
006	CMR-MW56S-200623	Aqueous	2,4-Dimethylphenol	8270E	27		ug/L	71
006	CMR-MW56S-200623	Aqueous	Fluorene	8270E	1.4		ug/L	71
006	CMR-MW56S-200623	Aqueous	2-Methylnaphthalene	8270E	37		ug/L	72
006	CMR-MW56S-200623	Aqueous	2-Methylphenol	8270E	8.7		ug/L	72
006	CMR-MW56S-200623	Aqueous	3+4-Methylphenol	8270E	12		ug/L	72
006	CMR-MW56S-200623	Aqueous	Naphthalene	8270E	84	B	ug/L	72
006	CMR-MW56S-200623	Aqueous	Phenanthrene	8270E	0.85	J	ug/L	72
006	CMR-MW56S-200623	Aqueous	Phenol	8270E	75		ug/L	72

Detection Summary (Continued)

Lot Number: VF24007

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
006	CMR-MW56S-200623	Aqueous	TEH	Montana EPH	4100		ug/L	75
006	CMR-MW56S-200623	Aqueous	C9 - C18 Aliphatics	Montana EPH	740		ug/L	76
006	CMR-MW56S-200623	Aqueous	TEH, post-fractionation	Montana EPH	1500		ug/L	76
006	CMR-MW56S-200623	Aqueous	C11 - C22 Aromatics	Montana EPH	520		ug/L	77
006	CMR-MW56S-200623	Aqueous	C5 - C8 Aliphatics,	Montana VPH	5400	J	ug/L	78
006	CMR-MW56S-200623	Aqueous	Benzene	Montana VPH	5500		ug/L	79
006	CMR-MW56S-200623	Aqueous	C9 - C10 Aromatics	Montana VPH	1200	J	ug/L	79
006	CMR-MW56S-200623	Aqueous	Ethylbenzene	Montana VPH	780		ug/L	79
006	CMR-MW56S-200623	Aqueous	Naphthalene	Montana VPH	160	J	ug/L	79
006	CMR-MW56S-200623	Aqueous	Toluene	Montana VPH	710		ug/L	79
006	CMR-MW56S-200623	Aqueous	m+p - Xylenes	Montana VPH	590		ug/L	79
006	CMR-MW56S-200623	Aqueous	o - Xylenes	Montana VPH	160	J	ug/L	79
006	CMR-MW56S-200623	Aqueous	TPH	Montana VPH	14000	J	ug/L	80
006	CMR-MW56S-200623	Aqueous	Arsenic	6020B	1.6	J	ug/L	81
006	CMR-MW56S-200623	Aqueous	Barium	6020B	220		ug/L	81
006	CMR-MW56S-200623	Aqueous	Copper	6020B	5.5		ug/L	81
006	CMR-MW56S-200623	Aqueous	Lead	6020B	0.90	J	ug/L	81
006	CMR-MW56S-200623	Aqueous	Zinc	6020B	15		ug/L	81

(207 detections)

Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	10	06/27/2020 0316	JTH		58271
2	5030B	8260D	10	07/01/2020 1703	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	**67-64-1**	**8260D**	**220**		**100**	**40**	**ug/L**	**2**
Benzene	**71-43-2**	**8260D**	**1000**		**5.0**	**4.0**	**ug/L**	**1**
Bromochloromethane	74-97-5	8260D	ND		5.0	4.0	ug/L	1
Bromodichloromethane	75-27-4	8260D	ND		5.0	4.0	ug/L	1
Bromoform	75-25-2	8260D	ND		5.0	4.0	ug/L	1
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		5.0	4.0	ug/L	1
2-Butanone (MEK)	**78-93-3**	**8260D**	**89**	**J**	**100**	**20**	**ug/L**	**2**
Carbon disulfide	75-15-0	8260D	ND		5.0	4.0	ug/L	1
Carbon tetrachloride	56-23-5	8260D	ND		5.0	4.0	ug/L	1
Chlorobenzene	108-90-7	8260D	ND		5.0	4.0	ug/L	1
Chloroethane	75-00-3	8260D	ND		5.0	4.0	ug/L	1
Chloroform	**67-66-3**	**8260D**	**4.0**	**J**	**5.0**	**4.0**	**ug/L**	**1**
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		5.0	4.0	ug/L	1
Cyclohexane	**110-82-7**	**8260D**	**24**		**5.0**	**4.0**	**ug/L**	**1**
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		5.0	4.0	ug/L	1
Dibromochloromethane	124-48-1	8260D	ND		5.0	4.0	ug/L	1
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		5.0	4.0	ug/L	1
1,2-Dichlorobenzene	95-50-1	8260D	ND		5.0	4.0	ug/L	1
1,3-Dichlorobenzene	541-73-1	8260D	ND		5.0	4.0	ug/L	1
1,4-Dichlorobenzene	106-46-7	8260D	ND		5.0	4.0	ug/L	1
Dichlorodifluoromethane	75-71-8	8260D	ND		5.0	4.0	ug/L	1
1,1-Dichloroethane	75-34-3	8260D	ND		5.0	4.0	ug/L	1
1,2-Dichloroethane	107-06-2	8260D	ND		5.0	4.0	ug/L	1
1,1-Dichloroethene	75-35-4	8260D	ND		5.0	4.0	ug/L	1
cis-1,2-Dichloroethene	156-59-2	8260D	ND		5.0	4.0	ug/L	1
trans-1,2-Dichloroethene	156-60-5	8260D	ND		5.0	4.0	ug/L	1
1,2-Dichloropropane	78-87-5	8260D	ND		5.0	4.0	ug/L	1
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		5.0	4.0	ug/L	1
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		5.0	4.0	ug/L	1
1,4-Dioxane	123-91-1	8260D	ND		200	130	ug/L	2
Ethylbenzene	**100-41-4**	**8260D**	**370**		**5.0**	**4.0**	**ug/L**	**1**
2-Hexanone	591-78-6	8260D	ND		100	20	ug/L	1
Isopropylbenzene	**98-82-8**	**8260D**	**10**		**5.0**	**4.0**	**ug/L**	**1**
Methyl acetate	79-20-9	8260D	ND		10	4.0	ug/L	1
Methyl tertiary butyl ether (MTBE)	1634-04-4	8260D	ND		5.0	4.0	ug/L	1
4-Methyl-2-pentanone	108-10-1	8260D	ND		100	20	ug/L	2
Methylcyclohexane	**108-87-2**	**8260D**	**11**	**J**	**50**	**4.0**	**ug/L**	**1**
Methylene chloride	75-09-2	8260D	ND		5.0	4.0	ug/L	1
Naphthalene	**91-20-3**	**8260D**	**31**		**5.0**	**4.0**	**ug/L**	**1**
Styrene	100-42-5	8260D	ND		5.0	4.1	ug/L	1
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		5.0	4.0	ug/L	1
Tetrachloroethene	127-18-4	8260D	ND		5.0	4.0	ug/L	1
Toluene	**108-88-3**	**8260D**	**82**		**5.0**	**4.0**	**ug/L**	**1**

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

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	10	06/27/2020 0316	JTH		58271
2	5030B	8260D	10	07/01/2020 1703	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		10	4.2	ug/L	1
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		5.0	4.0	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		5.0	4.0	ug/L	1
1,1,1-Trichloroethane	71-55-6	8260D	ND		5.0	4.0	ug/L	1
1,1,2-Trichloroethane	79-00-5	8260D	ND		5.0	4.0	ug/L	1
Trichloroethene	79-01-6	8260D	ND		5.0	4.0	ug/L	1
Trichlorofluoromethane	75-69-4	8260D	ND		5.0	4.0	ug/L	1
Vinyl chloride	75-01-4	8260D	ND		5.0	4.0	ug/L	1
Xylenes (total)	**1330-20-7**	**8260D**	**620**		**10**	**4.0**	**ug/L**	**1**
m+p - Xylenes	**179601-23-1**	**8260D**	**550**		**5.0**	**4.0**	**ug/L**	**1**
o - Xylenes	**95-47-6**	**8260D**	**67**		**5.0**	**4.0**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
Bromofluorobenzene		98	70-130		98	70-130
1,2-Dichloroethane-d4		82	70-130		109	70-130
Toluene-d8		97	70-130		101	70-130

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** | Laboratory ID: **VF24007-001**

Description: **CMR-MW41S-200622** | Matrix: **Aqueous**

Date Sampled: **06/22/2020 1118**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1641	SCD	06/29/2020 1800	58389
2	3520C	8270E	5	07/07/2020 1612	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND		2.0	0.40	ug/L	1
Acenaphthylene	208-96-8	8270E	ND		2.0	0.40	ug/L	1
Anthracene	120-12-7	8270E	ND		2.0	0.60	ug/L	1
Benzo(a)anthracene	56-55-3	8270E	ND		2.0	0.40	ug/L	1
Benzo(a)pyrene	50-32-8	8270E	ND		2.0	0.70	ug/L	1
Benzo(b)fluoranthene	205-99-2	8270E	ND		2.0	0.40	ug/L	1
Benzo(g,h,i)perylene	191-24-2	8270E	ND		2.0	0.40	ug/L	1
Benzo(k)fluoranthene	207-08-9	8270E	ND		2.0	0.40	ug/L	1
4-Bromophenyl phenyl ether	101-55-3	8270E	ND		8.0	5.0	ug/L	1
Butyl benzyl phthalate	85-68-7	8270E	ND		8.0	5.0	ug/L	1
Carbazole	86-74-8	8270E	ND		8.0	5.0	ug/L	1
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND		8.0	5.0	ug/L	1
4-Chloro-3-methyl phenol	59-50-7	8270E	ND		8.0	5.0	ug/L	1
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND		8.0	5.0	ug/L	1
bis(2-Chloroethyl)ether	111-44-4	8270E	ND		8.0	5.0	ug/L	1
2-Chloronaphthalene	91-58-7	8270E	ND		8.0	5.0	ug/L	1
2-Chlorophenol	95-57-8	8270E	ND		8.0	5.0	ug/L	1
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND		8.0	5.0	ug/L	1
Chrysene	218-01-9	8270E	ND		2.0	0.30	ug/L	1
Dibenzo(a,h)anthracene	53-70-3	8270E	ND		2.0	0.30	ug/L	1
Dibenzofuran	132-64-9	8270E	ND		8.0	5.0	ug/L	1
1,2-Dichlorobenzene	95-50-1	8270E	ND		8.0	5.0	ug/L	1
1,3-Dichlorobenzene	541-73-1	8270E	ND		8.0	5.0	ug/L	1
1,4-Dichlorobenzene	106-46-7	8270E	ND		8.0	5.0	ug/L	1
3,3'-Dichlorobenzidine	91-94-1	8270E	ND		40	18	ug/L	1
2,4-Dichlorophenol	120-83-2	8270E	ND		16	10	ug/L	1
Diethylphthalate	84-66-2	8270E	ND		8.0	5.0	ug/L	1
Dimethyl phthalate	131-11-3	8270E	ND		8.0	5.0	ug/L	1
2,4-Dimethylphenol	**105-67-9**	**8270E**	**84**		**8.0**	**4.8**	**ug/L**	**1**
Di-n-butyl phthalate	**84-74-2**	**8270E**	**6.1**	**BJ**	**8.0**	**5.0**	**ug/L**	**1**
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND		40	10	ug/L	1
2,4-Dinitrophenol	51-28-5	8270E	ND		40	10	ug/L	1
2,4-Dinitrotoluene	121-14-2	8270E	ND		16	5.0	ug/L	1
2,6-Dinitrotoluene	606-20-2	8270E	ND		16	5.0	ug/L	1
Di-n-octylphthalate	117-84-0	8270E	ND		8.0	5.0	ug/L	1
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**11**	**BJ**	**40**	**5.0**	**ug/L**	**1**
Fluoranthene	206-44-0	8270E	ND		2.0	1.0	ug/L	1
Fluorene	86-73-7	8270E	ND		2.0	0.30	ug/L	1
Hexachlorobenzene	118-74-1	8270E	ND		8.0	5.0	ug/L	1
Hexachlorobutadiene	87-68-3	8270E	ND		8.0	5.0	ug/L	1
Hexachlorocyclopentadiene	77-47-4	8270E	ND		40	20	ug/L	1
Hexachloroethane	67-72-1	8270E	ND		8.0	3.1	ug/L	1
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND		2.0	0.40	ug/L	1

LOQ = Limit of Quantitation | B = Detected in the method blank | E = Quantitation of compound exceeded the calibration range | DL = Detection Limit

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

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1641	SCD	06/29/2020 1800	58389
2	3520C	8270E	5	07/07/2020 1612	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND		8.0	5.0	ug/L	1
2-Methylnaphthalene	**91-57-6**	**8270E**	**5.4**		**2.0**	**0.40**	**ug/L**	**1**
2-Methylphenol	95-48-7	8270E	ND		8.0	2.1	ug/L	1
3+4-Methylphenol	106-44-5	8270E	ND		16	15	ug/L	1
Naphthalene	**91-20-3**	**8270E**	**24**	**B**	**2.0**	**0.50**	**ug/L**	**1**
2-Nitroaniline	88-74-4	8270E	ND		16	5.0	ug/L	1
3-Nitroaniline	99-09-2	8270E	ND		16	10	ug/L	1
4-Nitroaniline	100-01-6	8270E	ND		16	15	ug/L	1
Nitrobenzene	98-95-3	8270E	ND		8.0	5.5	ug/L	1
2-Nitrophenol	88-75-5	8270E	ND		16	10	ug/L	1
4-Nitrophenol	100-02-7	8270E	ND		40	20	ug/L	1
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND		8.0	5.0	ug/L	1
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND		8.0	5.0	ug/L	1
Pentachlorophenol	87-86-5	8270E	ND		40	20	ug/L	1
Phenanthrene	85-01-8	8270E	ND		2.0	0.60	ug/L	1
Phenol	**108-95-2**	**8270E**	**53**		**8.0**	**5.0**	**ug/L**	**1**
Pyrene	129-00-0	8270E	ND		2.0	1.0	ug/L	1
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND		8.0	2.5	ug/L	1
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND		16	5.5	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8270E	ND		8.0	3.7	ug/L	1
2,4,5-Trichlorophenol	95-95-4	8270E	ND		8.0	5.0	ug/L	1
2,4,6-Trichlorophenol	88-06-2	8270E	ND		8.0	5.0	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		73	37-129	H	67	37-129
2-Fluorophenol		41	24-127	H	36	24-127
Nitrobenzene-d5		79	38-127	HN	130	38-127
Phenol-d5		67	28-128	H	67	28-128
Terphenyl-d14		100	10-148	H	73	10-148
2,4,6-Tribromophenol		96	35-144	H	83	35-144

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-001**

Description: **CMR-MW41S-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1118**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1641	SCD	06/29/2020 1800	58389
2	3520C	8270E	5	07/07/2020 1612	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND	H	1.0	0.20	ug/L	2
Acenaphthylene	208-96-8	8270E	ND	H	1.0	0.20	ug/L	2
Anthracene	120-12-7	8270E	ND	H	1.0	0.30	ug/L	2
Benzo(a)anthracene	56-55-3	8270E	ND	H	1.0	0.20	ug/L	2
Benzo(a)pyrene	50-32-8	8270E	ND	H	1.0	0.35	ug/L	2
Benzo(b)fluoranthene	205-99-2	8270E	ND	H	1.0	0.20	ug/L	2
Benzo(g,h,i)perylene	191-24-2	8270E	ND	H	1.0	0.20	ug/L	2
Benzo(k)fluoranthene	207-08-9	8270E	ND	H	1.0	0.20	ug/L	2
4-Bromophenyl phenyl ether	101-55-3	8270E	ND	H	4.0	2.5	ug/L	2
Butyl benzyl phthalate	85-68-7	8270E	ND	H	4.0	2.5	ug/L	2
Carbazole	86-74-8	8270E	ND	H	4.0	2.5	ug/L	2
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND	H	4.0	2.5	ug/L	2
4-Chloro-3-methyl phenol	59-50-7	8270E	ND	H	4.0	2.5	ug/L	2
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND	H	4.0	2.5	ug/L	2
bis(2-Chloroethyl)ether	111-44-4	8270E	ND	H	4.0	2.5	ug/L	2
2-Chloronaphthalene	91-58-7	8270E	ND	H	4.0	2.5	ug/L	2
2-Chlorophenol	95-57-8	8270E	ND	H	4.0	2.5	ug/L	2
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND	H	4.0	2.5	ug/L	2
Chrysene	218-01-9	8270E	ND	H	1.0	0.15	ug/L	2
Dibenzo(a,h)anthracene	53-70-3	8270E	ND	H	1.0	0.15	ug/L	2
Dibenzofuran	132-64-9	8270E	ND	H	4.0	2.5	ug/L	2
1,2-Dichlorobenzene	95-50-1	8270E	ND	H	4.0	2.5	ug/L	2
1,3-Dichlorobenzene	541-73-1	8270E	ND	H	4.0	2.5	ug/L	2
1,4-Dichlorobenzene	106-46-7	8270E	ND	H	4.0	2.5	ug/L	2
3,3'-Dichlorobenzidine	91-94-1	8270E	ND	H	20	8.8	ug/L	2
2,4-Dichlorophenol	120-83-2	8270E	ND	H	8.0	5.0	ug/L	2
Diethylphthalate	84-66-2	8270E	ND	H	4.0	2.5	ug/L	2
Dimethyl phthalate	131-11-3	8270E	ND	H	4.0	2.5	ug/L	2
2,4-Dimethylphenol	**105-67-9**	**8270E**	**65**	**H**	**4.0**	**2.4**	**ug/L**	**2**
Di-n-butyl phthalate	84-74-2	8270E	ND	H	4.0	2.5	ug/L	2
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND	H	20	5.0	ug/L	2
2,4-Dinitrophenol	51-28-5	8270E	ND	H	20	5.0	ug/L	2
2,4-Dinitrotoluene	121-14-2	8270E	ND	H	8.0	2.5	ug/L	2
2,6-Dinitrotoluene	606-20-2	8270E	ND	H	8.0	2.5	ug/L	2
Di-n-octylphthalate	117-84-0	8270E	ND	H	4.0	2.5	ug/L	2
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**7.3**	**BHJ**	**20**	**2.5**	**ug/L**	**2**
Fluoranthene	206-44-0	8270E	ND	H	1.0	0.50	ug/L	2
Fluorene	86-73-7	8270E	ND	H	1.0	0.15	ug/L	2
Hexachlorobenzene	118-74-1	8270E	ND	H	4.0	2.5	ug/L	2
Hexachlorobutadiene	87-68-3	8270E	ND	H	4.0	2.5	ug/L	2
Hexachlorocyclopentadiene	77-47-4	8270E	ND	H	20	10	ug/L	2
Hexachloroethane	67-72-1	8270E	ND	H	4.0	1.6	ug/L	2
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND	H	1.0	0.20	ug/L	2

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1641	SCD	06/29/2020 1800	58389
2	3520C	8270E	5	07/07/2020 1612	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND	H	4.0	2.5	ug/L	2
2-Methylnaphthalene	**91-57-6**	**8270E**	**3.2**	**H**	**1.0**	**0.20**	**ug/L**	**2**
2-Methylphenol	**95-48-7**	**8270E**	**3.6**	**HJ**	**4.0**	**1.1**	**ug/L**	**2**
3+4-Methylphenol	106-44-5	8270E	ND	H	8.0	7.5	ug/L	2
Naphthalene	**91-20-3**	**8270E**	**17**	**H**	**1.0**	**0.25**	**ug/L**	**2**
2-Nitroaniline	88-74-4	8270E	ND	H	8.0	2.5	ug/L	2
3-Nitroaniline	99-09-2	8270E	ND	H	8.0	5.0	ug/L	2
4-Nitroaniline	100-01-6	8270E	ND	H	8.0	7.5	ug/L	2
Nitrobenzene	98-95-3	8270E	ND	H	4.0	2.8	ug/L	2
2-Nitrophenol	88-75-5	8270E	ND	H	8.0	5.0	ug/L	2
4-Nitrophenol	100-02-7	8270E	ND	H	20	10	ug/L	2
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND	H	4.0	2.5	ug/L	2
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND	H	4.0	2.5	ug/L	2
Pentachlorophenol	87-86-5	8270E	ND	H	20	10	ug/L	2
Phenanthrene	85-01-8	8270E	ND	H	1.0	0.30	ug/L	2
Phenol	108-95-2	8270E	ND	H	4.0	2.5	ug/L	2
Pyrene	129-00-0	8270E	ND	H	1.0	0.50	ug/L	2
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND	H	4.0	1.3	ug/L	2
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND	H	8.0	2.8	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8270E	ND	H	4.0	1.9	ug/L	2
2,4,5-Trichlorophenol	95-95-4	8270E	ND	H	4.0	2.5	ug/L	2
2,4,6-Trichlorophenol	88-06-2	8270E	ND	H	4.0	2.5	ug/L	2

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		73	37-129	H	67	37-129
2-Fluorophenol		41	24-127	H	36	24-127
Nitrobenzene-d5		79	38-127	HN	130	38-127
Phenol-d5		67	28-128	H	67	28-128
Terphenyl-d14		100	10-148	H	73	10-148
2,4,6-Tribromophenol		96	35-144	H	83	35-144

LOQ = Limit of Quantitation
B = Detected in the method blank
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DL = Detection Limit
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N = Recovery is out of criteria
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Montana EPH (screening)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/07/2020 1757	JJG	07/06/2020 1615	59047

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TEH		**Montana EPH**	**4300**		**650**	**650**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		87	40-140
1-Chloro-octadecane (aliphatic)		92	40-140
2-Fluorobiphenyl (fractionation 1)		127	40-140
o - Terphenyl (aromatic)		74	40-140

LOQ = Limit of Quantitation
B = Detected in the method blank
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ND = Not detected at or above the DL
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J = Estimated result < LOQ and ≥ DL
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Montana EPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/17/2020 0108	NCM	07/06/2020 1615	59573

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C19 - C36 Aliphatics		Montana EPH	ND		320	320	ug/L	1
C9 - C18 Aliphatics		Montana EPH	ND		320	320	ug/L	1
TEH, post-fractionation	68334-30-5S	Montana EPH	ND		650	320	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
1-Chloro-octadecane (aliphatic)		65	40-140

LOQ = Limit of Quantitation
ND = Not detected at or above the DL
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%
DL = Detection Limit
J = Estimated result < LOQ and ≥ DL

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Montana EPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/17/2020 0409	NCM	07/06/2020 1615	59574

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C11 - C22 Aromatics		Montana EPH	ND		320	320	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		79	40-140
2-Fluorobiphenyl (fractionation 1)		85	40-140
o - Terphenyl (aromatic)		71	40-140

LOQ = Limit of Quantitation
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DL = Detection Limit
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P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
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Montana VPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	10	06/30/2020 1655	ECB		58616

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C5 - C8 Aliphatics, Adjusted		**Montana VPH**	**680**	**J**	**750**	**150**	**ug/L**	**2**
C9 - C12 Aliphatics, Adjusted		**Montana VPH**	**1700**		**750**	**150**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		120	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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H = Out of holding time	W = Reported on wet weight basis		

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Montana VPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	10	06/30/2020 1655	ECB		58615

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Benzene	**71-43-2**	**Montana VPH**	**1100**		**50**	**5.1**	**ug/L**	**2**
C9 - C10 Aromatics		**Montana VPH**	**1100**		**250**	**50**	**ug/L**	**2**
Ethylbenzene	**100-41-4**	**Montana VPH**	**410**		**50**	**6.2**	**ug/L**	**2**
Methyl tertiary butyl ether (MTBE)	1634-04-4	Montana VPH	ND		50	12	ug/L	2
Naphthalene	**91-20-3**	**Montana VPH**	**45**	**J**	**50**	**7.0**	**ug/L**	**2**
Toluene	**108-88-3**	**Montana VPH**	**84**		**50**	**5.3**	**ug/L**	**2**
m+p - Xylenes	**179601-23-1**	**Montana VPH**	**610**		**50**	**12**	**ug/L**	**2**
o - Xylenes	**95-47-6**	**Montana VPH**	**79**		**50**	**5.8**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (PID)		118	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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H = Out of holding time	W = Reported on wet weight basis		

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Montana VPH (TPH)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	10	06/30/2020 1655	ECB		58617

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TPH		**Montana VPH**	**5000**		**1800**	**350**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		121	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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ICP-MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-001**
Description: **CMR-MW41S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1118**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7470A	1	06/25/2020 1725	JAB2	06/25/2020 1059	58030
1	3005A	6020B	1	07/02/2020 0100	BPK	07/01/2020 0346	58605

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Antimony	**7440-36-0**	**6020B**	**0.90**	**J**	**2.0**	**0.50**	**ug/L**	**1**
Arsenic	**7440-38-2**	**6020B**	**5.2**		**2.0**	**1.3**	**ug/L**	**1**
Barium	**7440-39-3**	**6020B**	**290**		**5.0**	**1.3**	**ug/L**	**1**
Beryllium	7440-41-7	6020B	ND		0.40	0.15	ug/L	1
Cadmium	**7440-43-9**	**6020B**	**0.15**	**J**	**0.50**	**0.13**	**ug/L**	**1**
Chromium	7440-47-3	6020B	ND		5.0	1.3	ug/L	1
Cobalt	7440-48-4	6020B	ND		5.0	1.3	ug/L	1
Copper	**7440-50-8**	**6020B**	**5.9**		**5.0**	**1.3**	**ug/L**	**1**
Lead	7439-92-1	6020B	ND		1.0	0.25	ug/L	1
Mercury	7439-97-6	7470A	ND		0.00020	0.000091	mg/L	1
Nickel	**7440-02-0**	**6020B**	**3.7**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Selenium	**7782-49-2**	**6020B**	**1.6**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Silver	7440-22-4	6020B	ND		1.0	0.25	ug/L	1
Vanadium	**7440-62-2**	**6020B**	**3.7**	**J**	**5.0**	**2.5**	**ug/L**	**1**
Zinc	7440-66-6	6020B	ND		10	2.5	ug/L	1

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	5030B	8260D	1	07/01/2020 1153	TML		58687
3	5030B	8260D	10	07/04/2020 2127	STM		58939

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	**67-64-1**	**8260D**	**480**		**100**	**40**	**ug/L**	**3**
Benzene	**71-43-2**	**8260D**	**96**		**5.0**	**4.0**	**ug/L**	**3**
Bromochloromethane	74-97-5	8260D	ND		0.50	0.40	ug/L	2
Bromodichloromethane	**75-27-4**	**8260D**	**0.81**		**0.50**	**0.40**	**ug/L**	**2**
Bromoform	75-25-2	8260D	ND		0.50	0.40	ug/L	2
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		0.50	0.40	ug/L	2
2-Butanone (MEK)	**78-93-3**	**8260D**	**290**		**10**	**2.0**	**ug/L**	**2**
Carbon disulfide	**75-15-0**	**8260D**	**1.1**		**0.50**	**0.40**	**ug/L**	**2**
Carbon tetrachloride	56-23-5	8260D	ND		0.50	0.40	ug/L	2
Chlorobenzene	108-90-7	8260D	ND		0.50	0.40	ug/L	2
Chloroethane	75-00-3	8260D	ND		0.50	0.40	ug/L	2
Chloroform	**67-66-3**	**8260D**	**4.9**		**0.50**	**0.40**	**ug/L**	**2**
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		0.50	0.40	ug/L	2
Cyclohexane	**110-82-7**	**8260D**	**25**		**0.50**	**0.40**	**ug/L**	**2**
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		0.50	0.40	ug/L	2
Dibromochloromethane	124-48-1	8260D	ND		0.50	0.40	ug/L	2
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		0.50	0.40	ug/L	2
1,2-Dichlorobenzene	95-50-1	8260D	ND		0.50	0.40	ug/L	2
1,3-Dichlorobenzene	541-73-1	8260D	ND		0.50	0.40	ug/L	2
1,4-Dichlorobenzene	106-46-7	8260D	ND		0.50	0.40	ug/L	2
Dichlorodifluoromethane	75-71-8	8260D	ND		0.50	0.40	ug/L	2
1,1-Dichloroethane	75-34-3	8260D	ND		0.50	0.40	ug/L	2
1,2-Dichloroethane	107-06-2	8260D	ND		0.50	0.40	ug/L	2
1,1-Dichloroethene	75-35-4	8260D	ND		0.50	0.40	ug/L	2
cis-1,2-Dichloroethene	156-59-2	8260D	ND		0.50	0.40	ug/L	2
trans-1,2-Dichloroethene	156-60-5	8260D	ND		0.50	0.40	ug/L	2
1,2-Dichloropropane	78-87-5	8260D	ND		0.50	0.40	ug/L	2
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		0.50	0.40	ug/L	2
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		0.50	0.40	ug/L	2
1,4-Dioxane	123-91-1	8260D	ND		20	13	ug/L	2
Ethylbenzene	**100-41-4**	**8260D**	**25**		**5.0**	**4.0**	**ug/L**	**3**
2-Hexanone	**591-78-6**	**8260D**	**16**		**10**	**2.0**	**ug/L**	**2**
Isopropylbenzene	**98-82-8**	**8260D**	**11**		**0.50**	**0.40**	**ug/L**	**2**
Methyl acetate	79-20-9	8260D	ND		1.0	0.40	ug/L	2
Methyl tertiary butyl ether (MTBE)	1634-04-4	8260D	ND		0.50	0.40	ug/L	2
4-Methyl-2-pentanone	**108-10-1**	**8260D**	**26**		**10**	**2.0**	**ug/L**	**2**
Methylcyclohexane	**108-87-2**	**8260D**	**12**		**5.0**	**0.40**	**ug/L**	**2**
Methylene chloride	75-09-2	8260D	ND		0.50	0.40	ug/L	2
Naphthalene	**91-20-3**	**8260D**	**3.0**		**0.50**	**0.40**	**ug/L**	**2**
Styrene	100-42-5	8260D	ND		0.50	0.41	ug/L	2
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		0.50	0.40	ug/L	2
Tetrachloroethene	127-18-4	8260D	ND		0.50	0.40	ug/L	2
Toluene	**108-88-3**	**8260D**	**19**		**0.50**	**0.40**	**ug/L**	**2**

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W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	5030B	8260D	1	07/01/2020 1153	TML		58687
3	5030B	8260D	10	07/04/2020 2127	STM		58939

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		1.0	0.42	ug/L	2
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		0.50	0.40	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		0.50	0.40	ug/L	2
1,1,1-Trichloroethane	71-55-6	8260D	ND		0.50	0.40	ug/L	2
1,1,2-Trichloroethane	79-00-5	8260D	ND		0.50	0.40	ug/L	2
Trichloroethene	79-01-6	8260D	ND		0.50	0.40	ug/L	2
Trichlorofluoromethane	75-69-4	8260D	ND		0.50	0.40	ug/L	2
Vinyl chloride	75-01-4	8260D	ND		0.50	0.40	ug/L	2
Xylenes (total)	**1330-20-7**	**8260D**	**64**		**10**	**4.0**	**ug/L**	**3**
m+p - Xylenes	**179601-23-1**	**8260D**	**64**		**5.0**	**4.0**	**ug/L**	**3**
o - Xylenes	**95-47-6**	**8260D**	**16**		**0.50**	**0.40**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits	Q	Run 3 % Recovery	Acceptance Limits
Bromofluorobenzene		105	70-130		102	70-130
1,2-Dichloroethane-d4		109	70-130		114	70-130
Toluene-d8		105	70-130		107	70-130

LOQ = Limit of Quantitation
B = Detected in the method blank
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DL = Detection Limit
ND = Not detected at or above the DL
N = Recovery is out of criteria
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-002**

Description: **CMR-TW203S-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1221**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1706	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/01/2020 1847	SCD	06/29/2020 1800	58389
3	3520C	8270E	1	07/07/2020 1320	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND		0.20	0.040	ug/L	1
Acenaphthylene	208-96-8	8270E	ND		0.20	0.040	ug/L	1
Anthracene	120-12-7	8270E	ND		0.20	0.060	ug/L	1
Benzo(a)anthracene	56-55-3	8270E	ND		0.20	0.040	ug/L	1
Benzo(a)pyrene	50-32-8	8270E	ND		0.20	0.070	ug/L	1
Benzo(b)fluoranthene	205-99-2	8270E	ND		0.20	0.040	ug/L	1
Benzo(g,h,i)perylene	191-24-2	8270E	ND		0.20	0.040	ug/L	1
Benzo(k)fluoranthene	207-08-9	8270E	ND		0.20	0.040	ug/L	1
4-Bromophenyl phenyl ether	101-55-3	8270E	ND		0.80	0.50	ug/L	1
Butyl benzyl phthalate	85-68-7	8270E	ND		0.80	0.50	ug/L	1
Carbazole	86-74-8	8270E	ND		0.80	0.50	ug/L	1
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND		0.80	0.50	ug/L	1
4-Chloro-3-methyl phenol	59-50-7	8270E	ND		0.80	0.50	ug/L	1
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND		0.80	0.50	ug/L	1
bis(2-Chloroethyl)ether	111-44-4	8270E	ND		0.80	0.50	ug/L	1
2-Chloronaphthalene	91-58-7	8270E	ND		0.80	0.50	ug/L	1
2-Chlorophenol	95-57-8	8270E	ND		0.80	0.50	ug/L	1
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND		0.80	0.50	ug/L	1
Chrysene	218-01-9	8270E	ND		0.20	0.030	ug/L	1
Dibenzo(a,h)anthracene	53-70-3	8270E	ND		0.20	0.030	ug/L	1
Dibenzofuran	132-64-9	8270E	ND		0.80	0.50	ug/L	1
1,2-Dichlorobenzene	95-50-1	8270E	ND		0.80	0.50	ug/L	1
1,3-Dichlorobenzene	541-73-1	8270E	ND		0.80	0.50	ug/L	1
1,4-Dichlorobenzene	106-46-7	8270E	ND		0.80	0.50	ug/L	1
3,3'-Dichlorobenzidine	91-94-1	8270E	ND		4.0	1.8	ug/L	1
2,4-Dichlorophenol	120-83-2	8270E	ND		1.6	1.0	ug/L	1
Diethylphthalate	**84-66-2**	**8270E**	**0.53**	**J**	**0.80**	**0.50**	**ug/L**	**1**
Dimethyl phthalate	131-11-3	8270E	ND		0.80	0.50	ug/L	1
2,4-Dimethylphenol	**105-67-9**	**8270E**	**74**		**8.0**	**4.8**	**ug/L**	**2**
Di-n-butyl phthalate	**84-74-2**	**8270E**	**0.77**	**BJ**	**0.80**	**0.50**	**ug/L**	**1**
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND		4.0	1.0	ug/L	1
2,4-Dinitrophenol	51-28-5	8270E	ND		4.0	1.0	ug/L	1
2,4-Dinitrotoluene	121-14-2	8270E	ND		1.6	0.50	ug/L	1
2,6-Dinitrotoluene	606-20-2	8270E	ND		1.6	0.50	ug/L	1
Di-n-octylphthalate	117-84-0	8270E	ND		0.80	0.50	ug/L	1
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**1.4**	**BJ**	**4.0**	**0.50**	**ug/L**	**1**
Fluoranthene	206-44-0	8270E	ND		0.20	0.10	ug/L	1
Fluorene	86-73-7	8270E	ND		0.20	0.030	ug/L	1
Hexachlorobenzene	118-74-1	8270E	ND		0.80	0.50	ug/L	1
Hexachlorobutadiene	87-68-3	8270E	ND		0.80	0.50	ug/L	1
Hexachlorocyclopentadiene	77-47-4	8270E	ND		4.0	2.0	ug/L	1
Hexachloroethane	67-72-1	8270E	ND		0.80	0.31	ug/L	1

LOQ = Limit of Quantitation
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
DL = Detection Limit
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N = Recovery is out of criteria
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1706	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/01/2020 1847	SCD	06/29/2020 1800	58389
3	3520C	8270E	1	07/07/2020 1320	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND		0.20	0.040	ug/L	1
Isophorone	78-59-1	8270E	ND		0.80	0.50	ug/L	1
2-Methylnaphthalene	**91-57-6**	**8270E**	**0.27**		**0.20**	**0.040**	**ug/L**	**1**
2-Methylphenol	95-48-7	8270E	ND		0.80	0.21	ug/L	1
3+4-Methylphenol	106-44-5	8270E	ND		1.6	1.5	ug/L	1
Naphthalene	91-20-3	8270E	ND		0.20	0.050	ug/L	1
2-Nitroaniline	88-74-4	8270E	ND		1.6	0.50	ug/L	1
3-Nitroaniline	99-09-2	8270E	ND		1.6	1.0	ug/L	1
4-Nitroaniline	100-01-6	8270E	ND		1.6	1.5	ug/L	1
Nitrobenzene	98-95-3	8270E	ND		0.80	0.55	ug/L	1
2-Nitrophenol	88-75-5	8270E	ND		1.6	1.0	ug/L	1
4-Nitrophenol	100-02-7	8270E	ND		4.0	2.0	ug/L	1
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND		0.80	0.50	ug/L	1
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND		0.80	0.50	ug/L	1
Pentachlorophenol	87-86-5	8270E	ND		4.0	2.0	ug/L	1
Phenanthrene	85-01-8	8270E	ND		0.20	0.060	ug/L	1
Phenol	108-95-2	8270E	ND		0.80	0.50	ug/L	1
Pyrene	129-00-0	8270E	ND		0.20	0.10	ug/L	1
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND		0.80	0.25	ug/L	1
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND		1.6	0.55	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8270E	ND		0.80	0.37	ug/L	1
2,4,5-Trichlorophenol	95-95-4	8270E	ND		0.80	0.50	ug/L	1
2,4,6-Trichlorophenol	88-06-2	8270E	ND		0.80	0.50	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits	Q	Run 3 % Recovery	Acceptance Limits
2-Fluorobiphenyl		77	37-129		75	37-129	H	72	37-129
2-Fluorophenol		45	24-127		40	24-127	H	36	24-127
Nitrobenzene-d5		44	38-127		61	38-127	H	78	38-127
Phenol-d5		89	28-128		52	28-128	H	47	28-128
Terphenyl-d14		89	10-148		92	10-148	H	85	10-148
2,4,6-Tribromophenol		97	35-144		81	35-144	H	68	35-144

LOQ = Limit of Quantitation
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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-002**

Description: **CMR-TW203S-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1221**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1706	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/01/2020 1847	SCD	06/29/2020 1800	58389
3	3520C	8270E	1	07/07/2020 1320	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND	H	0.20	0.040	ug/L	3
Acenaphthylene	208-96-8	8270E	ND	H	0.20	0.040	ug/L	3
Anthracene	120-12-7	8270E	ND	H	0.20	0.060	ug/L	3
Benzo(a)anthracene	56-55-3	8270E	ND	H	0.20	0.040	ug/L	3
Benzo(a)pyrene	50-32-8	8270E	ND	H	0.20	0.070	ug/L	3
Benzo(b)fluoranthene	205-99-2	8270E	ND	H	0.20	0.040	ug/L	3
Benzo(g,h,i)perylene	191-24-2	8270E	ND	H	0.20	0.040	ug/L	3
Benzo(k)fluoranthene	207-08-9	8270E	ND	H	0.20	0.040	ug/L	3
4-Bromophenyl phenyl ether	101-55-3	8270E	ND	H	0.80	0.50	ug/L	3
Butyl benzyl phthalate	85-68-7	8270E	ND	H	0.80	0.50	ug/L	3
Carbazole	86-74-8	8270E	ND	H	0.80	0.50	ug/L	3
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND	H	0.80	0.50	ug/L	3
4-Chloro-3-methyl phenol	59-50-7	8270E	ND	H	0.80	0.50	ug/L	3
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND	H	0.80	0.50	ug/L	3
bis(2-Chloroethyl)ether	111-44-4	8270E	ND	H	0.80	0.50	ug/L	3
2-Chloronaphthalene	91-58-7	8270E	ND	H	0.80	0.50	ug/L	3
2-Chlorophenol	95-57-8	8270E	ND	H	0.80	0.50	ug/L	3
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND	H	0.80	0.50	ug/L	3
Chrysene	218-01-9	8270E	ND	H	0.20	0.030	ug/L	3
Dibenzo(a,h)anthracene	53-70-3	8270E	ND	H	0.20	0.030	ug/L	3
Dibenzofuran	132-64-9	8270E	ND	H	0.80	0.50	ug/L	3
1,2-Dichlorobenzene	95-50-1	8270E	ND	H	0.80	0.50	ug/L	3
1,3-Dichlorobenzene	541-73-1	8270E	ND	H	0.80	0.50	ug/L	3
1,4-Dichlorobenzene	106-46-7	8270E	ND	H	0.80	0.50	ug/L	3
3,3'-Dichlorobenzidine	91-94-1	8270E	ND	H	4.0	1.8	ug/L	3
2,4-Dichlorophenol	120-83-2	8270E	ND	H	1.6	1.0	ug/L	3
Diethylphthalate	84-66-2	8270E	ND	H	0.80	0.50	ug/L	3
Dimethyl phthalate	131-11-3	8270E	ND	H	0.80	0.50	ug/L	3
2,4-Dimethylphenol	105-67-9	8270E	ND	H	0.80	0.48	ug/L	3
Di-n-butyl phthalate	84-74-2	8270E	ND	H	0.80	0.50	ug/L	3
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND	H	4.0	1.0	ug/L	3
2,4-Dinitrophenol	51-28-5	8270E	ND	H	4.0	1.0	ug/L	3
2,4-Dinitrotoluene	121-14-2	8270E	ND	H	1.6	0.50	ug/L	3
2,6-Dinitrotoluene	606-20-2	8270E	ND	H	1.6	0.50	ug/L	3
Di-n-octylphthalate	117-84-0	8270E	ND	H	0.80	0.50	ug/L	3
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**1.3**	**BHJ**	**4.0**	**0.50**	**ug/L**	**3**
Fluoranthene	206-44-0	8270E	ND	H	0.20	0.10	ug/L	3
Fluorene	86-73-7	8270E	ND	H	0.20	0.030	ug/L	3
Hexachlorobenzene	118-74-1	8270E	ND	H	0.80	0.50	ug/L	3
Hexachlorobutadiene	87-68-3	8270E	ND	H	0.80	0.50	ug/L	3
Hexachlorocyclopentadiene	77-47-4	8270E	ND	H	4.0	2.0	ug/L	3
Hexachloroethane	67-72-1	8270E	ND	H	0.80	0.31	ug/L	3

LOQ = Limit of Quantitation
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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1706	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/01/2020 1847	SCD	06/29/2020 1800	58389
3	3520C	8270E	1	07/07/2020 1320	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND	H	0.20	0.040	ug/L	3
Isophorone	78-59-1	8270E	ND	H	0.80	0.50	ug/L	3
2-Methylnaphthalene	91-57-6	8270E	ND	H	0.20	0.040	ug/L	3
2-Methylphenol	95-48-7	8270E	ND	H	0.80	0.21	ug/L	3
3+4-Methylphenol	106-44-5	8270E	ND	H	1.6	1.5	ug/L	3
Naphthalene	91-20-3	8270E	ND	H	0.20	0.050	ug/L	3
2-Nitroaniline	88-74-4	8270E	ND	H	1.6	0.50	ug/L	3
3-Nitroaniline	99-09-2	8270E	ND	H	1.6	1.0	ug/L	3
4-Nitroaniline	100-01-6	8270E	ND	H	1.6	1.5	ug/L	3
Nitrobenzene	98-95-3	8270E	ND	H	0.80	0.55	ug/L	3
2-Nitrophenol	88-75-5	8270E	ND	H	1.6	1.0	ug/L	3
4-Nitrophenol	100-02-7	8270E	ND	H	4.0	2.0	ug/L	3
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND	H	0.80	0.50	ug/L	3
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND	H	0.80	0.50	ug/L	3
Pentachlorophenol	87-86-5	8270E	ND	H	4.0	2.0	ug/L	3
Phenanthrene	85-01-8	8270E	ND	H	0.20	0.060	ug/L	3
Phenol	108-95-2	8270E	ND	H	0.80	0.50	ug/L	3
Pyrene	129-00-0	8270E	ND	H	0.20	0.10	ug/L	3
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND	H	0.80	0.25	ug/L	3
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND	H	1.6	0.55	ug/L	3
1,2,4-Trichlorobenzene	120-82-1	8270E	ND	H	0.80	0.37	ug/L	3
2,4,5-Trichlorophenol	95-95-4	8270E	ND	H	0.80	0.50	ug/L	3
2,4,6-Trichlorophenol	88-06-2	8270E	ND	H	0.80	0.50	ug/L	3

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits	Q	Run 3 % Recovery	Acceptance Limits
2-Fluorobiphenyl		77	37-129		75	37-129	H	72	37-129
2-Fluorophenol		45	24-127		40	24-127	H	36	24-127
Nitrobenzene-d5		44	38-127		61	38-127	H	78	38-127
Phenol-d5		89	28-128		52	28-128	H	47	28-128
Terphenyl-d14		89	10-148		92	10-148	H	85	10-148
2,4,6-Tribromophenol		97	35-144		81	35-144	H	68	35-144

LOQ = Limit of Quantitation
B = Detected in the method blank
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P = The RPD between two GC columns exceeds 40%
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Montana VPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	5	06/30/2020 1558	ECB		58616

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C5 - C8 Aliphatics, Adjusted		**Montana VPH**	**530**		**380**	**75**	**ug/L**	**2**
C9 - C12 Aliphatics, Adjusted		**Montana VPH**	**880**		**380**	**75**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		110	70-130

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

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Montana VPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	5	06/30/2020 1558	ECB		58615

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Benzene	**71-43-2**	**Montana VPH**	**240**		**25**	**2.6**	**ug/L**	**2**
C9 - C10 Aromatics		**Montana VPH**	**1000**		**130**	**25**	**ug/L**	**2**
Ethylbenzene	**100-41-4**	**Montana VPH**	**110**		**25**	**3.1**	**ug/L**	**2**
Methyl tertiary butyl ether (MTBE)	1634-04-4	Montana VPH	ND		25	6.0	ug/L	2
Naphthalene	**91-20-3**	**Montana VPH**	**6.2**	**J**	**25**	**3.5**	**ug/L**	**2**
Toluene	**108-88-3**	**Montana VPH**	**11**	**J**	**25**	**2.7**	**ug/L**	**2**
m+p - Xylenes	**179601-23-1**	**Montana VPH**	**590**		**25**	**6.0**	**ug/L**	**2**
o - Xylenes	**95-47-6**	**Montana VPH**	**17**	**J**	**25**	**2.9**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (PID)		110	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL
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Montana VPH (TPH)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	5	06/30/2020 1558	ECB		58617

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TPH		**Montana VPH**	**3500**		**880**	**180**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		110	70-130

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

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CVAA

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7470A	1	07/02/2020 1507	JMH	07/02/2020 1122	58789

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Dissolved Mercury	7439-97-6	7470A	ND		0.00020	0.000091	mg/L	1

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ICP-MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-002**
Description: **CMR-TW203S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1221**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3005A	6020B	1	07/02/2020 1019	BNW	07/01/2020 1647	58723

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Dissolved Antimony	**7440-36-0**	**6020B**	**1.1**	**J**	**2.0**	**0.50**	**ug/L**	**1**
Dissolved Arsenic	**7440-38-2**	**6020B**	**4.1**		**2.0**	**1.3**	**ug/L**	**1**
Dissolved Barium	**7440-39-3**	**6020B**	**240**		**5.0**	**1.3**	**ug/L**	**1**
Dissolved Beryllium	7440-41-7	6020B	ND		0.40	0.15	ug/L	1
Dissolved Cadmium	7440-43-9	6020B	ND		0.50	0.13	ug/L	1
Dissolved Chromium	7440-47-3	6020B	ND		5.0	1.3	ug/L	1
Dissolved Cobalt	7440-48-4	6020B	ND		5.0	1.3	ug/L	1
Dissolved Copper	**7440-50-8**	**6020B**	**1.9**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Dissolved Lead	7439-92-1	6020B	ND		1.0	0.25	ug/L	1
Dissolved Nickel	**7440-02-0**	**6020B**	**2.2**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Dissolved Selenium	**7782-49-2**	**6020B**	**6.8**		**5.0**	**1.3**	**ug/L**	**1**
Dissolved Silver	7440-22-4	6020B	ND		1.0	0.25	ug/L	1
Dissolved Vanadium	**7440-62-2**	**6020B**	**3.7**	**J**	**5.0**	**2.5**	**ug/L**	**1**
Dissolved Zinc	7440-66-6	6020B	ND		10	2.5	ug/L	1

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	1	06/27/2020 0210	JTH		58271
2	5030B	8260D	1	07/01/2020 1216	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	**67-64-1**	**8260D**	**100**		**10**	**4.0**	**ug/L**	**2**
Benzene	**71-43-2**	**8260D**	**3.8**		**0.50**	**0.40**	**ug/L**	**1**
Bromochloromethane	74-97-5	8260D	ND		0.50	0.40	ug/L	1
Bromodichloromethane	**75-27-4**	**8260D**	**0.96**		**0.50**	**0.40**	**ug/L**	**1**
Bromoform	75-25-2	8260D	ND		0.50	0.40	ug/L	1
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		0.50	0.40	ug/L	1
2-Butanone (MEK)	**78-93-3**	**8260D**	**19**		**10**	**2.0**	**ug/L**	**1**
Carbon disulfide	75-15-0	8260D	ND		0.50	0.40	ug/L	1
Carbon tetrachloride	56-23-5	8260D	ND		0.50	0.40	ug/L	1
Chlorobenzene	108-90-7	8260D	ND		0.50	0.40	ug/L	1
Chloroethane	75-00-3	8260D	ND		0.50	0.40	ug/L	1
Chloroform	**67-66-3**	**8260D**	**3.1**		**0.50**	**0.40**	**ug/L**	**1**
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		0.50	0.40	ug/L	1
Cyclohexane	110-82-7	8260D	ND		0.50	0.40	ug/L	1
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		0.50	0.40	ug/L	1
Dibromochloromethane	124-48-1	8260D	ND		0.50	0.40	ug/L	1
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichlorobenzene	95-50-1	8260D	ND		0.50	0.40	ug/L	1
1,3-Dichlorobenzene	541-73-1	8260D	ND		0.50	0.40	ug/L	1
1,4-Dichlorobenzene	106-46-7	8260D	ND		0.50	0.40	ug/L	1
Dichlorodifluoromethane	75-71-8	8260D	ND		0.50	0.40	ug/L	1
1,1-Dichloroethane	75-34-3	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichloroethane	107-06-2	8260D	ND		0.50	0.40	ug/L	1
1,1-Dichloroethene	75-35-4	8260D	ND		0.50	0.40	ug/L	1
cis-1,2-Dichloroethene	156-59-2	8260D	ND		0.50	0.40	ug/L	1
trans-1,2-Dichloroethene	156-60-5	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichloropropane	78-87-5	8260D	ND		0.50	0.40	ug/L	1
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		0.50	0.40	ug/L	1
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		0.50	0.40	ug/L	1
1,4-Dioxane	123-91-1	8260D	ND		20	13	ug/L	2
Ethylbenzene	**100-41-4**	**8260D**	**2.3**		**0.50**	**0.40**	**ug/L**	**1**
2-Hexanone	**591-78-6**	**8260D**	**4.4**	**J**	**10**	**2.0**	**ug/L**	**1**
Isopropylbenzene	98-82-8	8260D	ND		0.50	0.40	ug/L	1
Methyl acetate	79-20-9	8260D	ND		1.0	0.40	ug/L	1
Methyl tertiary butyl ether (MTBE)	**1634-04-4**	**8260D**	**0.95**		**0.50**	**0.40**	**ug/L**	**1**
4-Methyl-2-pentanone	**108-10-1**	**8260D**	**13**		**10**	**2.0**	**ug/L**	**1**
Methylcyclohexane	**108-87-2**	**8260D**	**0.82**	**J**	**5.0**	**0.40**	**ug/L**	**1**
Methylene chloride	75-09-2	8260D	ND		0.50	0.40	ug/L	1
Naphthalene	**91-20-3**	**8260D**	**0.91**		**0.50**	**0.40**	**ug/L**	**1**
Styrene	100-42-5	8260D	ND		0.50	0.41	ug/L	1
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		0.50	0.40	ug/L	1
Tetrachloroethene	127-18-4	8260D	ND		0.50	0.40	ug/L	1
Toluene	**108-88-3**	**8260D**	**2.1**		**0.50**	**0.40**	**ug/L**	**1**

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	1	06/27/2020 0210	JTH		58271
2	5030B	8260D	1	07/01/2020 1216	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		1.0	0.42	ug/L	1
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		0.50	0.40	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		0.50	0.40	ug/L	1
1,1,1-Trichloroethane	71-55-6	8260D	ND		0.50	0.40	ug/L	1
1,1,2-Trichloroethane	79-00-5	8260D	ND		0.50	0.40	ug/L	1
Trichloroethene	79-01-6	8260D	ND		0.50	0.40	ug/L	1
Trichlorofluoromethane	75-69-4	8260D	ND		0.50	0.40	ug/L	1
Vinyl chloride	75-01-4	8260D	ND		0.50	0.40	ug/L	1
Xylenes (total)	**1330-20-7**	**8260D**	**16**		**1.0**	**0.40**	**ug/L**	**1**
m+p - Xylenes	**179601-23-1**	**8260D**	**9.2**		**0.50**	**0.40**	**ug/L**	**1**
o - Xylenes	**95-47-6**	**8260D**	**6.3**		**0.50**	**0.40**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
Bromofluorobenzene		103	70-130		105	70-130
1,2-Dichloroethane-d4		84	70-130		114	70-130
Toluene-d8		99	70-130		108	70-130

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-003**

Description: **CMR-TW202D-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1317**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1731	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/07/2020 1345	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	**83-32-9**	**8270E**	**0.19**	**J**	**0.20**	**0.040**	**ug/L**	**1**
Acenaphthylene	208-96-8	8270E	ND		0.20	0.040	ug/L	1
Anthracene	120-12-7	8270E	ND		0.20	0.060	ug/L	1
Benzo(a)anthracene	56-55-3	8270E	ND		0.20	0.040	ug/L	1
Benzo(a)pyrene	50-32-8	8270E	ND		0.20	0.070	ug/L	1
Benzo(b)fluoranthene	205-99-2	8270E	ND		0.20	0.040	ug/L	1
Benzo(g,h,i)perylene	191-24-2	8270E	ND		0.20	0.040	ug/L	1
Benzo(k)fluoranthene	207-08-9	8270E	ND		0.20	0.040	ug/L	1
4-Bromophenyl phenyl ether	101-55-3	8270E	ND		0.80	0.50	ug/L	1
Butyl benzyl phthalate	85-68-7	8270E	ND		0.80	0.50	ug/L	1
Carbazole	86-74-8	8270E	ND		0.80	0.50	ug/L	1
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND		0.80	0.50	ug/L	1
4-Chloro-3-methyl phenol	59-50-7	8270E	ND		0.80	0.50	ug/L	1
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND		0.80	0.50	ug/L	1
bis(2-Chloroethyl)ether	111-44-4	8270E	ND		0.80	0.50	ug/L	1
2-Chloronaphthalene	91-58-7	8270E	ND		0.80	0.50	ug/L	1
2-Chlorophenol	95-57-8	8270E	ND		0.80	0.50	ug/L	1
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND		0.80	0.50	ug/L	1
Chrysene	218-01-9	8270E	ND		0.20	0.030	ug/L	1
Dibenzo(a,h)anthracene	53-70-3	8270E	ND		0.20	0.030	ug/L	1
Dibenzofuran	132-64-9	8270E	ND		0.80	0.50	ug/L	1
1,2-Dichlorobenzene	95-50-1	8270E	ND		0.80	0.50	ug/L	1
1,3-Dichlorobenzene	541-73-1	8270E	ND		0.80	0.50	ug/L	1
1,4-Dichlorobenzene	106-46-7	8270E	ND		0.80	0.50	ug/L	1
3,3'-Dichlorobenzidine	91-94-1	8270E	ND		4.0	1.8	ug/L	1
2,4-Dichlorophenol	120-83-2	8270E	ND		1.6	1.0	ug/L	1
Diethylphthalate	**84-66-2**	**8270E**	**0.98**		**0.80**	**0.50**	**ug/L**	**1**
Dimethyl phthalate	131-11-3	8270E	ND		0.80	0.50	ug/L	1
2,4-Dimethylphenol	105-67-9	8270E	ND		0.80	0.48	ug/L	1
Di-n-butyl phthalate	**84-74-2**	**8270E**	**1.1**	**B**	**0.80**	**0.50**	**ug/L**	**1**
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND		4.0	1.0	ug/L	1
2,4-Dinitrophenol	51-28-5	8270E	ND		4.0	1.0	ug/L	1
2,4-Dinitrotoluene	121-14-2	8270E	ND		1.6	0.50	ug/L	1
2,6-Dinitrotoluene	606-20-2	8270E	ND		1.6	0.50	ug/L	1
Di-n-octylphthalate	117-84-0	8270E	ND		0.80	0.50	ug/L	1
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**1.1**	**BJ**	**4.0**	**0.50**	**ug/L**	**1**
Fluoranthene	206-44-0	8270E	ND		0.20	0.10	ug/L	1
Fluorene	**86-73-7**	**8270E**	**0.36**		**0.20**	**0.030**	**ug/L**	**1**
Hexachlorobenzene	118-74-1	8270E	ND		0.80	0.50	ug/L	1
Hexachlorobutadiene	87-68-3	8270E	ND		0.80	0.50	ug/L	1
Hexachlorocyclopentadiene	77-47-4	8270E	ND		4.0	2.0	ug/L	1
Hexachloroethane	67-72-1	8270E	ND		0.80	0.31	ug/L	1
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND		0.20	0.040	ug/L	1

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1731	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/07/2020 1345	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND		0.80	0.50	ug/L	1
2-Methylnaphthalene	91-57-6	8270E	ND		0.20	0.040	ug/L	1
2-Methylphenol	95-48-7	8270E	ND		0.80	0.21	ug/L	1
3+4-Methylphenol	106-44-5	8270E	ND		1.6	1.5	ug/L	1
Naphthalene	91-20-3	8270E	ND		0.20	0.050	ug/L	1
2-Nitroaniline	88-74-4	8270E	ND		1.6	0.50	ug/L	1
3-Nitroaniline	99-09-2	8270E	ND		1.6	1.0	ug/L	1
4-Nitroaniline	100-01-6	8270E	ND		1.6	1.5	ug/L	1
Nitrobenzene	98-95-3	8270E	ND		0.80	0.55	ug/L	1
2-Nitrophenol	88-75-5	8270E	ND		1.6	1.0	ug/L	1
4-Nitrophenol	100-02-7	8270E	ND		4.0	2.0	ug/L	1
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND		0.80	0.50	ug/L	1
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND		0.80	0.50	ug/L	1
Pentachlorophenol	87-86-5	8270E	ND		4.0	2.0	ug/L	1
Phenanthrene	**85-01-8**	**8270E**	**0.22**		**0.20**	**0.060**	**ug/L**	**1**
Phenol	108-95-2	8270E	ND		0.80	0.50	ug/L	1
Pyrene	129-00-0	8270E	ND		0.20	0.10	ug/L	1
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND		0.80	0.25	ug/L	1
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND		1.6	0.55	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8270E	ND		0.80	0.37	ug/L	1
2,4,5-Trichlorophenol	95-95-4	8270E	ND		0.80	0.50	ug/L	1
2,4,6-Trichlorophenol	88-06-2	8270E	ND		0.80	0.50	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		76	37-129	H	76	37-129
2-Fluorophenol		42	24-127	H	42	24-127
Nitrobenzene-d5		54	38-127	H	74	38-127
Phenol-d5		58	28-128	H	53	28-128
Terphenyl-d14		89	10-148	H	82	10-148
2,4,6-Tribromophenol		101	35-144	H	63	35-144

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1731	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/07/2020 1345	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND	H	2.0	0.40	ug/L	2
Acenaphthylene	208-96-8	8270E	ND	H	2.0	0.40	ug/L	2
Anthracene	120-12-7	8270E	ND	H	2.0	0.60	ug/L	2
Benzo(a)anthracene	56-55-3	8270E	ND	H	2.0	0.40	ug/L	2
Benzo(a)pyrene	50-32-8	8270E	ND	H	2.0	0.70	ug/L	2
Benzo(b)fluoranthene	205-99-2	8270E	ND	H	2.0	0.40	ug/L	2
Benzo(g,h,i)perylene	191-24-2	8270E	ND	H	2.0	0.40	ug/L	2
Benzo(k)fluoranthene	207-08-9	8270E	ND	H	2.0	0.40	ug/L	2
4-Bromophenyl phenyl ether	101-55-3	8270E	ND	H	8.0	5.0	ug/L	2
Butyl benzyl phthalate	85-68-7	8270E	ND	H	8.0	5.0	ug/L	2
Carbazole	86-74-8	8270E	ND	H	8.0	5.0	ug/L	2
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND	H	8.0	5.0	ug/L	2
4-Chloro-3-methyl phenol	59-50-7	8270E	ND	H	8.0	5.0	ug/L	2
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND	H	8.0	5.0	ug/L	2
bis(2-Chloroethyl)ether	111-44-4	8270E	ND	H	8.0	5.0	ug/L	2
2-Chloronaphthalene	91-58-7	8270E	ND	H	8.0	5.0	ug/L	2
2-Chlorophenol	95-57-8	8270E	ND	H	8.0	5.0	ug/L	2
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND	H	8.0	5.0	ug/L	2
Chrysene	218-01-9	8270E	ND	H	2.0	0.30	ug/L	2
Dibenzo(a,h)anthracene	53-70-3	8270E	ND	H	2.0	0.30	ug/L	2
Dibenzofuran	132-64-9	8270E	ND	H	8.0	5.0	ug/L	2
1,2-Dichlorobenzene	95-50-1	8270E	ND	H	8.0	5.0	ug/L	2
1,3-Dichlorobenzene	541-73-1	8270E	ND	H	8.0	5.0	ug/L	2
1,4-Dichlorobenzene	106-46-7	8270E	ND	H	8.0	5.0	ug/L	2
3,3'-Dichlorobenzidine	91-94-1	8270E	ND	H	40	18	ug/L	2
2,4-Dichlorophenol	120-83-2	8270E	ND	H	16	10	ug/L	2
Diethylphthalate	84-66-2	8270E	ND	H	8.0	5.0	ug/L	2
Dimethyl phthalate	131-11-3	8270E	ND	H	8.0	5.0	ug/L	2
2,4-Dimethylphenol	105-67-9	8270E	ND	H	8.0	4.8	ug/L	2
Di-n-butyl phthalate	84-74-2	8270E	ND	H	8.0	5.0	ug/L	2
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND	H	40	10	ug/L	2
2,4-Dinitrophenol	51-28-5	8270E	ND	H	40	10	ug/L	2
2,4-Dinitrotoluene	121-14-2	8270E	ND	H	16	5.0	ug/L	2
2,6-Dinitrotoluene	606-20-2	8270E	ND	H	16	5.0	ug/L	2
Di-n-octylphthalate	117-84-0	8270E	ND	H	8.0	5.0	ug/L	2
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**5.1**	**BHJ**	**40**	**5.0**	**ug/L**	**2**
Fluoranthene	206-44-0	8270E	ND	H	2.0	1.0	ug/L	2
Fluorene	86-73-7	8270E	ND	H	2.0	0.30	ug/L	2
Hexachlorobenzene	118-74-1	8270E	ND	H	8.0	5.0	ug/L	2
Hexachlorobutadiene	87-68-3	8270E	ND	H	8.0	5.0	ug/L	2
Hexachlorocyclopentadiene	77-47-4	8270E	ND	H	40	20	ug/L	2
Hexachloroethane	67-72-1	8270E	ND	H	8.0	3.1	ug/L	2
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND	H	2.0	0.40	ug/L	2

LOQ = Limit of Quantitation
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J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1731	SCD	06/29/2020 1800	58389
2	3520C	8270E	10	07/07/2020 1345	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND	H	8.0	5.0	ug/L	2
2-Methylnaphthalene	91-57-6	8270E	ND	H	2.0	0.40	ug/L	2
2-Methylphenol	95-48-7	8270E	ND	H	8.0	2.1	ug/L	2
3+4-Methylphenol	106-44-5	8270E	ND	H	16	15	ug/L	2
Naphthalene	91-20-3	8270E	ND	H	2.0	0.50	ug/L	2
2-Nitroaniline	88-74-4	8270E	ND	H	16	5.0	ug/L	2
3-Nitroaniline	99-09-2	8270E	ND	H	16	10	ug/L	2
4-Nitroaniline	100-01-6	8270E	ND	H	16	15	ug/L	2
Nitrobenzene	98-95-3	8270E	ND	H	8.0	5.5	ug/L	2
2-Nitrophenol	88-75-5	8270E	ND	H	16	10	ug/L	2
4-Nitrophenol	100-02-7	8270E	ND	H	40	20	ug/L	2
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND	H	8.0	5.0	ug/L	2
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND	H	8.0	5.0	ug/L	2
Pentachlorophenol	87-86-5	8270E	ND	H	40	20	ug/L	2
Phenanthrene	85-01-8	8270E	ND	H	2.0	0.60	ug/L	2
Phenol	108-95-2	8270E	ND	H	8.0	5.0	ug/L	2
Pyrene	129-00-0	8270E	ND	H	2.0	1.0	ug/L	2
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND	H	8.0	2.5	ug/L	2
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND	H	16	5.5	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8270E	ND	H	8.0	3.7	ug/L	2
2,4,5-Trichlorophenol	95-95-4	8270E	ND	H	8.0	5.0	ug/L	2
2,4,6-Trichlorophenol	88-06-2	8270E	ND	H	8.0	5.0	ug/L	2

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		76	37-129	H	76	37-129
2-Fluorophenol		42	24-127	H	42	24-127
Nitrobenzene-d5		54	38-127	H	74	38-127
Phenol-d5		58	28-128	H	53	28-128
Terphenyl-d14		89	10-148	H	82	10-148
2,4,6-Tribromophenol		101	35-144	H	63	35-144

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W = Reported on wet weight basis

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Montana EPH (screening)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/07/2020 1828	JJG	07/06/2020 1615	59047

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TEH		**Montana EPH**	**1900**		**1300**	**1300**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		92	40-140
1-Chloro-octadecane (aliphatic)		90	40-140
2-Fluorobiphenyl (fractionation 1)		92	40-140
o - Terphenyl (aromatic)		70	40-140

LOQ = Limit of Quantitation
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DL = Detection Limit
ND = Not detected at or above the DL
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J = Estimated result < LOQ and ≥ DL
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W = Reported on wet weight basis

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Montana EPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/17/2020 0139	NCM	07/06/2020 1615	59573

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C19 - C36 Aliphatics		Montana EPH	ND		670	670	ug/L	1
C9 - C18 Aliphatics		Montana EPH	ND		670	670	ug/L	1
TEH, post-fractionation	68334-30-5S	Montana EPH	ND		1300	670	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
1-Chloro-octadecane (aliphatic)		70	40-140

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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H = Out of holding time	W = Reported on wet weight basis		

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Montana EPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/17/2020 0439	NCM	07/06/2020 1615	59574

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C11 - C22 Aromatics		Montana EPH	ND		670	670	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		84	40-140
2-Fluorobiphenyl (fractionation 1)		89	40-140
o - Terphenyl (aromatic)		74	40-140

LOQ = Limit of Quantitation
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J = Estimated result < LOQ and ≥ DL
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W = Reported on wet weight basis

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Montana VPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	1	06/30/2020 1501	ECB		58616

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C5 - C8 Aliphatics, Adjusted		**Montana VPH**	**59**	**J**	**75**	**15**	**ug/L**	**2**
C9 - C12 Aliphatics, Adjusted		**Montana VPH**	**120**		**75**	**15**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		93	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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Montana VPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	1	06/30/2020 1501	ECB		58615

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Benzene	**71-43-2**	**Montana VPH**	**3.9**	**J**	**5.0**	**0.51**	**ug/L**	**2**
C9 - C10 Aromatics		**Montana VPH**	**170**		**25**	**5.0**	**ug/L**	**2**
Ethylbenzene	**100-41-4**	**Montana VPH**	**1.9**	**J**	**5.0**	**0.62**	**ug/L**	**2**
Methyl tertiary butyl ether (MTBE)	1634-04-4	Montana VPH	ND		5.0	1.2	ug/L	2
Naphthalene	**91-20-3**	**Montana VPH**	**6.8**		**5.0**	**0.70**	**ug/L**	**2**
Toluene	**108-88-3**	**Montana VPH**	**2.7**	**J**	**5.0**	**0.53**	**ug/L**	**2**
m+p - Xylenes	**179601-23-1**	**Montana VPH**	**7.7**		**5.0**	**1.2**	**ug/L**	**2**
o - Xylenes	**95-47-6**	**Montana VPH**	**6.5**		**5.0**	**0.58**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (PID)		103	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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Montana VPH (TPH)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	1	06/30/2020 1501	ECB		58617

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TPH		**Montana VPH**	**370**		**180**	**35**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		95	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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ICP-MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-003**
Description: **CMR-TW202D-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1317**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7470A	1	06/25/2020 1727	JAB2	06/25/2020 1059	58030
1	3005A	6020B	1	07/02/2020 0108	BPK	07/01/2020 0346	58605
2	3005A	6020B	10	07/02/2020 1556	BPK	07/01/2020 0346	58605

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Antimony	**7440-36-0**	**6020B**	**0.55**	**J**	**2.0**	**0.50**	**ug/L**	**1**
Arsenic	**7440-38-2**	**6020B**	**3.2**		**2.0**	**1.3**	**ug/L**	**1**
Barium	**7440-39-3**	**6020B**	**320**		**50**	**13**	**ug/L**	**2**
Beryllium	7440-41-7	6020B	ND		0.40	0.15	ug/L	1
Cadmium	7440-43-9	6020B	ND		0.50	0.13	ug/L	1
Chromium	7440-47-3	6020B	ND		5.0	1.3	ug/L	1
Cobalt	7440-48-4	6020B	ND		5.0	1.3	ug/L	1
Copper	**7440-50-8**	**6020B**	**2.5**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Lead	7439-92-1	6020B	ND		1.0	0.25	ug/L	1
Mercury	7439-97-6	7470A	ND		0.00020	0.000091	mg/L	1
Nickel	**7440-02-0**	**6020B**	**1.9**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Selenium	**7782-49-2**	**6020B**	**2.5**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Silver	7440-22-4	6020B	ND		1.0	0.25	ug/L	1
Vanadium	**7440-62-2**	**6020B**	**6.7**		**5.0**	**2.5**	**ug/L**	**1**
Zinc	7440-66-6	6020B	ND		10	2.5	ug/L	1

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W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-004**

Description: **CMR-TW202S-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1356**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	5030B	8260D	5	07/01/2020 1639	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	**67-64-1**	**8260D**	**280**		**50**	**20**	**ug/L**	**2**
Benzene	**71-43-2**	**8260D**	**290**		**2.5**	**2.0**	**ug/L**	**2**
Bromochloromethane	74-97-5	8260D	ND		2.5	2.0	ug/L	2
Bromodichloromethane	75-27-4	8260D	ND		2.5	2.0	ug/L	2
Bromoform	75-25-2	8260D	ND		2.5	2.0	ug/L	2
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		2.5	2.0	ug/L	2
2-Butanone (MEK)	**78-93-3**	**8260D**	**87**		**50**	**10**	**ug/L**	**2**
Carbon disulfide	75-15-0	8260D	ND		2.5	2.0	ug/L	2
Carbon tetrachloride	56-23-5	8260D	ND		2.5	2.0	ug/L	2
Chlorobenzene	108-90-7	8260D	ND		2.5	2.0	ug/L	2
Chloroethane	75-00-3	8260D	ND		2.5	2.0	ug/L	2
Chloroform	**67-66-3**	**8260D**	**4.5**		**2.5**	**2.0**	**ug/L**	**2**
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		2.5	2.0	ug/L	2
Cyclohexane	**110-82-7**	**8260D**	**29**		**2.5**	**2.0**	**ug/L**	**2**
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		2.5	2.0	ug/L	2
Dibromochloromethane	124-48-1	8260D	ND		2.5	2.0	ug/L	2
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		2.5	2.0	ug/L	2
1,2-Dichlorobenzene	95-50-1	8260D	ND		2.5	2.0	ug/L	2
1,3-Dichlorobenzene	541-73-1	8260D	ND		2.5	2.0	ug/L	2
1,4-Dichlorobenzene	106-46-7	8260D	ND		2.5	2.0	ug/L	2
Dichlorodifluoromethane	75-71-8	8260D	ND		2.5	2.0	ug/L	2
1,1-Dichloroethane	75-34-3	8260D	ND		2.5	2.0	ug/L	2
1,2-Dichloroethane	107-06-2	8260D	ND		2.5	2.0	ug/L	2
1,1-Dichloroethene	75-35-4	8260D	ND		2.5	2.0	ug/L	2
cis-1,2-Dichloroethene	156-59-2	8260D	ND		2.5	2.0	ug/L	2
trans-1,2-Dichloroethene	156-60-5	8260D	ND		2.5	2.0	ug/L	2
1,2-Dichloropropane	78-87-5	8260D	ND		2.5	2.0	ug/L	2
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		2.5	2.0	ug/L	2
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		2.5	2.0	ug/L	2
1,4-Dioxane	123-91-1	8260D	ND		100	67	ug/L	2
Ethylbenzene	**100-41-4**	**8260D**	**240**		**2.5**	**2.0**	**ug/L**	**2**
2-Hexanone	**591-78-6**	**8260D**	**12**	**J**	**50**	**10**	**ug/L**	**2**
Isopropylbenzene	**98-82-8**	**8260D**	**8.5**		**2.5**	**2.0**	**ug/L**	**2**
Methyl acetate	79-20-9	8260D	ND		5.0	2.0	ug/L	2
Methyl tertiary butyl ether (MTBE)	1634-04-4	8260D	ND		2.5	2.0	ug/L	2
4-Methyl-2-pentanone	**108-10-1**	**8260D**	**19**	**J**	**50**	**10**	**ug/L**	**2**
Methylcyclohexane	**108-87-2**	**8260D**	**16**	**J**	**25**	**2.0**	**ug/L**	**2**
Methylene chloride	75-09-2	8260D	ND		2.5	2.0	ug/L	2
Naphthalene	**91-20-3**	**8260D**	**16**		**2.5**	**2.0**	**ug/L**	**2**
Styrene	100-42-5	8260D	ND		2.5	2.1	ug/L	2
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		2.5	2.0	ug/L	2
Tetrachloroethene	127-18-4	8260D	ND		2.5	2.0	ug/L	2
Toluene	**108-88-3**	**8260D**	**9.3**		**2.5**	**2.0**	**ug/L**	**2**
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		5.0	2.1	ug/L	2

LOQ = Limit of Quantitation
B = Detected in the method blank
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DL = Detection Limit
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P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	5030B	8260D	5	07/01/2020 1639	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		2.5	2.0	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		2.5	2.0	ug/L	2
1,1,1-Trichloroethane	71-55-6	8260D	ND		2.5	2.0	ug/L	2
1,1,2-Trichloroethane	79-00-5	8260D	ND		2.5	2.0	ug/L	2
Trichloroethene	79-01-6	8260D	ND		2.5	2.0	ug/L	2
Trichlorofluoromethane	75-69-4	8260D	ND		2.5	2.0	ug/L	2
Vinyl chloride	75-01-4	8260D	ND		2.5	2.0	ug/L	2
Xylenes (total)	**1330-20-7**	**8260D**	**210**		**5.0**	**2.0**	**ug/L**	**2**
m+p - Xylenes	**179601-23-1**	**8260D**	**200**		**2.5**	**2.0**	**ug/L**	**2**
o - Xylenes	**95-47-6**	**8260D**	**12**		**2.5**	**2.0**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
Bromofluorobenzene		103	70-130
1,2-Dichloroethane-d4		115	70-130
Toluene-d8		104	70-130

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	10	07/01/2020 1500	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1409	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND		2.0	0.40	ug/L	1
Acenaphthylene	208-96-8	8270E	ND		2.0	0.40	ug/L	1
Anthracene	120-12-7	8270E	ND		2.0	0.60	ug/L	1
Benzo(a)anthracene	56-55-3	8270E	ND		2.0	0.40	ug/L	1
Benzo(a)pyrene	50-32-8	8270E	ND		2.0	0.70	ug/L	1
Benzo(b)fluoranthene	205-99-2	8270E	ND		2.0	0.40	ug/L	1
Benzo(g,h,i)perylene	191-24-2	8270E	ND		2.0	0.40	ug/L	1
Benzo(k)fluoranthene	207-08-9	8270E	ND		2.0	0.40	ug/L	1
4-Bromophenyl phenyl ether	101-55-3	8270E	ND		8.0	5.0	ug/L	1
Butyl benzyl phthalate	85-68-7	8270E	ND		8.0	5.0	ug/L	1
Carbazole	86-74-8	8270E	ND		8.0	5.0	ug/L	1
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND		8.0	5.0	ug/L	1
4-Chloro-3-methyl phenol	59-50-7	8270E	ND		8.0	5.0	ug/L	1
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND		8.0	5.0	ug/L	1
bis(2-Chloroethyl)ether	111-44-4	8270E	ND		8.0	5.0	ug/L	1
2-Chloronaphthalene	91-58-7	8270E	ND		8.0	5.0	ug/L	1
2-Chlorophenol	95-57-8	8270E	ND		8.0	5.0	ug/L	1
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND		8.0	5.0	ug/L	1
Chrysene	218-01-9	8270E	ND		2.0	0.30	ug/L	1
Dibenzo(a,h)anthracene	53-70-3	8270E	ND		2.0	0.30	ug/L	1
Dibenzofuran	132-64-9	8270E	ND		8.0	5.0	ug/L	1
1,2-Dichlorobenzene	95-50-1	8270E	ND		8.0	5.0	ug/L	1
1,3-Dichlorobenzene	541-73-1	8270E	ND		8.0	5.0	ug/L	1
1,4-Dichlorobenzene	106-46-7	8270E	ND		8.0	5.0	ug/L	1
3,3'-Dichlorobenzidine	91-94-1	8270E	ND		40	18	ug/L	1
2,4-Dichlorophenol	120-83-2	8270E	ND		16	10	ug/L	1
Diethylphthalate	84-66-2	8270E	ND		8.0	5.0	ug/L	1
Dimethyl phthalate	131-11-3	8270E	ND		8.0	5.0	ug/L	1
2,4-Dimethylphenol	**105-67-9**	**8270E**	**24**		**8.0**	**4.8**	**ug/L**	**1**
Di-n-butyl phthalate	84-74-2	8270E	ND		8.0	5.0	ug/L	1
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND		40	10	ug/L	1
2,4-Dinitrophenol	51-28-5	8270E	ND		40	10	ug/L	1
2,4-Dinitrotoluene	121-14-2	8270E	ND		16	5.0	ug/L	1
2,6-Dinitrotoluene	606-20-2	8270E	ND		16	5.0	ug/L	1
Di-n-octylphthalate	117-84-0	8270E	ND		8.0	5.0	ug/L	1
bis(2-Ethylhexyl)phthalate	117-81-7	8270E	ND		40	5.0	ug/L	1
Fluoranthene	206-44-0	8270E	ND		2.0	1.0	ug/L	1
Fluorene	**86-73-7**	**8270E**	**0.85**	**J**	**2.0**	**0.30**	**ug/L**	**1**
Hexachlorobenzene	118-74-1	8270E	ND		8.0	5.0	ug/L	1
Hexachlorobutadiene	87-68-3	8270E	ND		8.0	5.0	ug/L	1
Hexachlorocyclopentadiene	77-47-4	8270E	ND		40	20	ug/L	1
Hexachloroethane	67-72-1	8270E	ND		8.0	3.1	ug/L	1
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND		2.0	0.40	ug/L	1

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	10	07/01/2020 1500	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1409	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND		8.0	5.0	ug/L	1
2-Methylnaphthalene	**91-57-6**	**8270E**	**4.8**		**2.0**	**0.40**	**ug/L**	**1**
2-Methylphenol	95-48-7	8270E	ND		8.0	2.1	ug/L	1
3+4-Methylphenol	106-44-5	8270E	ND		16	15	ug/L	1
Naphthalene	**91-20-3**	**8270E**	**2.2**	**B**	**2.0**	**0.50**	**ug/L**	**1**
2-Nitroaniline	88-74-4	8270E	ND		16	5.0	ug/L	1
3-Nitroaniline	99-09-2	8270E	ND		16	10	ug/L	1
4-Nitroaniline	100-01-6	8270E	ND		16	15	ug/L	1
Nitrobenzene	98-95-3	8270E	ND		8.0	5.5	ug/L	1
2-Nitrophenol	88-75-5	8270E	ND		16	10	ug/L	1
4-Nitrophenol	100-02-7	8270E	ND		40	20	ug/L	1
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND		8.0	5.0	ug/L	1
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND		8.0	5.0	ug/L	1
Pentachlorophenol	87-86-5	8270E	ND		40	20	ug/L	1
Phenanthrene	85-01-8	8270E	ND		2.0	0.60	ug/L	1
Phenol	108-95-2	8270E	ND		8.0	5.0	ug/L	1
Pyrene	129-00-0	8270E	ND		2.0	1.0	ug/L	1
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND		8.0	2.5	ug/L	1
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND		16	5.5	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8270E	ND		8.0	3.7	ug/L	1
2,4,5-Trichlorophenol	95-95-4	8270E	ND		8.0	5.0	ug/L	1
2,4,6-Trichlorophenol	88-06-2	8270E	ND		8.0	5.0	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		78	37-129	H	72	37-129
2-Fluorophenol		45	24-127	H	37	24-127
Nitrobenzene-d5		70	38-127	H	76	38-127
Phenol-d5		72	28-128	H	52	28-128
Terphenyl-d14		96	10-148	H	89	10-148
2,4,6-Tribromophenol		80	35-144	H	65	35-144

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	10	07/01/2020 1500	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1409	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND	H	0.20	0.040	ug/L	2
Acenaphthylene	208-96-8	8270E	ND	H	0.20	0.040	ug/L	2
Anthracene	120-12-7	8270E	ND	H	0.20	0.060	ug/L	2
Benzo(a)anthracene	56-55-3	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(a)pyrene	50-32-8	8270E	ND	H	0.20	0.070	ug/L	2
Benzo(b)fluoranthene	205-99-2	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(g,h,i)perylene	191-24-2	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(k)fluoranthene	207-08-9	8270E	ND	H	0.20	0.040	ug/L	2
4-Bromophenyl phenyl ether	101-55-3	8270E	ND	H	0.80	0.50	ug/L	2
Butyl benzyl phthalate	85-68-7	8270E	ND	H	0.80	0.50	ug/L	2
Carbazole	86-74-8	8270E	ND	H	0.80	0.50	ug/L	2
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND	H	0.80	0.50	ug/L	2
4-Chloro-3-methyl phenol	59-50-7	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Chloroethyl)ether	111-44-4	8270E	ND	H	0.80	0.50	ug/L	2
2-Chloronaphthalene	91-58-7	8270E	ND	H	0.80	0.50	ug/L	2
2-Chlorophenol	95-57-8	8270E	ND	H	0.80	0.50	ug/L	2
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND	H	0.80	0.50	ug/L	2
Chrysene	218-01-9	8270E	ND	H	0.20	0.030	ug/L	2
Dibenzo(a,h)anthracene	53-70-3	8270E	ND	H	0.20	0.030	ug/L	2
Dibenzofuran	132-64-9	8270E	ND	H	0.80	0.50	ug/L	2
1,2-Dichlorobenzene	95-50-1	8270E	ND	H	0.80	0.50	ug/L	2
1,3-Dichlorobenzene	541-73-1	8270E	ND	H	0.80	0.50	ug/L	2
1,4-Dichlorobenzene	106-46-7	8270E	ND	H	0.80	0.50	ug/L	2
3,3'-Dichlorobenzidine	91-94-1	8270E	ND	H	4.0	1.8	ug/L	2
2,4-Dichlorophenol	120-83-2	8270E	ND	H	1.6	1.0	ug/L	2
Diethylphthalate	84-66-2	8270E	ND	H	0.80	0.50	ug/L	2
Dimethyl phthalate	131-11-3	8270E	ND	H	0.80	0.50	ug/L	2
2,4-Dimethylphenol	105-67-9	8270E	ND	H	0.80	0.48	ug/L	2
Di-n-butyl phthalate	**84-74-2**	**8270E**	**0.78**	**HJ**	**0.80**	**0.50**	**ug/L**	**2**
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND	H	4.0	1.0	ug/L	2
2,4-Dinitrophenol	51-28-5	8270E	ND	H	4.0	1.0	ug/L	2
2,4-Dinitrotoluene	121-14-2	8270E	ND	H	1.6	0.50	ug/L	2
2,6-Dinitrotoluene	606-20-2	8270E	ND	H	1.6	0.50	ug/L	2
Di-n-octylphthalate	117-84-0	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**2.5**	**BHJ**	**4.0**	**0.50**	**ug/L**	**2**
Fluoranthene	206-44-0	8270E	ND	H	0.20	0.10	ug/L	2
Fluorene	86-73-7	8270E	ND	H	0.20	0.030	ug/L	2
Hexachlorobenzene	118-74-1	8270E	ND	H	0.80	0.50	ug/L	2
Hexachlorobutadiene	87-68-3	8270E	ND	H	0.80	0.50	ug/L	2
Hexachlorocyclopentadiene	77-47-4	8270E	ND	H	4.0	2.0	ug/L	2
Hexachloroethane	67-72-1	8270E	ND	H	0.80	0.31	ug/L	2
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND	H	0.20	0.040	ug/L	2

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	10	07/01/2020 1500	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1409	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND	H	0.80	0.50	ug/L	2
2-Methylnaphthalene	91-57-6	8270E	ND	H	0.20	0.040	ug/L	2
2-Methylphenol	95-48-7	8270E	ND	H	0.80	0.21	ug/L	2
3+4-Methylphenol	106-44-5	8270E	ND	H	1.6	1.5	ug/L	2
Naphthalene	91-20-3	8270E	ND	H	0.20	0.050	ug/L	2
2-Nitroaniline	88-74-4	8270E	ND	H	1.6	0.50	ug/L	2
3-Nitroaniline	99-09-2	8270E	ND	H	1.6	1.0	ug/L	2
4-Nitroaniline	100-01-6	8270E	ND	H	1.6	1.5	ug/L	2
Nitrobenzene	98-95-3	8270E	ND	H	0.80	0.55	ug/L	2
2-Nitrophenol	88-75-5	8270E	ND	H	1.6	1.0	ug/L	2
4-Nitrophenol	100-02-7	8270E	ND	H	4.0	2.0	ug/L	2
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND	H	0.80	0.50	ug/L	2
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND	H	0.80	0.50	ug/L	2
Pentachlorophenol	87-86-5	8270E	ND	H	4.0	2.0	ug/L	2
Phenanthrene	85-01-8	8270E	ND	H	0.20	0.060	ug/L	2
Phenol	108-95-2	8270E	ND	H	0.80	0.50	ug/L	2
Pyrene	129-00-0	8270E	ND	H	0.20	0.10	ug/L	2
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND	H	0.80	0.25	ug/L	2
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND	H	1.6	0.55	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8270E	ND	H	0.80	0.37	ug/L	2
2,4,5-Trichlorophenol	95-95-4	8270E	ND	H	0.80	0.50	ug/L	2
2,4,6-Trichlorophenol	88-06-2	8270E	ND	H	0.80	0.50	ug/L	2

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		78	37-129	H	72	37-129
2-Fluorophenol		45	24-127	H	37	24-127
Nitrobenzene-d5		70	38-127	H	76	38-127
Phenol-d5		72	28-128	H	52	28-128
Terphenyl-d14		96	10-148	H	89	10-148
2,4,6-Tribromophenol		80	35-144	H	65	35-144

LOQ = Limit of Quantitation
B = Detected in the method blank
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DL = Detection Limit
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P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Montana VPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	5	06/30/2020 1627	ECB		58616

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C5 - C8 Aliphatics, Adjusted		**Montana VPH**	**760**		**380**	**75**	**ug/L**	**2**
C9 - C12 Aliphatics, Adjusted		**Montana VPH**	**630**		**380**	**75**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		104	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL
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Montana VPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	5	06/30/2020 1627	ECB		58615

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Benzene	**71-43-2**	**Montana VPH**	**290**		**25**	**2.6**	**ug/L**	**2**
C9 - C10 Aromatics		**Montana VPH**	**1400**		**130**	**25**	**ug/L**	**2**
Ethylbenzene	**100-41-4**	**Montana VPH**	**260**		**25**	**3.1**	**ug/L**	**2**
Methyl tertiary butyl ether (MTBE)	1634-04-4	Montana VPH	ND		25	6.0	ug/L	2
Naphthalene	**91-20-3**	**Montana VPH**	**27**		**25**	**3.5**	**ug/L**	**2**
Toluene	**108-88-3**	**Montana VPH**	**14**	**J**	**25**	**2.7**	**ug/L**	**2**
m+p - Xylenes	**179601-23-1**	**Montana VPH**	**220**		**25**	**6.0**	**ug/L**	**2**
o - Xylenes	**95-47-6**	**Montana VPH**	**15**	**J**	**25**	**2.9**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (PID)		105	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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Montana VPH (TPH)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	5	06/30/2020 1627	ECB		58617

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TPH		**Montana VPH**	**3500**		**880**	**180**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		103	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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CVAA

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7470A	1	07/02/2020 1509	JMH	07/02/2020 1122	58789

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Dissolved Mercury	7439-97-6	7470A	ND		0.00020	0.000091	mg/L	1

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ICP-MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-004**
Description: **CMR-TW202S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1356**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3005A	6020B	1	07/02/2020 1025	BNW	07/01/2020 1647	58723

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Dissolved Antimony	**7440-36-0**	**6020B**	**1.1**	**J**	**2.0**	**0.50**	**ug/L**	**1**
Dissolved Arsenic	**7440-38-2**	**6020B**	**1.8**	**J**	**2.0**	**1.3**	**ug/L**	**1**
Dissolved Barium	**7440-39-3**	**6020B**	**190**		**5.0**	**1.3**	**ug/L**	**1**
Dissolved Beryllium	7440-41-7	6020B	ND		0.40	0.15	ug/L	1
Dissolved Cadmium	7440-43-9	6020B	ND		0.50	0.13	ug/L	1
Dissolved Chromium	7440-47-3	6020B	ND		5.0	1.3	ug/L	1
Dissolved Cobalt	7440-48-4	6020B	ND		5.0	1.3	ug/L	1
Dissolved Copper	**7440-50-8**	**6020B**	**3.5**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Dissolved Lead	**7439-92-1**	**6020B**	**0.36**	**J**	**1.0**	**0.25**	**ug/L**	**1**
Dissolved Nickel	**7440-02-0**	**6020B**	**3.0**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Dissolved Selenium	**7782-49-2**	**6020B**	**3.3**	**J**	**5.0**	**1.3**	**ug/L**	**1**
Dissolved Silver	7440-22-4	6020B	ND		1.0	0.25	ug/L	1
Dissolved Vanadium	**7440-62-2**	**6020B**	**2.8**	**J**	**5.0**	**2.5**	**ug/L**	**1**
Dissolved Zinc	**7440-66-6**	**6020B**	**4.8**	**J**	**10**	**2.5**	**ug/L**	**1**

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** | Laboratory ID: **VF24007-005**

Description: **CMR-MW59S-200622** | Matrix: **Aqueous**

Date Sampled: **06/22/2020 1508**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	1	06/27/2020 0232	JTH		58271
2	5030B	8260D	1	07/01/2020 1241	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	**67-64-1**	**8260D**	**6.4**	**J**	**10**	**4.0**	**ug/L**	**2**
Benzene	71-43-2	8260D	ND		0.50	0.40	ug/L	1
Bromochloromethane	74-97-5	8260D	ND		0.50	0.40	ug/L	1
Bromodichloromethane	75-27-4	8260D	ND		0.50	0.40	ug/L	1
Bromoform	75-25-2	8260D	ND		0.50	0.40	ug/L	1
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		0.50	0.40	ug/L	1
2-Butanone (MEK)	78-93-3	8260D	ND		10	2.0	ug/L	1
Carbon disulfide	75-15-0	8260D	ND		0.50	0.40	ug/L	1
Carbon tetrachloride	56-23-5	8260D	ND		0.50	0.40	ug/L	1
Chlorobenzene	108-90-7	8260D	ND		0.50	0.40	ug/L	1
Chloroethane	75-00-3	8260D	ND		0.50	0.40	ug/L	1
Chloroform	67-66-3	8260D	ND		0.50	0.40	ug/L	1
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		0.50	0.40	ug/L	1
Cyclohexane	110-82-7	8260D	ND		0.50	0.40	ug/L	1
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		0.50	0.40	ug/L	1
Dibromochloromethane	124-48-1	8260D	ND		0.50	0.40	ug/L	1
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichlorobenzene	95-50-1	8260D	ND		0.50	0.40	ug/L	1
1,3-Dichlorobenzene	541-73-1	8260D	ND		0.50	0.40	ug/L	1
1,4-Dichlorobenzene	106-46-7	8260D	ND		0.50	0.40	ug/L	1
Dichlorodifluoromethane	75-71-8	8260D	ND		0.50	0.40	ug/L	1
1,1-Dichloroethane	75-34-3	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichloroethane	107-06-2	8260D	ND		0.50	0.40	ug/L	1
1,1-Dichloroethene	75-35-4	8260D	ND		0.50	0.40	ug/L	1
cis-1,2-Dichloroethene	156-59-2	8260D	ND		0.50	0.40	ug/L	1
trans-1,2-Dichloroethene	156-60-5	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichloropropane	78-87-5	8260D	ND		0.50	0.40	ug/L	1
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		0.50	0.40	ug/L	1
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		0.50	0.40	ug/L	1
1,4-Dioxane	123-91-1	8260D	ND		20	13	ug/L	2
Ethylbenzene	100-41-4	8260D	ND		0.50	0.40	ug/L	1
2-Hexanone	591-78-6	8260D	ND		10	2.0	ug/L	1
Isopropylbenzene	98-82-8	8260D	ND		0.50	0.40	ug/L	1
Methyl acetate	79-20-9	8260D	ND		1.0	0.40	ug/L	1
Methyl tertiary butyl ether (MTBE)	1634-04-4	8260D	ND		0.50	0.40	ug/L	1
4-Methyl-2-pentanone	108-10-1	8260D	ND		10	2.0	ug/L	1
Methylcyclohexane	108-87-2	8260D	ND		5.0	0.40	ug/L	1
Methylene chloride	75-09-2	8260D	ND		0.50	0.40	ug/L	1
Naphthalene	91-20-3	8260D	ND		0.50	0.40	ug/L	1
Styrene	100-42-5	8260D	ND		0.50	0.41	ug/L	1
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		0.50	0.40	ug/L	1
Tetrachloroethene	127-18-4	8260D	ND		0.50	0.40	ug/L	1
Toluene	108-88-3	8260D	ND		0.50	0.40	ug/L	1

LOQ = Limit of Quantitation | B = Detected in the method blank | E = Quantitation of compound exceeded the calibration range | DL = Detection Limit

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H = Out of holding time | W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	1	06/27/2020 0232	JTH		58271
2	5030B	8260D	1	07/01/2020 1241	TML		58687

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		1.0	0.42	ug/L	1
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		0.50	0.40	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		0.50	0.40	ug/L	1
1,1,1-Trichloroethane	71-55-6	8260D	ND		0.50	0.40	ug/L	1
1,1,2-Trichloroethane	79-00-5	8260D	ND		0.50	0.40	ug/L	1
Trichloroethene	79-01-6	8260D	ND		0.50	0.40	ug/L	1
Trichlorofluoromethane	75-69-4	8260D	ND		0.50	0.40	ug/L	1
Vinyl chloride	75-01-4	8260D	ND		0.50	0.40	ug/L	1
Xylenes (total)	1330-20-7	8260D	ND		1.0	0.40	ug/L	1
m+p - Xylenes	179601-23-1	8260D	ND		0.50	0.40	ug/L	1
o - Xylenes	95-47-6	8260D	ND		0.50	0.40	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
Bromofluorobenzene		105	70-130		98	70-130
1,2-Dichloroethane-d4		87	70-130		111	70-130
Toluene-d8		103	70-130		103	70-130

LOQ = Limit of Quantitation
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J = Estimated result < LOQ and ≥ DL
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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-005**

Description: **CMR-MW59S-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1508**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1757	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1458	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND		0.20	0.040	ug/L	1
Acenaphthylene	208-96-8	8270E	ND		0.20	0.040	ug/L	1
Anthracene	120-12-7	8270E	ND		0.20	0.060	ug/L	1
Benzo(a)anthracene	56-55-3	8270E	ND		0.20	0.040	ug/L	1
Benzo(a)pyrene	50-32-8	8270E	ND		0.20	0.070	ug/L	1
Benzo(b)fluoranthene	205-99-2	8270E	ND		0.20	0.040	ug/L	1
Benzo(g,h,i)perylene	191-24-2	8270E	ND		0.20	0.040	ug/L	1
Benzo(k)fluoranthene	207-08-9	8270E	ND		0.20	0.040	ug/L	1
4-Bromophenyl phenyl ether	101-55-3	8270E	ND		0.80	0.50	ug/L	1
Butyl benzyl phthalate	85-68-7	8270E	ND		0.80	0.50	ug/L	1
Carbazole	86-74-8	8270E	ND		0.80	0.50	ug/L	1
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND		0.80	0.50	ug/L	1
4-Chloro-3-methyl phenol	59-50-7	8270E	ND		0.80	0.50	ug/L	1
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND		0.80	0.50	ug/L	1
bis(2-Chloroethyl)ether	111-44-4	8270E	ND		0.80	0.50	ug/L	1
2-Chloronaphthalene	91-58-7	8270E	ND		0.80	0.50	ug/L	1
2-Chlorophenol	95-57-8	8270E	ND		0.80	0.50	ug/L	1
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND		0.80	0.50	ug/L	1
Chrysene	218-01-9	8270E	ND		0.20	0.030	ug/L	1
Dibenzo(a,h)anthracene	53-70-3	8270E	ND		0.20	0.030	ug/L	1
Dibenzofuran	132-64-9	8270E	ND		0.80	0.50	ug/L	1
1,2-Dichlorobenzene	95-50-1	8270E	ND		0.80	0.50	ug/L	1
1,3-Dichlorobenzene	541-73-1	8270E	ND		0.80	0.50	ug/L	1
1,4-Dichlorobenzene	106-46-7	8270E	ND		0.80	0.50	ug/L	1
3,3'-Dichlorobenzidine	91-94-1	8270E	ND		4.0	1.8	ug/L	1
2,4-Dichlorophenol	120-83-2	8270E	ND		1.6	1.0	ug/L	1
Diethylphthalate	84-66-2	8270E	ND		0.80	0.50	ug/L	1
Dimethyl phthalate	131-11-3	8270E	ND		0.80	0.50	ug/L	1
2,4-Dimethylphenol	105-67-9	8270E	ND		0.80	0.48	ug/L	1
Di-n-butyl phthalate	**84-74-2**	**8270E**	**0.83**	**B**	**0.80**	**0.50**	**ug/L**	**1**
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND		4.0	1.0	ug/L	1
2,4-Dinitrophenol	51-28-5	8270E	ND		4.0	1.0	ug/L	1
2,4-Dinitrotoluene	121-14-2	8270E	ND		1.6	0.50	ug/L	1
2,6-Dinitrotoluene	606-20-2	8270E	ND		1.6	0.50	ug/L	1
Di-n-octylphthalate	117-84-0	8270E	ND		0.80	0.50	ug/L	1
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**2.6**	**BJ**	**4.0**	**0.50**	**ug/L**	**1**
Fluoranthene	206-44-0	8270E	ND		0.20	0.10	ug/L	1
Fluorene	86-73-7	8270E	ND		0.20	0.030	ug/L	1
Hexachlorobenzene	118-74-1	8270E	ND		0.80	0.50	ug/L	1
Hexachlorobutadiene	87-68-3	8270E	ND		0.80	0.50	ug/L	1
Hexachlorocyclopentadiene	77-47-4	8270E	ND		4.0	2.0	ug/L	1
Hexachloroethane	67-72-1	8270E	ND		0.80	0.31	ug/L	1
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND		0.20	0.040	ug/L	1

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W = Reported on wet weight basis

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** | Laboratory ID: **VF24007-005**

Description: **CMR-MW59S-200622** | Matrix: **Aqueous**

Date Sampled: **06/22/2020 1508**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1757	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1458	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND		0.80	0.50	ug/L	1
2-Methylnaphthalene	**91-57-6**	**8270E**	**0.047**	**J**	**0.20**	**0.040**	**ug/L**	**1**
2-Methylphenol	95-48-7	8270E	ND		0.80	0.21	ug/L	1
3+4-Methylphenol	106-44-5	8270E	ND		1.6	1.5	ug/L	1
Naphthalene	**91-20-3**	**8270E**	**0.074**	**BJ**	**0.20**	**0.050**	**ug/L**	**1**
2-Nitroaniline	88-74-4	8270E	ND		1.6	0.50	ug/L	1
3-Nitroaniline	99-09-2	8270E	ND		1.6	1.0	ug/L	1
4-Nitroaniline	100-01-6	8270E	ND		1.6	1.5	ug/L	1
Nitrobenzene	98-95-3	8270E	ND		0.80	0.55	ug/L	1
2-Nitrophenol	88-75-5	8270E	ND		1.6	1.0	ug/L	1
4-Nitrophenol	100-02-7	8270E	ND		4.0	2.0	ug/L	1
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND		0.80	0.50	ug/L	1
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND		0.80	0.50	ug/L	1
Pentachlorophenol	87-86-5	8270E	ND		4.0	2.0	ug/L	1
Phenanthrene	85-01-8	8270E	ND		0.20	0.060	ug/L	1
Phenol	108-95-2	8270E	ND		0.80	0.50	ug/L	1
Pyrene	129-00-0	8270E	ND		0.20	0.10	ug/L	1
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND		0.80	0.25	ug/L	1
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND		1.6	0.55	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8270E	ND		0.80	0.37	ug/L	1
2,4,5-Trichlorophenol	95-95-4	8270E	ND		0.80	0.50	ug/L	1
2,4,6-Trichlorophenol	88-06-2	8270E	ND		0.80	0.50	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		73	37-129	H	67	37-129
2-Fluorophenol		40	24-127	H	31	24-127
Nitrobenzene-d5		60	38-127	H	71	38-127
Phenol-d5		48	28-128	H	51	28-128
Terphenyl-d14		91	10-148	H	80	10-148
2,4,6-Tribromophenol		88	35-144	H	73	35-144

LOQ = Limit of Quantitation | B = Detected in the method blank | E = Quantitation of compound exceeded the calibration range | DL = Detection Limit

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

H = Out of holding time | W = Reported on wet weight basis

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** Laboratory ID: **VF24007-005**

Description: **CMR-MW59S-200622** Matrix: **Aqueous**

Date Sampled: **06/22/2020 1508**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1757	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1458	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND	H	0.20	0.040	ug/L	2
Acenaphthylene	208-96-8	8270E	ND	H	0.20	0.040	ug/L	2
Anthracene	120-12-7	8270E	ND	H	0.20	0.060	ug/L	2
Benzo(a)anthracene	56-55-3	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(a)pyrene	50-32-8	8270E	ND	H	0.20	0.070	ug/L	2
Benzo(b)fluoranthene	205-99-2	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(g,h,i)perylene	191-24-2	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(k)fluoranthene	207-08-9	8270E	ND	H	0.20	0.040	ug/L	2
4-Bromophenyl phenyl ether	101-55-3	8270E	ND	H	0.80	0.50	ug/L	2
Butyl benzyl phthalate	85-68-7	8270E	ND	H	0.80	0.50	ug/L	2
Carbazole	86-74-8	8270E	ND	H	0.80	0.50	ug/L	2
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND	H	0.80	0.50	ug/L	2
4-Chloro-3-methyl phenol	59-50-7	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Chloroethyl)ether	111-44-4	8270E	ND	H	0.80	0.50	ug/L	2
2-Chloronaphthalene	91-58-7	8270E	ND	H	0.80	0.50	ug/L	2
2-Chlorophenol	95-57-8	8270E	ND	H	0.80	0.50	ug/L	2
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND	H	0.80	0.50	ug/L	2
Chrysene	218-01-9	8270E	ND	H	0.20	0.030	ug/L	2
Dibenzo(a,h)anthracene	53-70-3	8270E	ND	H	0.20	0.030	ug/L	2
Dibenzofuran	132-64-9	8270E	ND	H	0.80	0.50	ug/L	2
1,2-Dichlorobenzene	95-50-1	8270E	ND	H	0.80	0.50	ug/L	2
1,3-Dichlorobenzene	541-73-1	8270E	ND	H	0.80	0.50	ug/L	2
1,4-Dichlorobenzene	106-46-7	8270E	ND	H	0.80	0.50	ug/L	2
3,3'-Dichlorobenzidine	91-94-1	8270E	ND	H	4.0	1.8	ug/L	2
2,4-Dichlorophenol	120-83-2	8270E	ND	H	1.6	1.0	ug/L	2
Diethylphthalate	84-66-2	8270E	ND	H	0.80	0.50	ug/L	2
Dimethyl phthalate	131-11-3	8270E	ND	H	0.80	0.50	ug/L	2
2,4-Dimethylphenol	105-67-9	8270E	ND	H	0.80	0.48	ug/L	2
Di-n-butyl phthalate	84-74-2	8270E	ND	H	0.80	0.50	ug/L	2
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND	H	4.0	1.0	ug/L	2
2,4-Dinitrophenol	51-28-5	8270E	ND	H	4.0	1.0	ug/L	2
2,4-Dinitrotoluene	121-14-2	8270E	ND	H	1.6	0.50	ug/L	2
2,6-Dinitrotoluene	606-20-2	8270E	ND	H	1.6	0.50	ug/L	2
Di-n-octylphthalate	117-84-0	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**7.6**	**BH**	**4.0**	**0.50**	**ug/L**	**2**
Fluoranthene	206-44-0	8270E	ND	H	0.20	0.10	ug/L	2
Fluorene	86-73-7	8270E	ND	H	0.20	0.030	ug/L	2
Hexachlorobenzene	118-74-1	8270E	ND	H	0.80	0.50	ug/L	2
Hexachlorobutadiene	87-68-3	8270E	ND	H	0.80	0.50	ug/L	2
Hexachlorocyclopentadiene	77-47-4	8270E	ND	H	4.0	2.0	ug/L	2
Hexachloroethane	67-72-1	8270E	ND	H	0.80	0.31	ug/L	2
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND	H	0.20	0.040	ug/L	2

LOQ = Limit of Quantitation
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
DL = Detection Limit
ND = Not detected at or above the DL
N = Recovery is out of criteria
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
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W = Reported on wet weight basis

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	1	07/01/2020 1757	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1458	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND	H	0.80	0.50	ug/L	2
2-Methylnaphthalene	91-57-6	8270E	ND	H	0.20	0.040	ug/L	2
2-Methylphenol	95-48-7	8270E	ND	H	0.80	0.21	ug/L	2
3+4-Methylphenol	106-44-5	8270E	ND	H	1.6	1.5	ug/L	2
Naphthalene	91-20-3	8270E	ND	H	0.20	0.050	ug/L	2
2-Nitroaniline	88-74-4	8270E	ND	H	1.6	0.50	ug/L	2
3-Nitroaniline	99-09-2	8270E	ND	H	1.6	1.0	ug/L	2
4-Nitroaniline	100-01-6	8270E	ND	H	1.6	1.5	ug/L	2
Nitrobenzene	98-95-3	8270E	ND	H	0.80	0.55	ug/L	2
2-Nitrophenol	88-75-5	8270E	ND	H	1.6	1.0	ug/L	2
4-Nitrophenol	100-02-7	8270E	ND	H	4.0	2.0	ug/L	2
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND	H	0.80	0.50	ug/L	2
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND	H	0.80	0.50	ug/L	2
Pentachlorophenol	87-86-5	8270E	ND	H	4.0	2.0	ug/L	2
Phenanthrene	85-01-8	8270E	ND	H	0.20	0.060	ug/L	2
Phenol	108-95-2	8270E	ND	H	0.80	0.50	ug/L	2
Pyrene	129-00-0	8270E	ND	H	0.20	0.10	ug/L	2
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND	H	0.80	0.25	ug/L	2
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND	H	1.6	0.55	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8270E	ND	H	0.80	0.37	ug/L	2
2,4,5-Trichlorophenol	95-95-4	8270E	ND	H	0.80	0.50	ug/L	2
2,4,6-Trichlorophenol	88-06-2	8270E	ND	H	0.80	0.50	ug/L	2

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		73	37-129	H	67	37-129
2-Fluorophenol		40	24-127	H	31	24-127
Nitrobenzene-d5		60	38-127	H	71	38-127
Phenol-d5		48	28-128	H	51	28-128
Terphenyl-d14		91	10-148	H	80	10-148
2,4,6-Tribromophenol		88	35-144	H	73	35-144

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Montana EPH (screening)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	Montana EPH	Montana EPH	1	07/08/2020 1911	JJG	07/06/2020 1615	59047

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TEH		**Montana EPH**	**270**		**210**	**210**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		73	40-140
1-Chloro-octadecane (aliphatic)		57	40-140
2-Fluorobiphenyl (fractionation 1)		80	40-140
o - Terphenyl (aromatic)		65	40-140

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Montana VPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	1	06/30/2020 1529	ECB		58616

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C5 - C8 Aliphatics, Adjusted		**Montana VPH**	**29**	**J**	**75**	**15**	**ug/L**	**2**
C9 - C12 Aliphatics, Adjusted		Montana VPH	ND		75	15	ug/L	2

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		114	70-130

LOQ = Limit of Quantitation
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Montana VPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	1	06/30/2020 1529	ECB		58615

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Benzene	71-43-2	Montana VPH	ND		5.0	0.51	ug/L	2
C9 - C10 Aromatics		Montana VPH	ND		25	5.0	ug/L	2
Ethylbenzene	100-41-4	Montana VPH	ND		5.0	0.62	ug/L	2
Methyl tertiary butyl ether (MTBE)	1634-04-4	Montana VPH	ND		5.0	1.2	ug/L	2
Naphthalene	91-20-3	Montana VPH	ND		5.0	0.70	ug/L	2
Toluene	108-88-3	Montana VPH	ND		5.0	0.53	ug/L	2
m+p - Xylenes	179601-23-1	Montana VPH	ND		5.0	1.2	ug/L	2
o - Xylenes	95-47-6	Montana VPH	ND		5.0	0.58	ug/L	2

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (PID)		112	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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Montana VPH (TPH)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	1	06/30/2020 1529	ECB		58617

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TPH		Montana VPH	ND		180	35	ug/L	2

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		112	70-130

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ICP-MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-005**
Description: **CMR-MW59S-200622**
Matrix: **Aqueous**
Date Sampled: **06/22/2020 1508**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7470A	1	06/25/2020 1730	JAB2	06/25/2020 1059	58030
1	3005A	6020B	1	07/02/2020 0115	BPK	07/01/2020 0346	58605

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Antimony	**7440-36-0**	**6020B**	**1.8**	**J**	**2.0**	**0.50**	**ug/L**	**1**
Arsenic	**7440-38-2**	**6020B**	**27**		**2.0**	**1.3**	**ug/L**	**1**
Barium	**7440-39-3**	**6020B**	**55**		**5.0**	**1.3**	**ug/L**	**1**
Beryllium	7440-41-7	6020B	ND		0.40	0.15	ug/L	1
Cadmium	**7440-43-9**	**6020B**	**0.49**	**J**	**0.50**	**0.13**	**ug/L**	**1**
Chromium	7440-47-3	6020B	ND		5.0	1.3	ug/L	1
Cobalt	**7440-48-4**	**6020B**	**7.1**		**5.0**	**1.3**	**ug/L**	**1**
Copper	**7440-50-8**	**6020B**	**61**		**5.0**	**1.3**	**ug/L**	**1**
Lead	**7439-92-1**	**6020B**	**0.50**	**J**	**1.0**	**0.25**	**ug/L**	**1**
Mercury	7439-97-6	7470A	ND		0.00020	0.000091	mg/L	1
Nickel	**7440-02-0**	**6020B**	**12**		**5.0**	**1.3**	**ug/L**	**1**
Selenium	7782-49-2	6020B	ND		5.0	1.3	ug/L	1
Silver	7440-22-4	6020B	ND		1.0	0.25	ug/L	1
Vanadium	7440-62-2	6020B	ND		5.0	2.5	ug/L	1
Zinc	**7440-66-6**	**6020B**	**79**		**10**	**2.5**	**ug/L**	**1**

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W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	100	06/27/2020 0444	JTH		58271

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	67-64-1	8260D	ND		1000	400	ug/L	1
Benzene	**71-43-2**	**8260D**	**5800**		**50**	**40**	**ug/L**	**1**
Bromochloromethane	74-97-5	8260D	ND		50	40	ug/L	1
Bromodichloromethane	75-27-4	8260D	ND		50	40	ug/L	1
Bromoform	75-25-2	8260D	ND		50	40	ug/L	1
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		50	40	ug/L	1
2-Butanone (MEK)	78-93-3	8260D	ND		1000	200	ug/L	1
Carbon disulfide	75-15-0	8260D	ND		50	40	ug/L	1
Carbon tetrachloride	56-23-5	8260D	ND		50	40	ug/L	1
Chlorobenzene	108-90-7	8260D	ND		50	40	ug/L	1
Chloroethane	75-00-3	8260D	ND		50	40	ug/L	1
Chloroform	67-66-3	8260D	ND		50	40	ug/L	1
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		50	40	ug/L	1
Cyclohexane	**110-82-7**	**8260D**	**320**		**50**	**40**	**ug/L**	**1**
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		50	40	ug/L	1
Dibromochloromethane	124-48-1	8260D	ND		50	40	ug/L	1
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		50	40	ug/L	1
1,2-Dichlorobenzene	95-50-1	8260D	ND		50	40	ug/L	1
1,3-Dichlorobenzene	541-73-1	8260D	ND		50	40	ug/L	1
1,4-Dichlorobenzene	106-46-7	8260D	ND		50	40	ug/L	1
Dichlorodifluoromethane	75-71-8	8260D	ND		50	40	ug/L	1
1,1-Dichloroethane	75-34-3	8260D	ND		50	40	ug/L	1
1,2-Dichloroethane	107-06-2	8260D	ND		50	40	ug/L	1
1,1-Dichloroethene	75-35-4	8260D	ND		50	40	ug/L	1
cis-1,2-Dichloroethene	156-59-2	8260D	ND		50	40	ug/L	1
trans-1,2-Dichloroethene	156-60-5	8260D	ND		50	40	ug/L	1
1,2-Dichloropropane	78-87-5	8260D	ND		50	40	ug/L	1
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		50	40	ug/L	1
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		50	40	ug/L	1
1,4-Dioxane	123-91-1	8260D	ND		2000	1300	ug/L	1
Ethylbenzene	**100-41-4**	**8260D**	**860**		**50**	**40**	**ug/L**	**1**
2-Hexanone	591-78-6	8260D	ND		1000	200	ug/L	1
Isopropylbenzene	**98-82-8**	**8260D**	**61**		**50**	**40**	**ug/L**	**1**
Methyl acetate	79-20-9	8260D	ND		100	40	ug/L	1
Methyl tertiary butyl ether (MTBE)	1634-04-4	8260D	ND		50	40	ug/L	1
4-Methyl-2-pentanone	108-10-1	8260D	ND		1000	200	ug/L	1
Methylcyclohexane	**108-87-2**	**8260D**	**170**	**J**	**500**	**40**	**ug/L**	**1**
Methylene chloride	75-09-2	8260D	ND		50	40	ug/L	1
Naphthalene	**91-20-3**	**8260D**	**160**		**50**	**40**	**ug/L**	**1**
Styrene	100-42-5	8260D	ND		50	41	ug/L	1
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		50	40	ug/L	1
Tetrachloroethene	127-18-4	8260D	ND		50	40	ug/L	1
Toluene	**108-88-3**	**8260D**	**680**		**50**	**40**	**ug/L**	**1**
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		100	42	ug/L	1

LOQ = Limit of Quantitation
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
DL = Detection Limit
ND = Not detected at or above the DL
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P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
H = Out of holding time
W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	100	06/27/2020 0444	JTH		58271

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		50	40	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		50	40	ug/L	1
1,1,1-Trichloroethane	71-55-6	8260D	ND		50	40	ug/L	1
1,1,2-Trichloroethane	79-00-5	8260D	ND		50	40	ug/L	1
Trichloroethene	79-01-6	8260D	ND		50	40	ug/L	1
Trichlorofluoromethane	75-69-4	8260D	ND		50	40	ug/L	1
Vinyl chloride	75-01-4	8260D	ND		50	40	ug/L	1
Xylenes (total)	**1330-20-7**	**8260D**	**770**		**100**	**40**	**ug/L**	**1**
m+p - Xylenes	**179601-23-1**	**8260D**	**630**		**50**	**40**	**ug/L**	**1**
o - Xylenes	**95-47-6**	**8260D**	**150**		**50**	**40**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
Bromofluorobenzene		104	70-130
1,2-Dichloroethane-d4		87	70-130
Toluene-d8		101	70-130

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** | Laboratory ID: **VF24007-006**

Description: **CMR-MW56S-200623** | Matrix: **Aqueous**

Date Sampled: **06/23/2020 0920**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	5	07/01/2020 1822	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1434	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	**83-32-9**	**8270E**	**0.43**	**J**	**1.0**	**0.20**	**ug/L**	**1**
Acenaphthylene	208-96-8	8270E	ND		1.0	0.20	ug/L	1
Anthracene	120-12-7	8270E	ND		1.0	0.30	ug/L	1
Benzo(a)anthracene	56-55-3	8270E	ND		1.0	0.20	ug/L	1
Benzo(a)pyrene	50-32-8	8270E	ND		1.0	0.35	ug/L	1
Benzo(b)fluoranthene	205-99-2	8270E	ND		1.0	0.20	ug/L	1
Benzo(g,h,i)perylene	191-24-2	8270E	ND		1.0	0.20	ug/L	1
Benzo(k)fluoranthene	207-08-9	8270E	ND		1.0	0.20	ug/L	1
4-Bromophenyl phenyl ether	101-55-3	8270E	ND		4.0	2.5	ug/L	1
Butyl benzyl phthalate	85-68-7	8270E	ND		4.0	2.5	ug/L	1
Carbazole	86-74-8	8270E	ND		4.0	2.5	ug/L	1
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND		4.0	2.5	ug/L	1
4-Chloro-3-methyl phenol	59-50-7	8270E	ND		4.0	2.5	ug/L	1
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND		4.0	2.5	ug/L	1
bis(2-Chloroethyl)ether	111-44-4	8270E	ND		4.0	2.5	ug/L	1
2-Chloronaphthalene	91-58-7	8270E	ND		4.0	2.5	ug/L	1
2-Chlorophenol	95-57-8	8270E	ND		4.0	2.5	ug/L	1
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND		4.0	2.5	ug/L	1
Chrysene	218-01-9	8270E	ND		1.0	0.15	ug/L	1
Dibenzo(a,h)anthracene	53-70-3	8270E	ND		1.0	0.15	ug/L	1
Dibenzofuran	132-64-9	8270E	ND		4.0	2.5	ug/L	1
1,2-Dichlorobenzene	95-50-1	8270E	ND		4.0	2.5	ug/L	1
1,3-Dichlorobenzene	541-73-1	8270E	ND		4.0	2.5	ug/L	1
1,4-Dichlorobenzene	106-46-7	8270E	ND		4.0	2.5	ug/L	1
3,3'-Dichlorobenzidine	91-94-1	8270E	ND		20	8.8	ug/L	1
2,4-Dichlorophenol	120-83-2	8270E	ND		8.0	5.0	ug/L	1
Diethylphthalate	84-66-2	8270E	ND		4.0	2.5	ug/L	1
Dimethyl phthalate	131-11-3	8270E	ND		4.0	2.5	ug/L	1
2,4-Dimethylphenol	**105-67-9**	**8270E**	**27**		**4.0**	**2.4**	**ug/L**	**1**
Di-n-butyl phthalate	84-74-2	8270E	ND		4.0	2.5	ug/L	1
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND		20	5.0	ug/L	1
2,4-Dinitrophenol	51-28-5	8270E	ND		20	5.0	ug/L	1
2,4-Dinitrotoluene	121-14-2	8270E	ND		8.0	2.5	ug/L	1
2,6-Dinitrotoluene	606-20-2	8270E	ND		8.0	2.5	ug/L	1
Di-n-octylphthalate	117-84-0	8270E	ND		4.0	2.5	ug/L	1
bis(2-Ethylhexyl)phthalate	117-81-7	8270E	ND		20	2.5	ug/L	1
Fluoranthene	206-44-0	8270E	ND		1.0	0.50	ug/L	1
Fluorene	**86-73-7**	**8270E**	**1.4**		**1.0**	**0.15**	**ug/L**	**1**
Hexachlorobenzene	118-74-1	8270E	ND		4.0	2.5	ug/L	1
Hexachlorobutadiene	87-68-3	8270E	ND		4.0	2.5	ug/L	1
Hexachlorocyclopentadiene	77-47-4	8270E	ND		20	10	ug/L	1
Hexachloroethane	67-72-1	8270E	ND		4.0	1.6	ug/L	1
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND		1.0	0.20	ug/L	1

LOQ = Limit of Quantitation | B = Detected in the method blank | E = Quantitation of compound exceeded the calibration range | DL = Detection Limit

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** | Laboratory ID: **VF24007-006**

Description: **CMR-MW56S-200623** | Matrix: **Aqueous**

Date Sampled: **06/23/2020 0920**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	5	07/01/2020 1822	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1434	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND		4.0	2.5	ug/L	1
2-Methylnaphthalene	**91-57-6**	**8270E**	**37**		**1.0**	**0.20**	**ug/L**	**1**
2-Methylphenol	**95-48-7**	**8270E**	**8.7**		**4.0**	**1.1**	**ug/L**	**1**
3+4-Methylphenol	**106-44-5**	**8270E**	**12**		**8.0**	**7.5**	**ug/L**	**1**
Naphthalene	**91-20-3**	**8270E**	**84**	**B**	**1.0**	**0.25**	**ug/L**	**1**
2-Nitroaniline	88-74-4	8270E	ND		8.0	2.5	ug/L	1
3-Nitroaniline	99-09-2	8270E	ND		8.0	5.0	ug/L	1
4-Nitroaniline	100-01-6	8270E	ND		8.0	7.5	ug/L	1
Nitrobenzene	98-95-3	8270E	ND		4.0	2.8	ug/L	1
2-Nitrophenol	88-75-5	8270E	ND		8.0	5.0	ug/L	1
4-Nitrophenol	100-02-7	8270E	ND		20	10	ug/L	1
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND		4.0	2.5	ug/L	1
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND		4.0	2.5	ug/L	1
Pentachlorophenol	87-86-5	8270E	ND		20	10	ug/L	1
Phenanthrene	**85-01-8**	**8270E**	**0.85**	**J**	**1.0**	**0.30**	**ug/L**	**1**
Phenol	**108-95-2**	**8270E**	**75**		**4.0**	**2.5**	**ug/L**	**1**
Pyrene	129-00-0	8270E	ND		1.0	0.50	ug/L	1
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND		4.0	1.3	ug/L	1
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND		8.0	2.8	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8270E	ND		4.0	1.9	ug/L	1
2,4,5-Trichlorophenol	95-95-4	8270E	ND		4.0	2.5	ug/L	1
2,4,6-Trichlorophenol	88-06-2	8270E	ND		4.0	2.5	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		87	37-129	H	63	37-129
2-Fluorophenol		68	24-127	H	27	24-127
Nitrobenzene-d5		94	38-127	H	65	38-127
Phenol-d5		66	28-128	H	38	28-128
Terphenyl-d14		108	10-148	H	78	10-148
2,4,6-Tribromophenol		115	35-144	H	58	35-144

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation** | Laboratory ID: **VF24007-006**

Description: **CMR-MW56S-200623** | Matrix: **Aqueous**

Date Sampled: **06/23/2020 0920**

Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	5	07/01/2020 1822	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1434	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acenaphthene	83-32-9	8270E	ND	H	0.20	0.040	ug/L	2
Acenaphthylene	208-96-8	8270E	ND	H	0.20	0.040	ug/L	2
Anthracene	120-12-7	8270E	ND	H	0.20	0.060	ug/L	2
Benzo(a)anthracene	56-55-3	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(a)pyrene	50-32-8	8270E	ND	H	0.20	0.070	ug/L	2
Benzo(b)fluoranthene	205-99-2	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(g,h,i)perylene	191-24-2	8270E	ND	H	0.20	0.040	ug/L	2
Benzo(k)fluoranthene	207-08-9	8270E	ND	H	0.20	0.040	ug/L	2
4-Bromophenyl phenyl ether	101-55-3	8270E	ND	H	0.80	0.50	ug/L	2
Butyl benzyl phthalate	85-68-7	8270E	ND	H	0.80	0.50	ug/L	2
Carbazole	86-74-8	8270E	ND	H	0.80	0.50	ug/L	2
bis (2-Chloro-1-methylethyl) ether	108-60-1	8270E	ND	H	0.80	0.50	ug/L	2
4-Chloro-3-methyl phenol	59-50-7	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Chloroethoxy)methane	111-91-1	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Chloroethyl)ether	111-44-4	8270E	ND	H	0.80	0.50	ug/L	2
2-Chloronaphthalene	91-58-7	8270E	ND	H	0.80	0.50	ug/L	2
2-Chlorophenol	95-57-8	8270E	ND	H	0.80	0.50	ug/L	2
4-Chlorophenyl phenyl ether	7005-72-3	8270E	ND	H	0.80	0.50	ug/L	2
Chrysene	218-01-9	8270E	ND	H	0.20	0.030	ug/L	2
Dibenzo(a,h)anthracene	53-70-3	8270E	ND	H	0.20	0.030	ug/L	2
Dibenzofuran	132-64-9	8270E	ND	H	0.80	0.50	ug/L	2
1,2-Dichlorobenzene	95-50-1	8270E	ND	H	0.80	0.50	ug/L	2
1,3-Dichlorobenzene	541-73-1	8270E	ND	H	0.80	0.50	ug/L	2
1,4-Dichlorobenzene	106-46-7	8270E	ND	H	0.80	0.50	ug/L	2
3,3'-Dichlorobenzidine	91-94-1	8270E	ND	H	4.0	1.8	ug/L	2
2,4-Dichlorophenol	120-83-2	8270E	ND	H	1.6	1.0	ug/L	2
Diethylphthalate	84-66-2	8270E	ND	H	0.80	0.50	ug/L	2
Dimethyl phthalate	131-11-3	8270E	ND	H	0.80	0.50	ug/L	2
2,4-Dimethylphenol	105-67-9	8270E	ND	H	0.80	0.48	ug/L	2
Di-n-butyl phthalate	84-74-2	8270E	ND	H	0.80	0.50	ug/L	2
4,6-Dinitro-2-methylphenol	534-52-1	8270E	ND	H	4.0	1.0	ug/L	2
2,4-Dinitrophenol	51-28-5	8270E	ND	H	4.0	1.0	ug/L	2
2,4-Dinitrotoluene	121-14-2	8270E	ND	H	1.6	0.50	ug/L	2
2,6-Dinitrotoluene	606-20-2	8270E	ND	H	1.6	0.50	ug/L	2
Di-n-octylphthalate	117-84-0	8270E	ND	H	0.80	0.50	ug/L	2
bis(2-Ethylhexyl)phthalate	**117-81-7**	**8270E**	**0.98**	**BHJ**	**4.0**	**0.50**	**ug/L**	**2**
Fluoranthene	206-44-0	8270E	ND	H	0.20	0.10	ug/L	2
Fluorene	86-73-7	8270E	ND	H	0.20	0.030	ug/L	2
Hexachlorobenzene	118-74-1	8270E	ND	H	0.80	0.50	ug/L	2
Hexachlorobutadiene	87-68-3	8270E	ND	H	0.80	0.50	ug/L	2
Hexachlorocyclopentadiene	77-47-4	8270E	ND	H	4.0	2.0	ug/L	2
Hexachloroethane	67-72-1	8270E	ND	H	0.80	0.31	ug/L	2
Indeno(1,2,3-c,d)pyrene	193-39-5	8270E	ND	H	0.20	0.040	ug/L	2

LOQ = Limit of Quantitation | B = Detected in the method blank | E = Quantitation of compound exceeded the calibration range | DL = Detection Limit

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Semivolatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8270E	5	07/01/2020 1822	SCD	06/29/2020 1800	58389
2	3520C	8270E	1	07/07/2020 1434	SCD	07/02/2020 1630	58869

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Isophorone	78-59-1	8270E	ND	H	0.80	0.50	ug/L	2
2-Methylnaphthalene	91-57-6	8270E	ND	H	0.20	0.040	ug/L	2
2-Methylphenol	95-48-7	8270E	ND	H	0.80	0.21	ug/L	2
3+4-Methylphenol	106-44-5	8270E	ND	H	1.6	1.5	ug/L	2
Naphthalene	91-20-3	8270E	ND	H	0.20	0.050	ug/L	2
2-Nitroaniline	88-74-4	8270E	ND	H	1.6	0.50	ug/L	2
3-Nitroaniline	99-09-2	8270E	ND	H	1.6	1.0	ug/L	2
4-Nitroaniline	100-01-6	8270E	ND	H	1.6	1.5	ug/L	2
Nitrobenzene	98-95-3	8270E	ND	H	0.80	0.55	ug/L	2
2-Nitrophenol	88-75-5	8270E	ND	H	1.6	1.0	ug/L	2
4-Nitrophenol	100-02-7	8270E	ND	H	4.0	2.0	ug/L	2
N-Nitrosodi-n-propylamine	621-64-7	8270E	ND	H	0.80	0.50	ug/L	2
N-Nitrosodiphenylamine (Diphenylamine)	86-30-6	8270E	ND	H	0.80	0.50	ug/L	2
Pentachlorophenol	87-86-5	8270E	ND	H	4.0	2.0	ug/L	2
Phenanthrene	85-01-8	8270E	ND	H	0.20	0.060	ug/L	2
Phenol	108-95-2	8270E	ND	H	0.80	0.50	ug/L	2
Pyrene	129-00-0	8270E	ND	H	0.20	0.10	ug/L	2
1,2,4,5-Tetrachlorobenzene	95-94-3	8270E	ND	H	0.80	0.25	ug/L	2
2,3,4,6-Tetrachlorophenol	58-90-2	8270E	ND	H	1.6	0.55	ug/L	2
1,2,4-Trichlorobenzene	120-82-1	8270E	ND	H	0.80	0.37	ug/L	2
2,4,5-Trichlorophenol	95-95-4	8270E	ND	H	0.80	0.50	ug/L	2
2,4,6-Trichlorophenol	88-06-2	8270E	ND	H	0.80	0.50	ug/L	2

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
2-Fluorobiphenyl		87	37-129	H	63	37-129
2-Fluorophenol		68	24-127	H	27	24-127
Nitrobenzene-d5		94	38-127	H	65	38-127
Phenol-d5		66	28-128	H	38	28-128
Terphenyl-d14		108	10-148	H	78	10-148
2,4,6-Tribromophenol		115	35-144	H	58	35-144

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

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Montana EPH (screening)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/07/2020 1928	JJG	07/06/2020 1615	59047

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TEH		**Montana EPH**	**4100**		**670**	**670**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		121	40-140
1-Chloro-octadecane (aliphatic)		102	40-140
2-Fluorobiphenyl (fractionation 1)		92	40-140
o - Terphenyl (aromatic)		84	40-140

LOQ = Limit of Quantitation
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
DL = Detection Limit
ND = Not detected at or above the DL
N = Recovery is out of criteria
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
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W = Reported on wet weight basis

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Montana EPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/17/2020 0209	NCM	07/06/2020 1615	59573

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C19 - C36 Aliphatics		Montana EPH	ND		330	330	ug/L	1
C9 - C18 Aliphatics		**Montana EPH**	**740**		**330**	**330**	**ug/L**	**1**
TEH, post-fractionation	**68334-30-5S**	**Montana EPH**	**1500**		**670**	**330**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
1-Chloro-octadecane (aliphatic)		58	40-140

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

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Montana EPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	Montana EPH	Montana EPH	1	07/17/2020 0509	NCM	07/06/2020 1615	59574

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C11 - C22 Aromatics		**Montana EPH**	**520**		**330**	**330**	**ug/L**	**1**

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
2-Bromonaphthalene (fractionation 2)		88	40-140
2-Fluorobiphenyl (fractionation 1)		94	40-140
o - Terphenyl (aromatic)		74	40-140

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

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Montana VPH (aliphatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	100	06/30/2020 1724	ECB		58616

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
C5 - C8 Aliphatics, Adjusted		**Montana VPH**	**5400**	**J**	**7500**	**1500**	**ug/L**	**2**
C9 - C12 Aliphatics, Adjusted		Montana VPH	ND		7500	1500	ug/L	2

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		116	70-130

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

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Montana VPH (aromatics)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	100	06/30/2020 1724	ECB		58615

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Benzene	**71-43-2**	**Montana VPH**	**5500**		**500**	**51**	**ug/L**	**2**
C9 - C10 Aromatics		**Montana VPH**	**1200**	**J**	**2500**	**500**	**ug/L**	**2**
Ethylbenzene	**100-41-4**	**Montana VPH**	**780**		**500**	**62**	**ug/L**	**2**
Methyl tertiary butyl ether (MTBE)	1634-04-4	Montana VPH	ND		500	120	ug/L	2
Naphthalene	**91-20-3**	**Montana VPH**	**160**	**J**	**500**	**70**	**ug/L**	**2**
Toluene	**108-88-3**	**Montana VPH**	**710**		**500**	**53**	**ug/L**	**2**
m+p - Xylenes	**179601-23-1**	**Montana VPH**	**590**		**500**	**120**	**ug/L**	**2**
o - Xylenes	**95-47-6**	**Montana VPH**	**160**	**J**	**500**	**58**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (PID)		109	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit
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H = Out of holding time	W = Reported on wet weight basis		

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Montana VPH (TPH)

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
2	VPH	Montana VPH	100	06/30/2020 1724	ECB		58617

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
TPH		**Montana VPH**	**14000**	**J**	**18000**	**3500**	**ug/L**	**2**

Surrogate	Q	Run 2 % Recovery	Acceptance Limits
2,5-Dibromotoluene (FID)		116	70-130

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

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ICP-MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-006**
Description: **CMR-MW56S-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020 0920**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7470A	1	06/25/2020 1732	JAB2	06/25/2020 1059	58030
1	3005A	6020B	1	07/02/2020 0123	BPK	07/01/2020 0346	58605

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Antimony	7440-36-0	6020B	ND		2.0	0.50	ug/L	1
Arsenic	**7440-38-2**	**6020B**	**1.6**	**J**	**2.0**	**1.3**	**ug/L**	**1**
Barium	**7440-39-3**	**6020B**	**220**		**5.0**	**1.3**	**ug/L**	**1**
Beryllium	7440-41-7	6020B	ND		0.40	0.15	ug/L	1
Cadmium	7440-43-9	6020B	ND		0.50	0.13	ug/L	1
Chromium	7440-47-3	6020B	ND		5.0	1.3	ug/L	1
Cobalt	7440-48-4	6020B	ND		5.0	1.3	ug/L	1
Copper	**7440-50-8**	**6020B**	**5.5**		**5.0**	**1.3**	**ug/L**	**1**
Lead	**7439-92-1**	**6020B**	**0.90**	**J**	**1.0**	**0.25**	**ug/L**	**1**
Mercury	7439-97-6	7470A	ND		0.00020	0.000091	mg/L	1
Nickel	7440-02-0	6020B	ND		5.0	1.3	ug/L	1
Selenium	7782-49-2	6020B	ND		5.0	1.3	ug/L	1
Silver	7440-22-4	6020B	ND		1.0	0.25	ug/L	1
Vanadium	7440-62-2	6020B	ND		5.0	2.5	ug/L	1
Zinc	**7440-66-6**	**6020B**	**15**		**10**	**2.5**	**ug/L**	**1**

LOQ = Limit of Quantitation
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H = Out of holding time
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E = Quantitation of compound exceeded the calibration range
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DL = Detection Limit
J = Estimated result < LOQ and ≥ DL

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-007**
Description: **CMR-TB01-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	1	06/26/2020 2359	JTH		58271

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Acetone	67-64-1	8260D	ND		10	4.0	ug/L	1
Benzene	71-43-2	8260D	ND		0.50	0.40	ug/L	1
Bromochloromethane	74-97-5	8260D	ND		0.50	0.40	ug/L	1
Bromodichloromethane	75-27-4	8260D	ND		0.50	0.40	ug/L	1
Bromoform	75-25-2	8260D	ND		0.50	0.40	ug/L	1
Bromomethane (Methyl bromide)	74-83-9	8260D	ND		0.50	0.40	ug/L	1
2-Butanone (MEK)	78-93-3	8260D	ND		10	2.0	ug/L	1
Carbon disulfide	75-15-0	8260D	ND		0.50	0.40	ug/L	1
Carbon tetrachloride	56-23-5	8260D	ND		0.50	0.40	ug/L	1
Chlorobenzene	108-90-7	8260D	ND		0.50	0.40	ug/L	1
Chloroethane	75-00-3	8260D	ND		0.50	0.40	ug/L	1
Chloroform	67-66-3	8260D	ND		0.50	0.40	ug/L	1
Chloromethane (Methyl chloride)	74-87-3	8260D	ND		0.50	0.40	ug/L	1
Cyclohexane	110-82-7	8260D	ND		0.50	0.40	ug/L	1
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260D	ND		0.50	0.40	ug/L	1
Dibromochloromethane	124-48-1	8260D	ND		0.50	0.40	ug/L	1
1,2-Dibromoethane (EDB)	106-93-4	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichlorobenzene	95-50-1	8260D	ND		0.50	0.40	ug/L	1
1,3-Dichlorobenzene	541-73-1	8260D	ND		0.50	0.40	ug/L	1
1,4-Dichlorobenzene	106-46-7	8260D	ND		0.50	0.40	ug/L	1
Dichlorodifluoromethane	75-71-8	8260D	ND		0.50	0.40	ug/L	1
1,1-Dichloroethane	75-34-3	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichloroethane	107-06-2	8260D	ND		0.50	0.40	ug/L	1
1,1-Dichloroethene	75-35-4	8260D	ND		0.50	0.40	ug/L	1
cis-1,2-Dichloroethene	156-59-2	8260D	ND		0.50	0.40	ug/L	1
trans-1,2-Dichloroethene	156-60-5	8260D	ND		0.50	0.40	ug/L	1
1,2-Dichloropropane	78-87-5	8260D	ND		0.50	0.40	ug/L	1
cis-1,3-Dichloropropene	10061-01-5	8260D	ND		0.50	0.40	ug/L	1
trans-1,3-Dichloropropene	10061-02-6	8260D	ND		0.50	0.40	ug/L	1
1,4-Dioxane	123-91-1	8260D	ND		20	13	ug/L	1
Ethylbenzene	100-41-4	8260D	ND		0.50	0.40	ug/L	1
2-Hexanone	591-78-6	8260D	ND		10	2.0	ug/L	1
Isopropylbenzene	98-82-8	8260D	ND		0.50	0.40	ug/L	1
Methyl acetate	79-20-9	8260D	ND		1.0	0.40	ug/L	1
Methyl tertiary butyl ether (MTBE)	1634-04-4	8260D	ND		0.50	0.40	ug/L	1
4-Methyl-2-pentanone	108-10-1	8260D	ND		10	2.0	ug/L	1
Methylcyclohexane	108-87-2	8260D	ND		5.0	0.40	ug/L	1
Methylene chloride	75-09-2	8260D	ND		0.50	0.40	ug/L	1
Naphthalene	91-20-3	8260D	ND		0.50	0.40	ug/L	1
Styrene	100-42-5	8260D	ND		0.50	0.41	ug/L	1
1,1,2,2-Tetrachloroethane	79-34-5	8260D	ND		0.50	0.40	ug/L	1
Tetrachloroethene	127-18-4	8260D	ND		0.50	0.40	ug/L	1
Toluene	108-88-3	8260D	ND		0.50	0.40	ug/L	1
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	8260D	ND		1.0	0.42	ug/L	1

LOQ = Limit of Quantitation
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
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ND = Not detected at or above the DL
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P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
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W = Reported on wet weight basis

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Volatile Organic Compounds by GC/MS

Client: **Ramboll US Corporation**
Laboratory ID: **VF24007-007**
Description: **CMR-TB01-200623**
Matrix: **Aqueous**
Date Sampled: **06/23/2020**
Date Received: **06/24/2020**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	5030B	8260D	1	06/26/2020 2359	JTH		58271

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
1,2,3-Trichlorobenzene	87-61-6	8260D	ND		0.50	0.40	ug/L	1
1,2,4-Trichlorobenzene	120-82-1	8260D	ND		0.50	0.40	ug/L	1
1,1,1-Trichloroethane	71-55-6	8260D	ND		0.50	0.40	ug/L	1
1,1,2-Trichloroethane	79-00-5	8260D	ND		0.50	0.40	ug/L	1
Trichloroethene	79-01-6	8260D	ND		0.50	0.40	ug/L	1
Trichlorofluoromethane	75-69-4	8260D	ND		0.50	0.40	ug/L	1
Vinyl chloride	75-01-4	8260D	ND		0.50	0.40	ug/L	1
Xylenes (total)	1330-20-7	8260D	ND		1.0	0.40	ug/L	1
m+p - Xylenes	179601-23-1	8260D	ND		0.50	0.40	ug/L	1
o - Xylenes	95-47-6	8260D	ND		0.50	0.40	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
Bromofluorobenzene		104	70-130
1,2-Dichloroethane-d4		86	70-130
Toluene-d8		101	70-130

LOQ = Limit of Quantitation
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
DL = Detection Limit
ND = Not detected at or above the DL
N = Recovery is out of criteria
P = The RPD between two GC columns exceeds 40%
J = Estimated result < LOQ and ≥ DL
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W = Reported on wet weight basis

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QC Summary

Volatile Organic Compounds by GC/MS - MB

Sample ID: VQ58271-001
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Acetone	ND		1	10	4.0	ug/L	06/26/2020 2229
Benzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Bromochloromethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Bromodichloromethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Bromoform	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Bromomethane (Methyl bromide)	ND		1	0.50	0.40	ug/L	06/26/2020 2229
2-Butanone (MEK)	ND		1	10	2.0	ug/L	06/26/2020 2229
Carbon disulfide	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Carbon tetrachloride	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Chlorobenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Chloroethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Chloroform	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Chloromethane (Methyl chloride)	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Cyclohexane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,2-Dibromo-3-chloropropane (DBCP)	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Dibromochloromethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,2-Dibromoethane (EDB)	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,2-Dichlorobenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,3-Dichlorobenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,4-Dichlorobenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Dichlorodifluoromethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,1-Dichloroethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,2-Dichloroethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,1-Dichloroethene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
cis-1,2-Dichloroethene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
trans-1,2-Dichloroethene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,2-Dichloropropane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
cis-1,3-Dichloropropene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
trans-1,3-Dichloropropene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,4-Dioxane	ND		1	20	13	ug/L	06/26/2020 2229
Ethylbenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
2-Hexanone	ND		1	10	2.0	ug/L	06/26/2020 2229
Isopropylbenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Methyl acetate	ND		1	1.0	0.40	ug/L	06/26/2020 2229
Methyl tertiary butyl ether (MTBE)	ND		1	0.50	0.40	ug/L	06/26/2020 2229
4-Methyl-2-pentanone	ND		1	10	2.0	ug/L	06/26/2020 2229
Methylcyclohexane	ND		1	5.0	0.40	ug/L	06/26/2020 2229
Methylene chloride	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Naphthalene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Styrene	ND		1	0.50	0.41	ug/L	06/26/2020 2229
1,1,2,2-Tetrachloroethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Tetrachloroethene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Toluene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,1,2-Trichloro-1,2,2-Trifluoroethane	ND		1	1.0	0.42	ug/L	06/26/2020 2229

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 DL
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

Volatile Organic Compounds by GC/MS - MB

Sample ID: VQ58271-001
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
1,2,3-Trichlorobenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,2,4-Trichlorobenzene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,1,1-Trichloroethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
1,1,2-Trichloroethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Trichloroethene	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Trichlorofluoromethane	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Vinyl chloride	ND		1	0.50	0.40	ug/L	06/26/2020 2229
Xylenes (total)	ND		1	1.0	0.40	ug/L	06/26/2020 2229
m+p - Xylenes	ND		1	0.50	0.40	ug/L	06/26/2020 2229
o - Xylenes	ND		1	0.50	0.40	ug/L	06/26/2020 2229

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		103	70-130
1,2-Dichloroethane-d4		85	70-130
Toluene-d8		101	70-130

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 DL

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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106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

Volatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58271-002
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acetone	100	130		1	127	60-140	06/26/2020 2042
Benzene	50	47		1	94	70-130	06/26/2020 2042
Bromochloromethane	50	41		1	82	70-130	06/26/2020 2042
Bromodichloromethane	50	46		1	92	70-130	06/26/2020 2042
Bromoform	50	50		1	99	70-130	06/26/2020 2042
Bromomethane (Methyl bromide)	50	40		1	80	70-130	06/26/2020 2042
2-Butanone (MEK)	100	110		1	114	70-130	06/26/2020 2042
Carbon disulfide	50	45		1	91	70-130	06/26/2020 2042
Carbon tetrachloride	50	45		1	90	70-130	06/26/2020 2042
Chlorobenzene	50	46		1	92	70-130	06/26/2020 2042
Chloroethane	50	44		1	88	70-130	06/26/2020 2042
Chloroform	50	42		1	84	70-130	06/26/2020 2042
Chloromethane (Methyl chloride)	50	48		1	97	60-140	06/26/2020 2042
Cyclohexane	50	48		1	97	70-130	06/26/2020 2042
1,2-Dibromo-3-chloropropane (DBCP)	50	48		1	96	70-130	06/26/2020 2042
Dibromochloromethane	50	47		1	93	70-130	06/26/2020 2042
1,2-Dibromoethane (EDB)	50	47		1	95	70-130	06/26/2020 2042
1,2-Dichlorobenzene	50	47		1	94	70-130	06/26/2020 2042
1,3-Dichlorobenzene	50	48		1	96	70-130	06/26/2020 2042
1,4-Dichlorobenzene	50	47		1	93	70-130	06/26/2020 2042
Dichlorodifluoromethane	50	48		1	96	60-140	06/26/2020 2042
1,1-Dichloroethane	50	46		1	92	70-130	06/26/2020 2042
1,2-Dichloroethane	50	43		1	86	70-130	06/26/2020 2042
1,1-Dichloroethene	50	46		1	91	70-130	06/26/2020 2042
cis-1,2-Dichloroethene	50	47		1	93	70-130	06/26/2020 2042
trans-1,2-Dichloroethene	50	45		1	91	70-130	06/26/2020 2042
1,2-Dichloropropane	50	50		1	99	70-130	06/26/2020 2042
cis-1,3-Dichloropropene	50	52		1	103	70-130	06/26/2020 2042
trans-1,3-Dichloropropene	50	50		1	100	70-130	06/26/2020 2042
1,4-Dioxane	500	730	N	1	146	60-140	06/26/2020 2042
Ethylbenzene	50	49		1	98	70-130	06/26/2020 2042
2-Hexanone	100	99		1	99	70-130	06/26/2020 2042
Isopropylbenzene	50	50		1	100	70-130	06/26/2020 2042
Methyl acetate	50	46		1	92	70-130	06/26/2020 2042
Methyl tertiary butyl ether (MTBE)	50	44		1	88	70-130	06/26/2020 2042
4-Methyl-2-pentanone	100	100		1	103	70-130	06/26/2020 2042
Methylcyclohexane	50	48		1	95	70-130	06/26/2020 2042
Methylene chloride	50	44		1	88	70-130	06/26/2020 2042
Naphthalene	50	50		1	100	70-130	06/26/2020 2042
Styrene	50	48		1	97	70-130	06/26/2020 2042
1,1,2,2-Tetrachloroethane	50	51		1	101	70-130	06/26/2020 2042
Tetrachloroethene	50	47		1	95	70-130	06/26/2020 2042
Toluene	50	50		1	99	70-130	06/26/2020 2042
1,1,2-Trichloro-1,2,2-Trifluoroethane	50	41		1	82	70-130	06/26/2020 2042

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 DL

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

Volatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58271-002
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
1,2,3-Trichlorobenzene	50	50		1	101	70-130	06/26/2020 2042
1,2,4-Trichlorobenzene	50	50		1	100	70-130	06/26/2020 2042
1,1,1-Trichloroethane	50	42		1	83	70-130	06/26/2020 2042
1,1,2-Trichloroethane	50	48		1	96	70-130	06/26/2020 2042
Trichloroethene	50	47		1	94	70-130	06/26/2020 2042
Trichlorofluoromethane	50	42		1	85	70-130	06/26/2020 2042
Vinyl chloride	50	50		1	99	70-130	06/26/2020 2042
Xylenes (total)	100	98		1	98	70-130	06/26/2020 2042
m+p - Xylenes	50	49		1	98	70-130	06/26/2020 2042
o - Xylenes	50	49		1	98	70-130	06/26/2020 2042

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		97	70-130
1,2-Dichloroethane-d4		89	70-130
Toluene-d8		101	70-130

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 DL

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

Volatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-001MS
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acetone	180	1000	910		10	72	60-140	06/27/2020 0611
Benzene	1000	500	1600		10	110	70-130	06/27/2020 0611
Bromochloromethane	ND	500	370		10	73	70-130	06/27/2020 0611
Bromodichloromethane	ND	500	430		10	86	70-130	06/27/2020 0611
Bromoform	ND	500	430		10	87	70-130	06/27/2020 0611
Bromomethane (Methyl bromide)	ND	500	230	N	10	46	70-130	06/27/2020 0611
2-Butanone (MEK)	100	1000	990		10	89	70-130	06/27/2020 0611
Carbon disulfide	ND	500	450		10	89	70-130	06/27/2020 0611
Carbon tetrachloride	ND	500	430		10	87	70-130	06/27/2020 0611
Chlorobenzene	ND	500	430		10	86	70-130	06/27/2020 0611
Chloroethane	ND	500	250	N	10	50	70-130	06/27/2020 0611
Chloroform	4.0	500	400		10	79	70-130	06/27/2020 0611
Chloromethane (Methyl chloride)	ND	500	270	N	10	54	60-140	06/27/2020 0611
Cyclohexane	24	500	480		10	92	70-130	06/27/2020 0611
1,2-Dibromo-3-chloropropane (DBCP)	ND	500	400		10	81	70-130	06/27/2020 0611
Dibromochloromethane	ND	500	420		10	84	70-130	06/27/2020 0611
1,2-Dibromoethane (EDB)	ND	500	420		10	84	70-130	06/27/2020 0611
1,2-Dichlorobenzene	ND	500	430		10	85	70-130	06/27/2020 0611
1,3-Dichlorobenzene	ND	500	430		10	87	70-130	06/27/2020 0611
1,4-Dichlorobenzene	ND	500	420		10	84	70-130	06/27/2020 0611
Dichlorodifluoromethane	ND	500	250	N	10	50	60-140	06/27/2020 0611
1,1-Dichloroethane	ND	500	440		10	89	70-130	06/27/2020 0611
1,2-Dichloroethane	ND	500	400		10	81	70-130	06/27/2020 0611
1,1-Dichloroethene	ND	500	450		10	90	70-130	06/27/2020 0611
cis-1,2-Dichloroethene	ND	500	430		10	86	70-130	06/27/2020 0611
trans-1,2-Dichloroethene	ND	500	440		10	88	70-130	06/27/2020 0611
1,2-Dichloropropane	ND	500	460		10	93	70-130	06/27/2020 0611
cis-1,3-Dichloropropene	ND	500	460		10	93	70-130	06/27/2020 0611
trans-1,3-Dichloropropene	ND	500	440		10	88	70-130	06/27/2020 0611
1,4-Dioxane	ND	5000	4700		10	94	60-140	06/27/2020 0611
Ethylbenzene	370	500	870		10	101	70-130	06/27/2020 0611
2-Hexanone	ND	1000	940		10	94	70-130	06/27/2020 0611
Isopropylbenzene	10	500	480		10	94	70-130	06/27/2020 0611
Methyl acetate	ND	500	370		10	74	70-130	06/27/2020 0611
Methyl tertiary butyl ether (MTBE)	ND	500	390		10	78	70-130	06/27/2020 0611
4-Methyl-2-pentanone	20	1000	930		10	91	70-130	06/27/2020 0611
Methylcyclohexane	11	500	500		10	97	70-130	06/27/2020 0611
Methylene chloride	ND	500	410		10	83	70-130	06/27/2020 0611
Naphthalene	31	500	480		10	89	70-130	06/27/2020 0611
Styrene	ND	500	440		10	89	70-130	06/27/2020 0611
1,1,2,2-Tetrachloroethane	ND	500	440		10	89	70-130	06/27/2020 0611
Tetrachloroethene	ND	500	460		10	92	70-130	06/27/2020 0611
Toluene	82	500	560		10	95	70-130	06/27/2020 0611
1,1,2-Trichloro-1,2,2-Trifluoroethane	ND	500	420		10	84	70-130	06/27/2020 0611

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 DL
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

Volatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-001MS
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
1,2,3-Trichlorobenzene	ND	500	440		10	88	70-130	06/27/2020 0611
1,2,4-Trichlorobenzene	ND	500	450		10	89	70-130	06/27/2020 0611
1,1,1-Trichloroethane	ND	500	410		10	83	70-130	06/27/2020 0611
1,1,2-Trichloroethane	ND	500	430		10	86	70-130	06/27/2020 0611
Trichloroethene	ND	500	440		10	89	70-130	06/27/2020 0611
Trichlorofluoromethane	ND	500	230	N	10	46	70-130	06/27/2020 0611
Vinyl chloride	ND	500	280	N	10	55	70-130	06/27/2020 0611
Xylenes (total)	620	1000	1600		10	97	70-130	06/27/2020 0611
m+p - Xylenes	550	500	1100		10	103	70-130	06/27/2020 0611
o - Xylenes	67	500	520		10	91	70-130	06/27/2020 0611

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene	N	69	70-130
1,2-Dichloroethane-d4	N	60	70-130
Toluene-d8		72	70-130

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 DL

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

Volatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-001MD
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Acetone	180	1000	1100		10	89	17	60-140	20	06/27/2020 0634
Benzene	1000	500	1600		10	121	3.5	70-130	20	06/27/2020 0634
Bromochloromethane	ND	500	460	+	10	92	22	70-130	20	06/27/2020 0634
Bromodichloromethane	ND	500	520		10	104	19	70-130	20	06/27/2020 0634
Bromoform	ND	500	520		10	105	19	70-130	20	06/27/2020 0634
Bromomethane (Methyl bromide)	ND	500	430	+	10	86	61	70-130	20	06/27/2020 0634
2-Butanone (MEK)	100	1000	1200		10	109	18	70-130	20	06/27/2020 0634
Carbon disulfide	ND	500	550	+	10	110	21	70-130	20	06/27/2020 0634
Carbon tetrachloride	ND	500	530	+	10	107	21	70-130	20	06/27/2020 0634
Chlorobenzene	ND	500	530		10	105	20	70-130	20	06/27/2020 0634
Chloroethane	ND	500	490	+	10	98	65	70-130	20	06/27/2020 0634
Chloroform	4.0	500	490		10	96	20	70-130	20	06/27/2020 0634
Chloromethane (Methyl chloride)	ND	500	530	+	10	106	64	60-140	20	06/27/2020 0634
Cyclohexane	24	500	590	+	10	114	21	70-130	20	06/27/2020 0634
1,2-Dibromo-3-chloropropane (DBCP)	ND	500	500	+	10	100	22	70-130	20	06/27/2020 0634
Dibromochloromethane	ND	500	500		10	101	19	70-130	20	06/27/2020 0634
1,2-Dibromoethane (EDB)	ND	500	510		10	103	20	70-130	20	06/27/2020 0634
1,2-Dichlorobenzene	ND	500	520		10	104	20	70-130	20	06/27/2020 0634
1,3-Dichlorobenzene	ND	500	530		10	106	20	70-130	20	06/27/2020 0634
1,4-Dichlorobenzene	ND	500	510		10	102	19	70-130	20	06/27/2020 0634
Dichlorodifluoromethane	ND	500	520	+	10	103	69	60-140	20	06/27/2020 0634
1,1-Dichloroethane	ND	500	540		10	108	20	70-130	20	06/27/2020 0634
1,2-Dichloroethane	ND	500	500	+	10	99	21	70-130	20	06/27/2020 0634
1,1-Dichloroethene	ND	500	560	+	10	112	21	70-130	20	06/27/2020 0634
cis-1,2-Dichloroethene	ND	500	520		10	104	19	70-130	20	06/27/2020 0634
trans-1,2-Dichloroethene	ND	500	540		10	107	19	70-130	20	06/27/2020 0634
1,2-Dichloropropane	ND	500	570		10	114	20	70-130	20	06/27/2020 0634
cis-1,3-Dichloropropene	ND	500	570		10	114	20	70-130	20	06/27/2020 0634
trans-1,3-Dichloropropene	ND	500	530		10	107	19	70-130	20	06/27/2020 0634
1,4-Dioxane	ND	5000	5900	+	10	118	23	60-140	20	06/27/2020 0634
Ethylbenzene	370	500	960		10	118	9.3	70-130	20	06/27/2020 0634
2-Hexanone	ND	1000	1200	+	10	118	23	70-130	20	06/27/2020 0634
Isopropylbenzene	10	500	590		10	116	20	70-130	20	06/27/2020 0634
Methyl acetate	ND	500	450		10	89	19	70-130	20	06/27/2020 0634
Methyl tertiary butyl ether (MTBE)	ND	500	480	+	10	96	21	70-130	20	06/27/2020 0634
4-Methyl-2-pentanone	20	1000	1100	+	10	113	21	70-130	20	06/27/2020 0634
Methylcyclohexane	11	500	600		10	117	18	70-130	20	06/27/2020 0634
Methylene chloride	ND	500	510		10	101	20	70-130	20	06/27/2020 0634
Naphthalene	31	500	570		10	108	18	70-130	20	06/27/2020 0634
Styrene	ND	500	550	+	10	109	21	70-130	20	06/27/2020 0634
1,1,2,2-Tetrachloroethane	ND	500	540		10	107	19	70-130	20	06/27/2020 0634
Tetrachloroethene	ND	500	550		10	111	19	70-130	20	06/27/2020 0634
Toluene	82	500	650		10	115	16	70-130	20	06/27/2020 0634
1,1,2-Trichloro-1,2,2-Trifluoroethane	ND	500	530	+	10	105	22	70-130	20	06/27/2020 0634

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 DL
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

Volatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-001MD
Batch: 58271
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
1,2,3-Trichlorobenzene	ND	500	550	+	10	111	23	70-130	20	06/27/2020 0634
1,2,4-Trichlorobenzene	ND	500	550		10	110	20	70-130	20	06/27/2020 0634
1,1,1-Trichloroethane	ND	500	510		10	101	20	70-130	20	06/27/2020 0634
1,1,2-Trichloroethane	ND	500	520		10	105	20	70-130	20	06/27/2020 0634
Trichloroethene	ND	500	550	+	10	110	22	70-130	20	06/27/2020 0634
Trichlorofluoromethane	ND	500	470	+	10	94	68	70-130	20	06/27/2020 0634
Vinyl chloride	ND	500	540	+	10	109	65	70-130	20	06/27/2020 0634
Xylenes (total)	620	1000	1800		10	115	11	70-130	20	06/27/2020 0634
m+p - Xylenes	550	500	1100		10	118	6.9	70-130	20	06/27/2020 0634
o - Xylenes	67	500	630		10	112	18	70-130	20	06/27/2020 0634

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		102	70-130
1,2-Dichloroethane-d4		89	70-130
Toluene-d8		108	70-130

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 DL

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

Volatile Organic Compounds by GC/MS - MB

Sample ID: VQ58687-001
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Acetone	ND		1	10	4.0	ug/L	07/01/2020 1028
Benzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Bromochloromethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Bromodichloromethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Bromoform	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Bromomethane (Methyl bromide)	ND		1	0.50	0.40	ug/L	07/01/2020 1028
2-Butanone (MEK)	ND		1	10	2.0	ug/L	07/01/2020 1028
Carbon disulfide	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Carbon tetrachloride	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Chlorobenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Chloroethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Chloroform	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Chloromethane (Methyl chloride)	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Cyclohexane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,2-Dibromo-3-chloropropane (DBCP)	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Dibromochloromethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,2-Dibromoethane (EDB)	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,2-Dichlorobenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,3-Dichlorobenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,4-Dichlorobenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Dichlorodifluoromethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,1-Dichloroethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,2-Dichloroethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,1-Dichloroethene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
cis-1,2-Dichloroethene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
trans-1,2-Dichloroethene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,2-Dichloropropane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
cis-1,3-Dichloropropene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
trans-1,3-Dichloropropene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,4-Dioxane	ND		1	20	13	ug/L	07/01/2020 1028
Ethylbenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
2-Hexanone	ND		1	10	2.0	ug/L	07/01/2020 1028
Isopropylbenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Methyl acetate	ND		1	1.0	0.40	ug/L	07/01/2020 1028
Methyl tertiary butyl ether (MTBE)	ND		1	0.50	0.40	ug/L	07/01/2020 1028
4-Methyl-2-pentanone	ND		1	10	2.0	ug/L	07/01/2020 1028
Methylcyclohexane	ND		1	5.0	0.40	ug/L	07/01/2020 1028
Methylene chloride	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Naphthalene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Styrene	ND		1	0.50	0.41	ug/L	07/01/2020 1028
1,1,2,2-Tetrachloroethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Tetrachloroethene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Toluene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,1,2-Trichloro-1,2,2-Trifluoroethane	ND		1	1.0	0.42	ug/L	07/01/2020 1028

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 DL
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

Volatile Organic Compounds by GC/MS - MB

Sample ID: VQ58687-001
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
1,2,3-Trichlorobenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,2,4-Trichlorobenzene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,1,1-Trichloroethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
1,1,2-Trichloroethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Trichloroethene	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Trichlorofluoromethane	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Vinyl chloride	ND		1	0.50	0.40	ug/L	07/01/2020 1028
Xylenes (total)	ND		1	1.0	0.40	ug/L	07/01/2020 1028
m+p - Xylenes	ND		1	0.50	0.40	ug/L	07/01/2020 1028
o - Xylenes	ND		1	0.50	0.40	ug/L	07/01/2020 1028

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		94	70-130
1,2-Dichloroethane-d4		112	70-130
Toluene-d8		103	70-130

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 DL

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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Volatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58687-002
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acetone	100	120		1	120	60-140	07/01/2020 0925
Benzene	50	52		1	103	70-130	07/01/2020 0925
Bromochloromethane	50	50		1	100	70-130	07/01/2020 0925
Bromodichloromethane	50	53		1	106	70-130	07/01/2020 0925
Bromoform	50	53		1	106	70-130	07/01/2020 0925
Bromomethane (Methyl bromide)	50	57		1	114	70-130	07/01/2020 0925
2-Butanone (MEK)	100	110		1	115	70-130	07/01/2020 0925
Carbon disulfide	50	53		1	106	70-130	07/01/2020 0925
Carbon tetrachloride	50	52		1	104	70-130	07/01/2020 0925
Chlorobenzene	50	50		1	99	70-130	07/01/2020 0925
Chloroethane	50	56		1	113	70-130	07/01/2020 0925
Chloroform	50	50		1	101	70-130	07/01/2020 0925
Chloromethane (Methyl chloride)	50	64		1	129	60-140	07/01/2020 0925
Cyclohexane	50	48		1	95	70-130	07/01/2020 0925
1,2-Dibromo-3-chloropropane (DBCP)	50	50		1	100	70-130	07/01/2020 0925
Dibromochloromethane	50	54		1	109	70-130	07/01/2020 0925
1,2-Dibromoethane (EDB)	50	52		1	103	70-130	07/01/2020 0925
1,2-Dichlorobenzene	50	49		1	97	70-130	07/01/2020 0925
1,3-Dichlorobenzene	50	49		1	98	70-130	07/01/2020 0925
1,4-Dichlorobenzene	50	48		1	96	70-130	07/01/2020 0925
Dichlorodifluoromethane	50	65		1	130	60-140	07/01/2020 0925
1,1-Dichloroethane	50	51		1	103	70-130	07/01/2020 0925
1,2-Dichloroethane	50	53		1	105	70-130	07/01/2020 0925
1,1-Dichloroethene	50	52		1	104	70-130	07/01/2020 0925
cis-1,2-Dichloroethene	50	49		1	98	70-130	07/01/2020 0925
trans-1,2-Dichloroethene	50	51		1	101	70-130	07/01/2020 0925
1,2-Dichloropropane	50	52		1	103	70-130	07/01/2020 0925
cis-1,3-Dichloropropene	50	54		1	109	70-130	07/01/2020 0925
trans-1,3-Dichloropropene	50	54		1	107	70-130	07/01/2020 0925
1,4-Dioxane	500	450		1	90	60-140	07/01/2020 0925
Ethylbenzene	50	52		1	104	70-130	07/01/2020 0925
2-Hexanone	100	120		1	117	70-130	07/01/2020 0925
Isopropylbenzene	50	54		1	107	70-130	07/01/2020 0925
Methyl acetate	50	55		1	111	70-130	07/01/2020 0925
Methyl tertiary butyl ether (MTBE)	50	50		1	100	70-130	07/01/2020 0925
4-Methyl-2-pentanone	100	110		1	114	70-130	07/01/2020 0925
Methylcyclohexane	50	50		1	99	70-130	07/01/2020 0925
Methylene chloride	50	51		1	102	70-130	07/01/2020 0925
Naphthalene	50	44		1	87	70-130	07/01/2020 0925
Styrene	50	56		1	112	70-130	07/01/2020 0925
1,1,2,2-Tetrachloroethane	50	47		1	93	70-130	07/01/2020 0925
Tetrachloroethene	50	50		1	99	70-130	07/01/2020 0925
Toluene	50	51		1	102	70-130	07/01/2020 0925
1,1,2-Trichloro-1,2,2-Trifluoroethane	50	53		1	106	70-130	07/01/2020 0925

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 DL

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

Volatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58687-002
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
1,2,3-Trichlorobenzene	50	52		1	103	70-130	07/01/2020 0925
1,2,4-Trichlorobenzene	50	49		1	99	70-130	07/01/2020 0925
1,1,1-Trichloroethane	50	52		1	103	70-130	07/01/2020 0925
1,1,2-Trichloroethane	50	50		1	100	70-130	07/01/2020 0925
Trichloroethene	50	50		1	99	70-130	07/01/2020 0925
Trichlorofluoromethane	50	59		1	117	70-130	07/01/2020 0925
Vinyl chloride	50	63		1	127	70-130	07/01/2020 0925
Xylenes (total)	100	100		1	104	70-130	07/01/2020 0925
m+p - Xylenes	50	52		1	104	70-130	07/01/2020 0925
o - Xylenes	50	52		1	103	70-130	07/01/2020 0925

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		98	70-130
1,2-Dichloroethane-d4		100	70-130
Toluene-d8		97	70-130

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 DL

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

Volatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-001MS
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acetone	220	1000	960		10	75	60-140	07/01/2020 1902
Benzene	1100	500	1600		10	94	70-130	07/01/2020 1902
Bromochloromethane	ND	500	510		10	102	70-130	07/01/2020 1902
Bromodichloromethane	ND	500	550		10	111	70-130	07/01/2020 1902
Bromoform	ND	500	530		10	106	70-130	07/01/2020 1902
Bromomethane (Methyl bromide)	ND	500	600		10	120	70-130	07/01/2020 1902
2-Butanone (MEK)	89	1000	1100		10	97	70-130	07/01/2020 1902
Carbon disulfide	ND	500	550		10	110	70-130	07/01/2020 1902
Carbon tetrachloride	ND	500	550		10	110	70-130	07/01/2020 1902
Chlorobenzene	ND	500	500		10	100	70-130	07/01/2020 1902
Chloroethane	ND	500	590		10	119	70-130	07/01/2020 1902
Chloroform	ND	500	530		10	106	70-130	07/01/2020 1902
Chloromethane (Methyl chloride)	ND	500	710	N	10	142	60-140	07/01/2020 1902
Cyclohexane	18	500	510		10	99	70-130	07/01/2020 1902
1,2-Dibromo-3-chloropropane (DBCP)	ND	500	510		10	102	70-130	07/01/2020 1902
Dibromochloromethane	ND	500	550		10	109	70-130	07/01/2020 1902
1,2-Dibromoethane (EDB)	ND	500	510		10	102	70-130	07/01/2020 1902
1,2-Dichlorobenzene	ND	500	490		10	97	70-130	07/01/2020 1902
1,3-Dichlorobenzene	ND	500	490		10	98	70-130	07/01/2020 1902
1,4-Dichlorobenzene	ND	500	480		10	97	70-130	07/01/2020 1902
Dichlorodifluoromethane	ND	500	730	N	10	146	60-140	07/01/2020 1902
1,1-Dichloroethane	ND	500	540		10	107	70-130	07/01/2020 1902
1,2-Dichloroethane	ND	500	540		10	108	70-130	07/01/2020 1902
1,1-Dichloroethene	ND	500	530		10	106	70-130	07/01/2020 1902
cis-1,2-Dichloroethene	ND	500	500		10	101	70-130	07/01/2020 1902
trans-1,2-Dichloroethene	ND	500	520		10	104	70-130	07/01/2020 1902
1,2-Dichloropropane	ND	500	530		10	106	70-130	07/01/2020 1902
cis-1,3-Dichloropropene	ND	500	540		10	109	70-130	07/01/2020 1902
trans-1,3-Dichloropropene	ND	500	540		10	108	70-130	07/01/2020 1902
1,4-Dioxane	ND	5000	4500		10	89	60-140	07/01/2020 1902
Ethylbenzene	380	500	920		10	108	70-130	07/01/2020 1902
2-Hexanone	ND	1000	1200		10	115	70-130	07/01/2020 1902
Isopropylbenzene	8.6	500	550		10	109	70-130	07/01/2020 1902
Methyl acetate	ND	500	540		10	107	70-130	07/01/2020 1902
Methyl tertiary butyl ether (MTBE)	ND	500	480		10	96	70-130	07/01/2020 1902
4-Methyl-2-pentanone	ND	1000	1200		10	118	70-130	07/01/2020 1902
Methylcyclohexane	7.1	500	520		10	103	70-130	07/01/2020 1902
Methylene chloride	ND	500	500		10	100	70-130	07/01/2020 1902
Naphthalene	26	500	480		10	90	70-130	07/01/2020 1902
Styrene	ND	500	570		10	114	70-130	07/01/2020 1902
1,1,2,2-Tetrachloroethane	ND	500	470		10	94	70-130	07/01/2020 1902
Tetrachloroethene	ND	500	510		10	102	70-130	07/01/2020 1902
Toluene	81	500	600		10	104	70-130	07/01/2020 1902
1,1,2-Trichloro-1,2,2-Trifluoroethane	ND	500	540		10	108	70-130	07/01/2020 1902

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 DL
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

Volatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-001MS
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
1,2,3-Trichlorobenzene	ND	500	520		10	104	70-130	07/01/2020 1902
1,2,4-Trichlorobenzene	ND	500	510		10	102	70-130	07/01/2020 1902
1,1,1-Trichloroethane	ND	500	550		10	109	70-130	07/01/2020 1902
1,1,2-Trichloroethane	ND	500	500		10	100	70-130	07/01/2020 1902
Trichloroethene	ND	500	510		10	102	70-130	07/01/2020 1902
Trichlorofluoromethane	ND	500	620		10	124	70-130	07/01/2020 1902
Vinyl chloride	ND	500	710	N	10	141	70-130	07/01/2020 1902
Xylenes (total)	670	1000	1700		10	106	70-130	07/01/2020 1902
m+p - Xylenes	610	500	1100		10	105	70-130	07/01/2020 1902
o - Xylenes	62	500	590		10	106	70-130	07/01/2020 1902

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		102	70-130
1,2-Dichloroethane-d4		105	70-130
Toluene-d8		101	70-130

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 DL

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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Volatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-001MD
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Acetone	220	1000	980		10	77	2.1	60-140	20	07/01/2020 1926
Benzene	1100	500	1500		10	80	4.4	70-130	20	07/01/2020 1926
Bromochloromethane	ND	500	500		10	100	2.3	70-130	20	07/01/2020 1926
Bromodichloromethane	ND	500	540		10	108	2.9	70-130	20	07/01/2020 1926
Bromoform	ND	500	520		10	104	2.2	70-130	20	07/01/2020 1926
Bromomethane (Methyl bromide)	ND	500	600		10	119	0.93	70-130	20	07/01/2020 1926
2-Butanone (MEK)	89	1000	1100		10	98	1.1	70-130	20	07/01/2020 1926
Carbon disulfide	ND	500	550		10	110	0.30	70-130	20	07/01/2020 1926
Carbon tetrachloride	ND	500	550		10	110	0.77	70-130	20	07/01/2020 1926
Chlorobenzene	ND	500	490		10	98	2.8	70-130	20	07/01/2020 1926
Chloroethane	ND	500	600		10	120	1.2	70-130	20	07/01/2020 1926
Chloroform	ND	500	520		10	103	2.5	70-130	20	07/01/2020 1926
Chloromethane (Methyl chloride)	ND	500	710	N	10	141	0.36	60-140	20	07/01/2020 1926
Cyclohexane	18	500	510		10	99	0.30	70-130	20	07/01/2020 1926
1,2-Dibromo-3-chloropropane (DBCP)	ND	500	520		10	104	1.7	70-130	20	07/01/2020 1926
Dibromochloromethane	ND	500	530		10	107	2.3	70-130	20	07/01/2020 1926
1,2-Dibromoethane (EDB)	ND	500	500		10	100	1.8	70-130	20	07/01/2020 1926
1,2-Dichlorobenzene	ND	500	480		10	95	1.7	70-130	20	07/01/2020 1926
1,3-Dichlorobenzene	ND	500	480		10	97	1.4	70-130	20	07/01/2020 1926
1,4-Dichlorobenzene	ND	500	470		10	94	2.3	70-130	20	07/01/2020 1926
Dichlorodifluoromethane	ND	500	730	N	10	146	0.19	60-140	20	07/01/2020 1926
1,1-Dichloroethane	ND	500	530		10	106	1.5	70-130	20	07/01/2020 1926
1,2-Dichloroethane	ND	500	520		10	104	3.4	70-130	20	07/01/2020 1926
1,1-Dichloroethene	ND	500	530		10	107	0.69	70-130	20	07/01/2020 1926
cis-1,2-Dichloroethene	ND	500	500		10	101	0.073	70-130	20	07/01/2020 1926
trans-1,2-Dichloroethene	ND	500	520		10	104	0.33	70-130	20	07/01/2020 1926
1,2-Dichloropropane	ND	500	520		10	105	1.8	70-130	20	07/01/2020 1926
cis-1,3-Dichloropropene	ND	500	530		10	106	2.4	70-130	20	07/01/2020 1926
trans-1,3-Dichloropropene	ND	500	530		10	107	1.3	70-130	20	07/01/2020 1926
1,4-Dioxane	ND	5000	4700		10	94	4.9	60-140	20	07/01/2020 1926
Ethylbenzene	380	500	890		10	102	3.5	70-130	20	07/01/2020 1926
2-Hexanone	ND	1000	1100		10	110	4.4	70-130	20	07/01/2020 1926
Isopropylbenzene	8.6	500	550		10	108	1.3	70-130	20	07/01/2020 1926
Methyl acetate	ND	500	530		10	106	0.49	70-130	20	07/01/2020 1926
Methyl tertiary butyl ether (MTBE)	ND	500	510		10	102	6.3	70-130	20	07/01/2020 1926
4-Methyl-2-pentanone	ND	1000	1100		10	114	3.6	70-130	20	07/01/2020 1926
Methylcyclohexane	7.1	500	520		10	103	0.11	70-130	20	07/01/2020 1926
Methylene chloride	ND	500	500		10	99	0.12	70-130	20	07/01/2020 1926
Naphthalene	26	500	480		10	91	0.36	70-130	20	07/01/2020 1926
Styrene	ND	500	550		10	111	3.3	70-130	20	07/01/2020 1926
1,1,2,2-Tetrachloroethane	ND	500	460		10	92	1.9	70-130	20	07/01/2020 1926
Tetrachloroethene	ND	500	490		10	99	3.2	70-130	20	07/01/2020 1926
Toluene	81	500	580		10	100	3.4	70-130	20	07/01/2020 1926
1,1,2-Trichloro-1,2,2-Trifluoroethane	ND	500	540		10	107	0.56	70-130	20	07/01/2020 1926

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 DL
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

Volatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-001MD
Batch: 58687
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
1,2,3-Trichlorobenzene	ND	500	530		10	105	0.89	70-130	20	07/01/2020 1926
1,2,4-Trichlorobenzene	ND	500	520		10	103	1.6	70-130	20	07/01/2020 1926
1,1,1-Trichloroethane	ND	500	540		10	109	0.47	70-130	20	07/01/2020 1926
1,1,2-Trichloroethane	ND	500	480		10	97	2.6	70-130	20	07/01/2020 1926
Trichloroethene	ND	500	500		10	99	2.8	70-130	20	07/01/2020 1926
Trichlorofluoromethane	ND	500	630		10	125	0.79	70-130	20	07/01/2020 1926
Vinyl chloride	ND	500	700	N	10	140	0.47	70-130	20	07/01/2020 1926
Xylenes (total)	670	1000	1700		10	100	3.1	70-130	20	07/01/2020 1926
m+p - Xylenes	610	500	1100		10	97	3.7	70-130	20	07/01/2020 1926
o - Xylenes	62	500	580		10	103	2.1	70-130	20	07/01/2020 1926

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		100	70-130
1,2-Dichloroethane-d4		103	70-130
Toluene-d8		100	70-130

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 DL

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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Volatile Organic Compounds by GC/MS - MB

Sample ID: VQ58939-001
Batch: 58939
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Acetone	ND		1	10	4.0	ug/L	07/04/2020 1410
Benzene	ND		1	0.50	0.40	ug/L	07/04/2020 1410
Ethylbenzene	ND		1	0.50	0.40	ug/L	07/04/2020 1410
Xylenes (total)	ND		1	1.0	0.40	ug/L	07/04/2020 1410
m+p - Xylenes	ND		1	0.50	0.40	ug/L	07/04/2020 1410

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		100	70-130
1,2-Dichloroethane-d4		117	70-130
Toluene-d8		107	70-130

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 DL

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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Volatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58939-002
Batch: 58939
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acetone	100	97		1	97	60-140	07/04/2020 1308
Benzene	50	52		1	104	70-130	07/04/2020 1308
Ethylbenzene	50	53		1	106	70-130	07/04/2020 1308
Xylenes (total)	100	110		1	106	70-130	07/04/2020 1308
m+p - Xylenes	50	53		1	107	70-130	07/04/2020 1308

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		98	70-130
1,2-Dichloroethane-d4		99	70-130
Toluene-d8		96	70-130

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 DL

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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Volatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-002MS
Batch: 58939
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acetone	480	1000	1300		10	81	60-140	07/04/2020 2215
Benzene	96	500	660		10	112	70-130	07/04/2020 2215
Ethylbenzene	25	500	610		10	116	70-130	07/04/2020 2215
Xylenes (total)	64	1000	1200		10	115	70-130	07/04/2020 2215
m+p - Xylenes	64	500	650		10	118	70-130	07/04/2020 2215

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		102	70-130
1,2-Dichloroethane-d4		102	70-130
Toluene-d8		101	70-130

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 DL

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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Volatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-002MD
Batch: 58939
Analytical Method: 8260D

Matrix: Aqueous
Prep Method: 5030B

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Acetone	480	1000	1200		10	76	3.6	60-140	20	07/04/2020 2238
Benzene	96	500	650		10	110	1.6	70-130	20	07/04/2020 2238
Ethylbenzene	25	500	590		10	113	2.2	70-130	20	07/04/2020 2238
Xylenes (total)	64	1000	1200		10	113	1.7	70-130	20	07/04/2020 2238
m+p - Xylenes	64	500	640		10	115	2.4	70-130	20	07/04/2020 2238

Surrogate	Q	% Rec	Acceptance Limit
Bromofluorobenzene		103	70-130
1,2-Dichloroethane-d4		103	70-130
Toluene-d8		103	70-130

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 DL

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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Semivolatile Organic Compounds by GC/MS - MB

Sample ID: VQ58389-001
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Acenaphthene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
Acenaphthylene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
Anthracene	ND		1	0.20	0.060	ug/L	07/01/2020 1136
Benzo(a)anthracene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
Benzo(a)pyrene	ND		1	0.20	0.070	ug/L	07/01/2020 1136
Benzo(b)fluoranthene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
Benzo(g,h,i)perylene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
Benzo(k)fluoranthene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
4-Bromophenyl phenyl ether	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Butyl benzyl phthalate	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Carbazole	ND		1	0.80	0.50	ug/L	07/01/2020 1136
bis (2-Chloro-1-methylethyl) ether	ND		1	0.80	0.50	ug/L	07/01/2020 1136
4-Chloro-3-methyl phenol	ND		1	0.80	0.50	ug/L	07/01/2020 1136
bis(2-Chloroethoxy)methane	ND		1	0.80	0.50	ug/L	07/01/2020 1136
bis(2-Chloroethyl)ether	ND		1	0.80	0.50	ug/L	07/01/2020 1136
2-Chloronaphthalene	ND		1	0.80	0.50	ug/L	07/01/2020 1136
2-Chlorophenol	ND		1	0.80	0.50	ug/L	07/01/2020 1136
4-Chlorophenyl phenyl ether	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Chrysene	ND		1	0.20	0.030	ug/L	07/01/2020 1136
Dibenzo(a,h)anthracene	ND		1	0.20	0.030	ug/L	07/01/2020 1136
Dibenzofuran	ND		1	0.80	0.50	ug/L	07/01/2020 1136
1,2-Dichlorobenzene	ND		1	0.80	0.50	ug/L	07/01/2020 1136
1,3-Dichlorobenzene	ND		1	0.80	0.50	ug/L	07/01/2020 1136
1,4-Dichlorobenzene	ND		1	0.80	0.50	ug/L	07/01/2020 1136
3,3'-Dichlorobenzidine	ND		1	4.0	1.8	ug/L	07/01/2020 1136
2,4-Dichlorophenol	ND		1	1.6	1.0	ug/L	07/01/2020 1136
Diethylphthalate	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Dimethyl phthalate	ND		1	0.80	0.50	ug/L	07/01/2020 1136
2,4-Dimethylphenol	ND		1	0.80	0.48	ug/L	07/01/2020 1136
Di-n-butyl phthalate	**0.75**	**J**	**1**	**0.80**	**0.50**	**ug/L**	**07/01/2020 1136**
4,6-Dinitro-2-methylphenol	ND		1	4.0	1.0	ug/L	07/01/2020 1136
2,4-Dinitrophenol	ND		1	4.0	1.0	ug/L	07/01/2020 1136
2,4-Dinitrotoluene	ND		1	1.6	0.50	ug/L	07/01/2020 1136
2,6-Dinitrotoluene	ND		1	1.6	0.50	ug/L	07/01/2020 1136
Di-n-octylphthalate	ND		1	0.80	0.50	ug/L	07/01/2020 1136
bis(2-Ethylhexyl)phthalate	**0.86**	**J**	**1**	**4.0**	**0.50**	**ug/L**	**07/01/2020 1136**
Fluoranthene	ND		1	0.20	0.10	ug/L	07/01/2020 1136
Fluorene	ND		1	0.20	0.030	ug/L	07/01/2020 1136
Hexachlorobenzene	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Hexachlorobutadiene	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Hexachlorocyclopentadiene	ND		1	4.0	2.0	ug/L	07/01/2020 1136
Hexachloroethane	ND		1	0.80	0.31	ug/L	07/01/2020 1136
Indeno(1,2,3-c,d)pyrene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
Isophorone	ND		1	0.80	0.50	ug/L	07/01/2020 1136

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 DL
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

Semivolatile Organic Compounds by GC/MS - MB

Sample ID: VQ58389-001
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
2-Methylnaphthalene	ND		1	0.20	0.040	ug/L	07/01/2020 1136
2-Methylphenol	ND		1	0.80	0.21	ug/L	07/01/2020 1136
3+4-Methylphenol	ND		1	1.6	1.5	ug/L	07/01/2020 1136
Naphthalene	**0.058**	**J**	**1**	**0.20**	**0.050**	**ug/L**	**07/01/2020 1136**
2-Nitroaniline	ND		1	1.6	0.50	ug/L	07/01/2020 1136
3-Nitroaniline	ND		1	1.6	1.0	ug/L	07/01/2020 1136
4-Nitroaniline	ND		1	1.6	1.5	ug/L	07/01/2020 1136
Nitrobenzene	ND		1	0.80	0.55	ug/L	07/01/2020 1136
2-Nitrophenol	ND		1	1.6	1.0	ug/L	07/01/2020 1136
4-Nitrophenol	ND		1	4.0	2.0	ug/L	07/01/2020 1136
N-Nitrosodi-n-propylamine	ND		1	0.80	0.50	ug/L	07/01/2020 1136
N-Nitrosodiphenylamine (Diphenylamine)	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Pentachlorophenol	ND		1	4.0	2.0	ug/L	07/01/2020 1136
Phenanthrene	ND		1	0.20	0.060	ug/L	07/01/2020 1136
Phenol	ND		1	0.80	0.50	ug/L	07/01/2020 1136
Pyrene	ND		1	0.20	0.10	ug/L	07/01/2020 1136
1,2,4,5-Tetrachlorobenzene	ND		1	0.80	0.25	ug/L	07/01/2020 1136
2,3,4,6-Tetrachlorophenol	ND		1	1.6	0.55	ug/L	07/01/2020 1136
1,2,4-Trichlorobenzene	ND		1	0.80	0.37	ug/L	07/01/2020 1136
2,4,5-Trichlorophenol	ND		1	0.80	0.50	ug/L	07/01/2020 1136
2,4,6-Trichlorophenol	ND		1	0.80	0.50	ug/L	07/01/2020 1136

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		83	37-129
2-Fluorophenol		45	24-127
Nitrobenzene-d5		71	38-127
Phenol-d5		66	28-128
Terphenyl-d14		109	10-148
2,4,6-Tribromophenol		85	35-144

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 DL
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

Semivolatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58389-002
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acenaphthene	8.0	5.8		1	73	30-122	07/01/2020 1201
Acenaphthylene	8.0	6.1		1	76	30-130	07/01/2020 1201
Anthracene	8.0	6.5		1	81	30-123	07/01/2020 1201
Benzo(a)anthracene	8.0	7.1		1	89	40-125	07/01/2020 1201
Benzo(a)pyrene	8.0	6.7		1	83	40-128	07/01/2020 1201
Benzo(b)fluoranthene	8.0	7.2		1	90	32-145	07/01/2020 1201
Benzo(g,h,i)perylene	8.0	8.1		1	102	42-128	07/01/2020 1201
Benzo(k)fluoranthene	8.0	7.4		1	93	50-135	07/01/2020 1201
4-Bromophenyl phenyl ether	8.0	6.2		1	78	30-124	07/01/2020 1201
Butyl benzyl phthalate	8.0	8.2		1	102	54-135	07/01/2020 1201
Carbazole	8.0	6.5		1	82	30-130	07/01/2020 1201
bis (2-Chloro-1-methylethyl) ether	8.0	6.7		1	84	34-110	07/01/2020 1201
4-Chloro-3-methyl phenol	8.0	5.7		1	72	30-123	07/01/2020 1201
bis(2-Chloroethoxy)methane	8.0	5.3		1	67	40-119	07/01/2020 1201
bis(2-Chloroethyl)ether	8.0	5.1		1	64	35-114	07/01/2020 1201
2-Chloronaphthalene	8.0	6.0		1	75	39-128	07/01/2020 1201
2-Chlorophenol	8.0	5.2		1	65	39-115	07/01/2020 1201
4-Chlorophenyl phenyl ether	8.0	6.0		1	74	30-121	07/01/2020 1201
Chrysene	8.0	7.4		1	93	50-130	07/01/2020 1201
Dibenzo(a,h)anthracene	8.0	7.8		1	97	30-130	07/01/2020 1201
Dibenzofuran	8.0	6.1		1	76	30-118	07/01/2020 1201
1,2-Dichlorobenzene	8.0	5.4		1	67	20-110	07/01/2020 1201
1,3-Dichlorobenzene	8.0	5.2		1	64	17-112	07/01/2020 1201
1,4-Dichlorobenzene	8.0	5.1		1	64	18-113	07/01/2020 1201
3,3'-Dichlorobenzidine	8.0	ND	N	1	0.00	10-126	07/01/2020 1201
2,4-Dichlorophenol	8.0	5.5		1	69	30-121	07/01/2020 1201
Diethylphthalate	8.0	6.8		1	85	40-125	07/01/2020 1201
Dimethyl phthalate	8.0	6.9		1	86	40-127	07/01/2020 1201
2,4-Dimethylphenol	8.0	6.8		1	85	20-125	07/01/2020 1201
Di-n-butyl phthalate	8.0	7.3		1	91	40-127	07/01/2020 1201
4,6-Dinitro-2-methylphenol	8.0	6.4		1	80	46-134	07/01/2020 1201
2,4-Dinitrophenol	16	9.8		1	61	11-126	07/01/2020 1201
2,4-Dinitrotoluene	8.0	7.3		1	91	51-128	07/01/2020 1201
2,6-Dinitrotoluene	8.0	6.9		1	87	48-133	07/01/2020 1201
Di-n-octylphthalate	8.0	6.6		1	83	55-143	07/01/2020 1201
bis(2-Ethylhexyl)phthalate	8.0	9.0		1	112	50-133	07/01/2020 1201
Fluoranthene	8.0	6.7		1	84	40-128	07/01/2020 1201
Fluorene	8.0	5.8		1	73	30-124	07/01/2020 1201
Hexachlorobenzene	8.0	6.4		1	80	30-125	07/01/2020 1201
Hexachlorobutadiene	8.0	4.6		1	58	24-110	07/01/2020 1201
Hexachlorocyclopentadiene	40	18		1	44	22-122	07/01/2020 1201
Hexachloroethane	8.0	4.8		1	60	28-116	07/01/2020 1201
Indeno(1,2,3-c,d)pyrene	8.0	7.8		1	97	50-125	07/01/2020 1201
Isophorone	8.0	6.3		1	79	30-130	07/01/2020 1201

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 DL
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

Semivolatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58389-002
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
2-Methylnaphthalene	8.0	5.5		1	69	40-132	07/01/2020 1201
2-Methylphenol	8.0	6.7		1	84	37-115	07/01/2020 1201
3+4-Methylphenol	8.0	6.0		1	74	44-112	07/01/2020 1201
Naphthalene	8.0	5.3		1	67	40-122	07/01/2020 1201
2-Nitroaniline	8.0	6.2		1	78	49-128	07/01/2020 1201
3-Nitroaniline	8.0	0.87	N	1	11	31-128	07/01/2020 1201
4-Nitroaniline	8.0	3.3		1	41	30-135	07/01/2020 1201
Nitrobenzene	8.0	5.9		1	74	39-123	07/01/2020 1201
2-Nitrophenol	8.0	6.1		1	76	36-123	07/01/2020 1201
4-Nitrophenol	16	8.2		1	52	31-145	07/01/2020 1201
N-Nitrosodi-n-propylamine	8.0	6.7		1	83	39-119	07/01/2020 1201
N-Nitrosodiphenylamine (Diphenylamine)	8.0	3.6		1	46	30-123	07/01/2020 1201
Pentachlorophenol	16	11		1	70	34-137	07/01/2020 1201
Phenanthrene	8.0	6.1		1	77	40-123	07/01/2020 1201
Phenol	8.0	4.6		1	58	30-130	07/01/2020 1201
Pyrene	8.0	7.9		1	98	40-126	07/01/2020 1201
1,2,4,5-Tetrachlorobenzene	8.0	5.1		1	64	30-130	07/01/2020 1201
2,3,4,6-Tetrachlorophenol	8.0	6.6		1	82	30-130	07/01/2020 1201
1,2,4-Trichlorobenzene	8.0	5.3		1	67	20-90	07/01/2020 1201
2,4,5-Trichlorophenol	8.0	6.0		1	74	30-123	07/01/2020 1201
2,4,6-Trichlorophenol	8.0	6.2		1	77	30-125	07/01/2020 1201

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		74	37-129
2-Fluorophenol		43	24-127
Nitrobenzene-d5		69	38-127
Phenol-d5		58	28-128
Terphenyl-d14		97	10-148
2,4,6-Tribromophenol		91	35-144

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 DL

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

Pace Analytical Services, LLC *(formerly Shealy Environmental Services, Inc.)*
106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

Semivolatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-001MS
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acenaphthene	ND	80	58		1	72	30-122	07/01/2020 1912
Acenaphthylene	ND	80	64		1	79	30-130	07/01/2020 1912
Anthracene	ND	80	61		1	76	30-123	07/01/2020 1912
Benzo(a)anthracene	ND	80	72		1	90	40-125	07/01/2020 1912
Benzo(a)pyrene	ND	80	65		1	82	40-128	07/01/2020 1912
Benzo(b)fluoranthene	ND	80	73		1	91	30-130	07/01/2020 1912
Benzo(g,h,i)perylene	ND	80	64		1	80	30-130	07/01/2020 1912
Benzo(k)fluoranthene	ND	80	71		1	89	30-130	07/01/2020 1912
4-Bromophenyl phenyl ether	ND	80	63		1	79	30-124	07/01/2020 1912
Butyl benzyl phthalate	ND	80	78		1	98	54-135	07/01/2020 1912
Carbazole	ND	80	66		1	82	30-130	07/01/2020 1912
bis (2-Chloro-1-methylethyl) ether	ND	80	170	N	1	216	30-130	07/01/2020 1912
4-Chloro-3-methyl phenol	ND	80	62		1	77	30-130	07/01/2020 1912
bis(2-Chloroethoxy)methane	ND	80	54		1	67	30-130	07/01/2020 1912
bis(2-Chloroethyl)ether	ND	80	72		1	90	30-130	07/01/2020 1912
2-Chloronaphthalene	ND	80	62		1	77	30-130	07/01/2020 1912
2-Chlorophenol	ND	80	57		1	71	30-130	07/01/2020 1912
4-Chlorophenyl phenyl ether	ND	80	65		1	81	30-121	07/01/2020 1912
Chrysene	ND	80	74		1	92	30-130	07/01/2020 1912
Dibenzo(a,h)anthracene	ND	80	64		1	79	30-130	07/01/2020 1912
Dibenzofuran	ND	80	62		1	78	30-118	07/01/2020 1912
1,2-Dichlorobenzene	ND	80	67		1	84	30-130	07/01/2020 1912
1,3-Dichlorobenzene	ND	80	49		1	61	30-130	07/01/2020 1912
1,4-Dichlorobenzene	ND	80	50		1	62	30-130	07/01/2020 1912
3,3'-Dichlorobenzidine	ND	80	ND	N	1	0.00	10-126	07/01/2020 1912
2,4-Dichlorophenol	ND	80	58		1	72	30-121	07/01/2020 1912
Diethylphthalate	ND	80	69		1	86	40-125	07/01/2020 1912
Dimethyl phthalate	ND	80	69		1	86	40-127	07/01/2020 1912
2,4-Dimethylphenol	84	80	160		1	99	20-125	07/01/2020 1912
Di-n-butyl phthalate	6.1	80	68		1	77	40-127	07/01/2020 1912
4,6-Dinitro-2-methylphenol	ND	80	59		1	74	30-130	07/01/2020 1912
2,4-Dinitrophenol	ND	160	89		1	56	30-130	07/01/2020 1912
2,4-Dinitrotoluene	ND	80	76		1	95	30-130	07/01/2020 1912
2,6-Dinitrotoluene	ND	80	72		1	90	30-130	07/01/2020 1912
Di-n-octylphthalate	ND	80	58		1	72	30-130	07/01/2020 1912
bis(2-Ethylhexyl)phthalate	11	80	80		1	86	30-130	07/01/2020 1912
Fluoranthene	ND	80	62		1	78	40-128	07/01/2020 1912
Fluorene	ND	80	63		1	79	30-124	07/01/2020 1912
Hexachlorobenzene	ND	80	65		1	82	30-125	07/01/2020 1912
Hexachlorobutadiene	ND	80	44		1	55	24-110	07/01/2020 1912
Hexachlorocyclopentadiene	ND	400	150		1	38	30-130	07/01/2020 1912
Hexachloroethane	ND	80	80		1	100	30-130	07/01/2020 1912
Indeno(1,2,3-c,d)pyrene	ND	80	63		1	79	30-130	07/01/2020 1912
Isophorone	ND	80	59		1	74	30-130	07/01/2020 1912

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 DL
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

Semivolatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-001MS
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
2-Methylnaphthalene	5.4	80	58		1	66	40-132	07/01/2020 1912
2-Methylphenol	ND	80	94		1	118	30-130	07/01/2020 1912
3+4-Methylphenol	ND	80	78		1	98	30-130	07/01/2020 1912
Naphthalene	24	80	80		1	71	30-130	07/01/2020 1912
2-Nitroaniline	ND	80	68		1	85	30-130	07/01/2020 1912
3-Nitroaniline	ND	80	18	N	1	22	30-130	07/01/2020 1912
4-Nitroaniline	ND	80	47		1	58	30-135	07/01/2020 1912
Nitrobenzene	ND	80	65		1	82	30-130	07/01/2020 1912
2-Nitrophenol	ND	80	64		1	80	30-130	07/01/2020 1912
4-Nitrophenol	ND	160	87		1	54	30-130	07/01/2020 1912
N-Nitrosodi-n-propylamine	ND	80	72		1	90	30-130	07/01/2020 1912
N-Nitrosodiphenylamine (Diphenylamine)	ND	80	69		1	87	30-123	07/01/2020 1912
Pentachlorophenol	ND	160	130		1	81	30-130	07/01/2020 1912
Phenanthrene	ND	80	61		1	76	40-123	07/01/2020 1912
Phenol	53	80	120		1	85	30-130	07/01/2020 1912
Pyrene	ND	80	71		1	89	40-126	07/01/2020 1912
1,2,4,5-Tetrachlorobenzene	ND	80	50		1	63	30-130	07/01/2020 1912
2,3,4,6-Tetrachlorophenol	ND	80	76		1	95	30-130	07/01/2020 1912
1,2,4-Trichlorobenzene	ND	80	49		1	61	20-90	07/01/2020 1912
2,4,5-Trichlorophenol	ND	80	64		1	80	30-123	07/01/2020 1912
2,4,6-Trichlorophenol	ND	80	63		1	79	30-125	07/01/2020 1912

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		76	37-129
2-Fluorophenol		45	24-127
Nitrobenzene-d5		83	38-127
Phenol-d5		73	28-128
Terphenyl-d14		87	10-148
2,4,6-Tribromophenol		97	35-144

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 DL
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

Semivolatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-001MD
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Acenaphthene	ND	80	61		1	76	4.9	30-122	40	07/01/2020 1938
Acenaphthylene	ND	80	65		1	82	3.0	30-130	40	07/01/2020 1938
Anthracene	ND	80	64		1	80	5.0	30-123	40	07/01/2020 1938
Benzo(a)anthracene	ND	80	74		1	92	3.2	40-125	40	07/01/2020 1938
Benzo(a)pyrene	ND	80	71		1	89	8.5	40-128	40	07/01/2020 1938
Benzo(b)fluoranthene	ND	80	77		1	96	5.2	30-130	40	07/01/2020 1938
Benzo(g,h,i)perylene	ND	80	62		1	78	3.0	30-130	40	07/01/2020 1938
Benzo(k)fluoranthene	ND	80	77		1	97	7.8	30-130	40	07/01/2020 1938
4-Bromophenyl phenyl ether	ND	80	67		1	84	5.8	30-124	40	07/01/2020 1938
Butyl benzyl phthalate	ND	80	79		1	99	0.93	54-135	40	07/01/2020 1938
Carbazole	ND	80	64		1	80	3.0	30-130	40	07/01/2020 1938
bis (2-Chloro-1-methylethyl) ether	ND	80	430	N,+	1	535	85	30-130	40	07/01/2020 1938
4-Chloro-3-methyl phenol	ND	80	60		1	75	3.0	30-130	40	07/01/2020 1938
bis(2-Chloroethoxy)methane	ND	80	54		1	67	0.45	30-130	40	07/01/2020 1938
bis(2-Chloroethyl)ether	ND	80	72		1	90	0.36	30-130	40	07/01/2020 1938
2-Chloronaphthalene	ND	80	60		1	75	2.6	30-130	40	07/01/2020 1938
2-Chlorophenol	ND	80	56		1	69	2.8	30-130	40	07/01/2020 1938
4-Chlorophenyl phenyl ether	ND	80	66		1	83	2.3	30-121	40	07/01/2020 1938
Chrysene	ND	80	75		1	94	1.6	30-130	40	07/01/2020 1938
Dibenzo(a,h)anthracene	ND	80	ND	N,+	1	0.00	200	30-130	40	07/01/2020 1938
Dibenzofuran	ND	80	65		1	81	4.1	30-118	40	07/01/2020 1938
1,2-Dichlorobenzene	ND	80	66		1	82	2.3	30-130	40	07/01/2020 1938
1,3-Dichlorobenzene	ND	80	47		1	59	3.1	30-130	40	07/01/2020 1938
1,4-Dichlorobenzene	ND	80	49		1	61	1.8	30-130	40	07/01/2020 1938
3,3'-Dichlorobenzidine	ND	80	ND	N	1	0.00	0.00	10-126	40	07/01/2020 1938
2,4-Dichlorophenol	ND	80	58		1	73	1.6	30-121	40	07/01/2020 1938
Diethylphthalate	ND	80	71		1	89	2.5	40-125	40	07/01/2020 1938
Dimethyl phthalate	ND	80	70		1	88	1.5	40-127	40	07/01/2020 1938
2,4-Dimethylphenol	84	80	220	N	1	173	31	20-125	40	07/01/2020 1938
Di-n-butyl phthalate	6.1	80	71		1	81	4.7	40-127	40	07/01/2020 1938
4,6-Dinitro-2-methylphenol	ND	80	57		1	72	3.1	30-130	40	07/01/2020 1938
2,4-Dinitrophenol	ND	160	91		1	57	1.7	30-130	40	07/01/2020 1938
2,4-Dinitrotoluene	ND	80	77		1	96	1.9	30-130	40	07/01/2020 1938
2,6-Dinitrotoluene	ND	80	76		1	95	5.1	30-130	40	07/01/2020 1938
Di-n-octylphthalate	ND	80	60		1	75	3.8	30-130	40	07/01/2020 1938
bis(2-Ethylhexyl)phthalate	11	80	100		1	117	27	30-130	40	07/01/2020 1938
Fluoranthene	ND	80	61		1	77	1.4	40-128	40	07/01/2020 1938
Fluorene	ND	80	66		1	82	3.5	30-124	40	07/01/2020 1938
Hexachlorobenzene	ND	80	68		1	85	4.6	30-125	40	07/01/2020 1938
Hexachlorobutadiene	ND	80	43		1	54	1.7	24-110	40	07/01/2020 1938
Hexachlorocyclopentadiene	ND	400	170		1	43	11	30-130	40	07/01/2020 1938
Hexachloroethane	ND	80	82		1	103	3.1	30-130	40	07/01/2020 1938
Indeno(1,2,3-c,d)pyrene	ND	80	65		1	81	2.3	30-130	40	07/01/2020 1938
Isophorone	ND	80	63		1	78	5.8	30-130	40	07/01/2020 1938

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 DL

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

Semivolatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-001MD
Batch: 58389
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 06/29/2020 1800

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
2-Methylnaphthalene	5.4	80	63		1	71	7.1	40-132	40	07/01/2020 1938
2-Methylphenol	ND	80	99		1	123	4.5	30-130	40	07/01/2020 1938
3+4-Methylphenol	ND	80	85		1	106	8.7	30-130	40	07/01/2020 1938
Naphthalene	24	80	95		1	88	16	30-130	40	07/01/2020 1938
2-Nitroaniline	ND	80	77		1	96	12	30-130	40	07/01/2020 1938
3-Nitroaniline	ND	80	5.5	N,+	1	6.8	110	30-130	40	07/01/2020 1938
4-Nitroaniline	ND	80	8.6	N,+	1	11	140	30-135	40	07/01/2020 1938
Nitrobenzene	ND	80	64		1	80	2.6	30-130	40	07/01/2020 1938
2-Nitrophenol	ND	80	68		1	85	5.5	30-130	40	07/01/2020 1938
4-Nitrophenol	ND	160	87		1	54	0.19	30-130	40	07/01/2020 1938
N-Nitrosodi-n-propylamine	ND	80	62		1	78	14	30-130	40	07/01/2020 1938
N-Nitrosodiphenylamine (Diphenylamine)	ND	80	72		1	90	4.1	30-123	40	07/01/2020 1938
Pentachlorophenol	ND	160	140		1	84	3.8	30-130	40	07/01/2020 1938
Phenanthrene	ND	80	63		1	79	3.3	40-123	40	07/01/2020 1938
Phenol	53	80	160		1	129	25	30-130	40	07/01/2020 1938
Pyrene	ND	80	70		1	87	1.8	40-126	40	07/01/2020 1938
1,2,4,5-Tetrachlorobenzene	ND	80	54		1	67	6.5	30-130	40	07/01/2020 1938
2,3,4,6-Tetrachlorophenol	ND	80	81		1	101	5.8	30-130	40	07/01/2020 1938
1,2,4-Trichlorobenzene	ND	80	48		1	60	0.66	20-90	40	07/01/2020 1938
2,4,5-Trichlorophenol	ND	80	70		1	87	8.4	30-123	40	07/01/2020 1938
2,4,6-Trichlorophenol	ND	80	66		1	83	4.9	30-125	40	07/01/2020 1938

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		76	37-129
2-Fluorophenol		45	24-127
Nitrobenzene-d5		78	38-127
Phenol-d5		74	28-128
Terphenyl-d14		86	10-148
2,4,6-Tribromophenol		101	35-144

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 DL
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

Semivolatile Organic Compounds by GC/MS - MB

Sample ID: VQ58869-001
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Acenaphthene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
Acenaphthylene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
Anthracene	ND		1	0.20	0.060	ug/L	07/07/2020 1117
Benzo(a)anthracene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
Benzo(a)pyrene	ND		1	0.20	0.070	ug/L	07/07/2020 1117
Benzo(b)fluoranthene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
Benzo(g,h,i)perylene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
Benzo(k)fluoranthene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
4-Bromophenyl phenyl ether	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Butyl benzyl phthalate	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Carbazole	ND		1	0.80	0.50	ug/L	07/07/2020 1117
bis (2-Chloro-1-methylethyl) ether	ND		1	0.80	0.50	ug/L	07/07/2020 1117
4-Chloro-3-methyl phenol	ND		1	0.80	0.50	ug/L	07/07/2020 1117
bis(2-Chloroethoxy)methane	ND		1	0.80	0.50	ug/L	07/07/2020 1117
bis(2-Chloroethyl)ether	ND		1	0.80	0.50	ug/L	07/07/2020 1117
2-Chloronaphthalene	ND		1	0.80	0.50	ug/L	07/07/2020 1117
2-Chlorophenol	ND		1	0.80	0.50	ug/L	07/07/2020 1117
4-Chlorophenyl phenyl ether	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Chrysene	ND		1	0.20	0.030	ug/L	07/07/2020 1117
Dibenzo(a,h)anthracene	ND		1	0.20	0.030	ug/L	07/07/2020 1117
Dibenzofuran	ND		1	0.80	0.50	ug/L	07/07/2020 1117
1,2-Dichlorobenzene	ND		1	0.80	0.50	ug/L	07/07/2020 1117
1,3-Dichlorobenzene	ND		1	0.80	0.50	ug/L	07/07/2020 1117
1,4-Dichlorobenzene	ND		1	0.80	0.50	ug/L	07/07/2020 1117
3,3'-Dichlorobenzidine	ND		1	4.0	1.8	ug/L	07/07/2020 1117
2,4-Dichlorophenol	ND		1	1.6	1.0	ug/L	07/07/2020 1117
Diethylphthalate	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Dimethyl phthalate	ND		1	0.80	0.50	ug/L	07/07/2020 1117
2,4-Dimethylphenol	ND		1	0.80	0.48	ug/L	07/07/2020 1117
Di-n-butyl phthalate	ND		1	0.80	0.50	ug/L	07/07/2020 1117
4,6-Dinitro-2-methylphenol	ND		1	4.0	1.0	ug/L	07/07/2020 1117
2,4-Dinitrophenol	ND		1	4.0	1.0	ug/L	07/07/2020 1117
2,4-Dinitrotoluene	ND		1	1.6	0.50	ug/L	07/07/2020 1117
2,6-Dinitrotoluene	ND		1	1.6	0.50	ug/L	07/07/2020 1117
Di-n-octylphthalate	ND		1	0.80	0.50	ug/L	07/07/2020 1117
bis(2-Ethylhexyl)phthalate	**1.1**	**J**	**1**	**4.0**	**0.50**	**ug/L**	**07/07/2020 1117**
Fluoranthene	ND		1	0.20	0.10	ug/L	07/07/2020 1117
Fluorene	ND		1	0.20	0.030	ug/L	07/07/2020 1117
Hexachlorobenzene	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Hexachlorobutadiene	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Hexachlorocyclopentadiene	ND		1	4.0	2.0	ug/L	07/07/2020 1117
Hexachloroethane	ND		1	0.80	0.31	ug/L	07/07/2020 1117
Indeno(1,2,3-c,d)pyrene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
Isophorone	ND		1	0.80	0.50	ug/L	07/07/2020 1117

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 DL
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

Semivolatile Organic Compounds by GC/MS - MB

Sample ID: VQ58869-001
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
2-Methylnaphthalene	ND		1	0.20	0.040	ug/L	07/07/2020 1117
2-Methylphenol	ND		1	0.80	0.21	ug/L	07/07/2020 1117
3+4-Methylphenol	ND		1	1.6	1.5	ug/L	07/07/2020 1117
Naphthalene	ND		1	0.20	0.050	ug/L	07/07/2020 1117
2-Nitroaniline	ND		1	1.6	0.50	ug/L	07/07/2020 1117
3-Nitroaniline	ND		1	1.6	1.0	ug/L	07/07/2020 1117
4-Nitroaniline	ND		1	1.6	1.5	ug/L	07/07/2020 1117
Nitrobenzene	ND		1	0.80	0.55	ug/L	07/07/2020 1117
2-Nitrophenol	ND		1	1.6	1.0	ug/L	07/07/2020 1117
4-Nitrophenol	ND		1	4.0	2.0	ug/L	07/07/2020 1117
N-Nitrosodi-n-propylamine	ND		1	0.80	0.50	ug/L	07/07/2020 1117
N-Nitrosodiphenylamine (Diphenylamine)	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Pentachlorophenol	ND		1	4.0	2.0	ug/L	07/07/2020 1117
Phenanthrene	ND		1	0.20	0.060	ug/L	07/07/2020 1117
Phenol	ND		1	0.80	0.50	ug/L	07/07/2020 1117
Pyrene	ND		1	0.20	0.10	ug/L	07/07/2020 1117
1,2,4,5-Tetrachlorobenzene	ND		1	0.80	0.25	ug/L	07/07/2020 1117
2,3,4,6-Tetrachlorophenol	ND		1	1.6	0.55	ug/L	07/07/2020 1117
1,2,4-Trichlorobenzene	ND		1	0.80	0.37	ug/L	07/07/2020 1117
2,4,5-Trichlorophenol	ND		1	0.80	0.50	ug/L	07/07/2020 1117
2,4,6-Trichlorophenol	ND		1	0.80	0.50	ug/L	07/07/2020 1117

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		66	37-129
2-Fluorophenol		30	24-127
Nitrobenzene-d5		70	38-127
Phenol-d5		48	28-128
Terphenyl-d14		78	10-148
2,4,6-Tribromophenol		60	35-144

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 DL
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

Semivolatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58869-002
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acenaphthene	8.0	5.2		1	64	30-122	07/07/2020 1141
Acenaphthylene	8.0	5.4		1	68	30-130	07/07/2020 1141
Anthracene	8.0	5.4		1	67	30-123	07/07/2020 1141
Benzo(a)anthracene	8.0	6.8		1	85	40-125	07/07/2020 1141
Benzo(a)pyrene	8.0	6.5		1	82	40-128	07/07/2020 1141
Benzo(b)fluoranthene	8.0	6.6		1	83	32-145	07/07/2020 1141
Benzo(g,h,i)perylene	8.0	7.1		1	89	42-128	07/07/2020 1141
Benzo(k)fluoranthene	8.0	6.9		1	86	50-135	07/07/2020 1141
4-Bromophenyl phenyl ether	8.0	4.8		1	60	30-124	07/07/2020 1141
Butyl benzyl phthalate	8.0	7.9		1	99	54-135	07/07/2020 1141
Carbazole	8.0	6.5		1	81	30-130	07/07/2020 1141
bis (2-Chloro-1-methylethyl) ether	8.0	7.1		1	89	34-110	07/07/2020 1141
4-Chloro-3-methyl phenol	8.0	5.5		1	68	30-123	07/07/2020 1141
bis(2-Chloroethoxy)methane	8.0	5.6		1	70	40-119	07/07/2020 1141
bis(2-Chloroethyl)ether	8.0	7.4		1	92	35-114	07/07/2020 1141
2-Chloronaphthalene	8.0	4.8		1	60	39-128	07/07/2020 1141
2-Chlorophenol	8.0	4.3		1	53	39-115	07/07/2020 1141
4-Chlorophenyl phenyl ether	8.0	4.9		1	62	30-121	07/07/2020 1141
Chrysene	8.0	6.8		1	85	50-130	07/07/2020 1141
Dibenzo(a,h)anthracene	8.0	6.8		1	85	30-130	07/07/2020 1141
Dibenzofuran	8.0	5.1		1	63	30-118	07/07/2020 1141
1,2-Dichlorobenzene	8.0	4.4		1	55	20-110	07/07/2020 1141
1,3-Dichlorobenzene	8.0	3.7		1	47	17-112	07/07/2020 1141
1,4-Dichlorobenzene	8.0	3.9		1	49	18-113	07/07/2020 1141
3,3'-Dichlorobenzidine	8.0	14	N	1	171	10-126	07/07/2020 1141
2,4-Dichlorophenol	8.0	4.5		1	56	30-121	07/07/2020 1141
Diethylphthalate	8.0	7.3		1	91	40-125	07/07/2020 1141
Dimethyl phthalate	8.0	5.8		1	73	40-127	07/07/2020 1141
2,4-Dimethylphenol	8.0	5.3		1	66	20-125	07/07/2020 1141
Di-n-butyl phthalate	8.0	7.4		1	93	40-127	07/07/2020 1141
4,6-Dinitro-2-methylphenol	8.0	5.6		1	70	46-134	07/07/2020 1141
2,4-Dinitrophenol	16	9.9		1	62	11-126	07/07/2020 1141
2,4-Dinitrotoluene	8.0	7.7		1	96	51-128	07/07/2020 1141
2,6-Dinitrotoluene	8.0	5.7		1	71	48-133	07/07/2020 1141
Di-n-octylphthalate	8.0	7.1		1	88	55-143	07/07/2020 1141
bis(2-Ethylhexyl)phthalate	8.0	8.8		1	109	50-133	07/07/2020 1141
Fluoranthene	8.0	5.7		1	72	40-128	07/07/2020 1141
Fluorene	8.0	5.0		1	63	30-124	07/07/2020 1141
Hexachlorobenzene	8.0	4.9		1	61	30-125	07/07/2020 1141
Hexachlorobutadiene	8.0	3.5		1	44	24-110	07/07/2020 1141
Hexachlorocyclopentadiene	40	13		1	33	22-122	07/07/2020 1141
Hexachloroethane	8.0	3.9		1	49	28-116	07/07/2020 1141
Indeno(1,2,3-c,d)pyrene	8.0	6.7		1	84	50-125	07/07/2020 1141
Isophorone	8.0	5.8		1	72	30-130	07/07/2020 1141

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 DL

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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Semivolatile Organic Compounds by GC/MS - LCS

Sample ID: VQ58869-002
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
2-Methylnaphthalene	8.0	4.7		1	59	40-132	07/07/2020 1141
2-Methylphenol	8.0	5.4		1	68	37-115	07/07/2020 1141
3+4-Methylphenol	8.0	7.1		1	89	44-112	07/07/2020 1141
Naphthalene	8.0	5.1		1	64	40-122	07/07/2020 1141
2-Nitroaniline	8.0	12	N	1	147	49-128	07/07/2020 1141
3-Nitroaniline	8.0	12	N	1	155	31-128	07/07/2020 1141
4-Nitroaniline	8.0	14	N	1	171	30-135	07/07/2020 1141
Nitrobenzene	8.0	5.2		1	66	39-123	07/07/2020 1141
2-Nitrophenol	8.0	5.1		1	64	36-123	07/07/2020 1141
4-Nitrophenol	16	13		1	79	31-145	07/07/2020 1141
N-Nitrosodi-n-propylamine	8.0	7.9		1	99	39-119	07/07/2020 1141
N-Nitrosodiphenylamine (Diphenylamine)	8.0	5.9		1	74	30-123	07/07/2020 1141
Pentachlorophenol	16	9.9		1	62	34-137	07/07/2020 1141
Phenanthrene	8.0	5.3		1	66	40-123	07/07/2020 1141
Phenol	8.0	4.2		1	52	30-130	07/07/2020 1141
Pyrene	8.0	7.1		1	88	40-126	07/07/2020 1141
1,2,4,5-Tetrachlorobenzene	8.0	3.9		1	49	30-130	07/07/2020 1141
2,3,4,6-Tetrachlorophenol	8.0	5.1		1	63	30-130	07/07/2020 1141
1,2,4-Trichlorobenzene	8.0	3.9		1	49	20-90	07/07/2020 1141
2,4,5-Trichlorophenol	8.0	5.0		1	63	30-123	07/07/2020 1141
2,4,6-Trichlorophenol	8.0	4.9		1	61	30-125	07/07/2020 1141

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		62	37-129
2-Fluorophenol		28	24-127
Nitrobenzene-d5		63	38-127
Phenol-d5		54	28-128
Terphenyl-d14		82	10-148
2,4,6-Tribromophenol		63	35-144

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 DL

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

Semivolatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-005MS
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Acenaphthene	ND	8.0	6.4		1	81	30-122	07/07/2020 1523
Acenaphthylene	ND	8.0	6.6		1	83	30-130	07/07/2020 1523
Anthracene	ND	8.0	6.2		1	77	30-123	07/07/2020 1523
Benzo(a)anthracene	ND	8.0	6.6		1	83	40-125	07/07/2020 1523
Benzo(a)pyrene	ND	8.0	6.2		1	77	40-128	07/07/2020 1523
Benzo(b)fluoranthene	ND	8.0	6.7		1	84	30-130	07/07/2020 1523
Benzo(g,h,i)perylene	ND	8.0	5.6		1	70	30-130	07/07/2020 1523
Benzo(k)fluoranthene	ND	8.0	6.6		1	83	30-130	07/07/2020 1523
4-Bromophenyl phenyl ether	ND	8.0	5.9		1	74	30-124	07/07/2020 1523
Butyl benzyl phthalate	ND	8.0	8.6		1	107	54-135	07/07/2020 1523
Carbazole	ND	8.0	6.6		1	83	30-130	07/07/2020 1523
bis (2-Chloro-1-methylethyl) ether	ND	8.0	7.7		1	96	30-130	07/07/2020 1523
4-Chloro-3-methyl phenol	ND	8.0	7.0		1	87	30-130	07/07/2020 1523
bis(2-Chloroethoxy)methane	ND	8.0	7.6		1	95	30-130	07/07/2020 1523
bis(2-Chloroethyl)ether	ND	8.0	7.4		1	92	30-130	07/07/2020 1523
2-Chloronaphthalene	ND	8.0	6.0		1	75	30-130	07/07/2020 1523
2-Chlorophenol	ND	8.0	5.5		1	69	30-130	07/07/2020 1523
4-Chlorophenyl phenyl ether	ND	8.0	6.1		1	76	30-121	07/07/2020 1523
Chrysene	ND	8.0	7.0		1	87	30-130	07/07/2020 1523
Dibenzo(a,h)anthracene	ND	8.0	5.6		1	70	30-130	07/07/2020 1523
Dibenzofuran	ND	8.0	6.3		1	78	30-118	07/07/2020 1523
1,2-Dichlorobenzene	ND	8.0	5.5		1	69	30-130	07/07/2020 1523
1,3-Dichlorobenzene	ND	8.0	5.5		1	69	30-130	07/07/2020 1523
1,4-Dichlorobenzene	ND	8.0	5.7		1	72	30-130	07/07/2020 1523
3,3'-Dichlorobenzidine	ND	8.0	ND	N	1	0.00	10-126	07/07/2020 1523
2,4-Dichlorophenol	ND	8.0	6.7		1	83	30-121	07/07/2020 1523
Diethylphthalate	ND	8.0	7.4		1	92	40-125	07/07/2020 1523
Dimethyl phthalate	ND	8.0	6.6		1	83	40-127	07/07/2020 1523
2,4-Dimethylphenol	ND	8.0	9.5		1	118	20-125	07/07/2020 1523
Di-n-butyl phthalate	ND	8.0	6.8		1	85	40-127	07/07/2020 1523
4,6-Dinitro-2-methylphenol	ND	8.0	4.8		1	59	30-130	07/07/2020 1523
2,4-Dinitrophenol	ND	16	9.2		1	57	30-130	07/07/2020 1523
2,4-Dinitrotoluene	ND	8.0	6.9		1	87	30-130	07/07/2020 1523
2,6-Dinitrotoluene	ND	8.0	6.5		1	82	30-130	07/07/2020 1523
Di-n-octylphthalate	ND	8.0	6.2		1	78	30-130	07/07/2020 1523
bis(2-Ethylhexyl)phthalate	7.6	8.0	7.9	N	1	4.1	30-130	07/07/2020 1523
Fluoranthene	ND	8.0	5.9		1	74	40-128	07/07/2020 1523
Fluorene	ND	8.0	6.2		1	77	30-124	07/07/2020 1523
Hexachlorobenzene	ND	8.0	5.7		1	72	30-125	07/07/2020 1523
Hexachlorobutadiene	ND	8.0	5.3		1	66	24-110	07/07/2020 1523
Hexachlorocyclopentadiene	ND	40	19		1	47	30-130	07/07/2020 1523
Hexachloroethane	ND	8.0	7.1		1	89	30-130	07/07/2020 1523
Indeno(1,2,3-c,d)pyrene	ND	8.0	5.5		1	68	30-130	07/07/2020 1523
Isophorone	ND	8.0	8.1		1	101	30-130	07/07/2020 1523

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 DL
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

Semivolatile Organic Compounds by GC/MS - MS

Sample ID: VF24007-005MS
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
2-Methylnaphthalene	ND	8.0	6.5		1	81	40-132	07/07/2020 1523
2-Methylphenol	ND	8.0	6.7		1	84	30-130	07/07/2020 1523
3+4-Methylphenol	ND	8.0	7.3		1	91	30-130	07/07/2020 1523
Naphthalene	ND	8.0	6.3		1	79	30-130	07/07/2020 1523
2-Nitroaniline	ND	8.0	13	N	1	164	30-130	07/07/2020 1523
3-Nitroaniline	ND	8.0	6.9		1	86	30-130	07/07/2020 1523
4-Nitroaniline	ND	8.0	8.6		1	107	30-135	07/07/2020 1523
Nitrobenzene	ND	8.0	7.2		1	89	30-130	07/07/2020 1523
2-Nitrophenol	ND	8.0	7.0		1	87	30-130	07/07/2020 1523
4-Nitrophenol	ND	16	13		1	83	30-130	07/07/2020 1523
N-Nitrosodi-n-propylamine	ND	8.0	8.3		1	104	30-130	07/07/2020 1523
N-Nitrosodiphenylamine (Diphenylamine)	ND	8.0	6.9		1	86	30-123	07/07/2020 1523
Pentachlorophenol	ND	16	12		1	74	30-130	07/07/2020 1523
Phenanthrene	ND	8.0	6.2		1	77	40-123	07/07/2020 1523
Phenol	ND	8.0	5.8		1	72	30-130	07/07/2020 1523
Pyrene	ND	8.0	7.5		1	94	40-126	07/07/2020 1523
1,2,4,5-Tetrachlorobenzene	ND	8.0	5.1		1	63	30-130	07/07/2020 1523
2,3,4,6-Tetrachlorophenol	ND	8.0	6.5		1	81	30-130	07/07/2020 1523
1,2,4-Trichlorobenzene	ND	8.0	5.6		1	70	20-90	07/07/2020 1523
2,4,5-Trichlorophenol	ND	8.0	5.9		1	74	30-123	07/07/2020 1523
2,4,6-Trichlorophenol	ND	8.0	5.6		1	70	30-125	07/07/2020 1523

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		71	37-129
2-Fluorophenol		42	24-127
Nitrobenzene-d5		91	38-127
Phenol-d5		74	28-128
Terphenyl-d14		84	10-148
2,4,6-Tribromophenol		79	35-144

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 DL
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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Semivolatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-005MD
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Acenaphthene	ND	8.0	6.0		1	75	7.6	30-122	40	07/07/2020 1548
Acenaphthylene	ND	8.0	6.1		1	76	8.0	30-130	40	07/07/2020 1548
Anthracene	ND	8.0	6.2		1	77	0.024	30-123	40	07/07/2020 1548
Benzo(a)anthracene	ND	8.0	6.8		1	85	2.4	40-125	40	07/07/2020 1548
Benzo(a)pyrene	ND	8.0	6.3		1	79	2.9	40-128	40	07/07/2020 1548
Benzo(b)fluoranthene	ND	8.0	6.7		1	84	0.74	30-130	40	07/07/2020 1548
Benzo(g,h,i)perylene	ND	8.0	5.3		1	66	4.9	30-130	40	07/07/2020 1548
Benzo(k)fluoranthene	ND	8.0	6.8		1	85	2.0	30-130	40	07/07/2020 1548
4-Bromophenyl phenyl ether	ND	8.0	5.6		1	70	5.2	30-124	40	07/07/2020 1548
Butyl benzyl phthalate	ND	8.0	7.5		1	94	13	54-135	40	07/07/2020 1548
Carbazole	ND	8.0	6.5		1	81	2.5	30-130	40	07/07/2020 1548
bis (2-Chloro-1-methylethyl) ether	ND	8.0	7.3		1	91	4.8	30-130	40	07/07/2020 1548
4-Chloro-3-methyl phenol	ND	8.0	6.6		1	83	5.1	30-130	40	07/07/2020 1548
bis(2-Chloroethoxy)methane	ND	8.0	6.4		1	80	18	30-130	40	07/07/2020 1548
bis(2-Chloroethyl)ether	ND	8.0	6.8		1	85	8.0	30-130	40	07/07/2020 1548
2-Chloronaphthalene	ND	8.0	6.4		1	81	6.8	30-130	40	07/07/2020 1548
2-Chlorophenol	ND	8.0	4.6		1	58	17	30-130	40	07/07/2020 1548
4-Chlorophenyl phenyl ether	ND	8.0	6.2		1	77	1.7	30-121	40	07/07/2020 1548
Chrysene	ND	8.0	6.9		1	87	1.1	30-130	40	07/07/2020 1548
Dibenzo(a,h)anthracene	ND	8.0	5.5		1	68	2.0	30-130	40	07/07/2020 1548
Dibenzofuran	ND	8.0	6.2		1	78	0.67	30-118	40	07/07/2020 1548
1,2-Dichlorobenzene	ND	8.0	5.4		1	67	2.3	30-130	40	07/07/2020 1548
1,3-Dichlorobenzene	ND	8.0	5.2		1	65	7.1	30-130	40	07/07/2020 1548
1,4-Dichlorobenzene	ND	8.0	5.3		1	66	8.7	30-130	40	07/07/2020 1548
3,3'-Dichlorobenzidine	ND	8.0	ND	N	1	0.00	0.00	10-126	40	07/07/2020 1548
2,4-Dichlorophenol	ND	8.0	5.6		1	70	17	30-121	40	07/07/2020 1548
Diethylphthalate	ND	8.0	7.6		1	95	3.2	40-125	40	07/07/2020 1548
Dimethyl phthalate	ND	8.0	7.1		1	88	6.5	40-127	40	07/07/2020 1548
2,4-Dimethylphenol	ND	8.0	7.9		1	98	19	20-125	40	07/07/2020 1548
Di-n-butyl phthalate	ND	8.0	7.8		1	98	14	40-127	40	07/07/2020 1548
4,6-Dinitro-2-methylphenol	ND	8.0	4.5		1	56	5.2	30-130	40	07/07/2020 1548
2,4-Dinitrophenol	ND	16	8.4		1	52	8.8	30-130	40	07/07/2020 1548
2,4-Dinitrotoluene	ND	8.0	7.2		1	90	3.9	30-130	40	07/07/2020 1548
2,6-Dinitrotoluene	ND	8.0	6.3		1	79	3.9	30-130	40	07/07/2020 1548
Di-n-octylphthalate	ND	8.0	5.5		1	69	12	30-130	40	07/07/2020 1548
bis(2-Ethylhexyl)phthalate	7.6	8.0	7.1	N	1	-6.1	11	30-130	40	07/07/2020 1548
Fluoranthene	ND	8.0	6.1		1	76	2.8	40-128	40	07/07/2020 1548
Fluorene	ND	8.0	6.4		1	80	3.7	30-124	40	07/07/2020 1548
Hexachlorobenzene	ND	8.0	5.1		1	64	11	30-125	40	07/07/2020 1548
Hexachlorobutadiene	ND	8.0	4.7		1	58	12	24-110	40	07/07/2020 1548
Hexachlorocyclopentadiene	ND	40	19		1	47	0.49	30-130	40	07/07/2020 1548
Hexachloroethane	ND	8.0	6.6		1	82	7.8	30-130	40	07/07/2020 1548
Indeno(1,2,3-c,d)pyrene	ND	8.0	5.3		1	67	2.4	30-130	40	07/07/2020 1548
Isophorone	ND	8.0	6.7		1	84	18	30-130	40	07/07/2020 1548

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 DL

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

Semivolatile Organic Compounds by GC/MS - MSD

Sample ID: VF24007-005MD
Batch: 58869
Analytical Method: 8270E

Matrix: Aqueous
Prep Method: 3520C
Prep Date: 07/02/2020 1630

Parameter	Sample Amount (ug/L)	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
2-Methylnaphthalene	ND	8.0	5.8		1	72	12	40-132	40	07/07/2020 1548
2-Methylphenol	ND	8.0	6.5		1	81	4.4	30-130	40	07/07/2020 1548
3+4-Methylphenol	ND	8.0	6.8		1	85	6.8	30-130	40	07/07/2020 1548
Naphthalene	ND	8.0	5.9		1	73	7.2	30-130	40	07/07/2020 1548
2-Nitroaniline	ND	8.0	15	N	1	188	14	30-130	40	07/07/2020 1548
3-Nitroaniline	ND	8.0	7.2		1	90	4.3	30-130	40	07/07/2020 1548
4-Nitroaniline	ND	8.0	9.3		1	116	8.0	30-135	40	07/07/2020 1548
Nitrobenzene	ND	8.0	6.0		1	75	18	30-130	40	07/07/2020 1548
2-Nitrophenol	ND	8.0	5.8		1	73	18	30-130	40	07/07/2020 1548
4-Nitrophenol	ND	16	13		1	83	0.17	30-130	40	07/07/2020 1548
N-Nitrosodi-n-propylamine	ND	8.0	7.7		1	96	7.8	30-130	40	07/07/2020 1548
N-Nitrosodiphenylamine (Diphenylamine)	ND	8.0	6.9		1	87	1.2	30-123	40	07/07/2020 1548
Pentachlorophenol	ND	16	12		1	72	3.0	30-130	40	07/07/2020 1548
Phenanthrene	ND	8.0	6.1		1	76	1.9	40-123	40	07/07/2020 1548
Phenol	ND	8.0	5.0		1	63	13	30-130	40	07/07/2020 1548
Pyrene	ND	8.0	6.7		1	84	12	40-126	40	07/07/2020 1548
1,2,4,5-Tetrachlorobenzene	ND	8.0	5.3		1	67	5.2	30-130	40	07/07/2020 1548
2,3,4,6-Tetrachlorophenol	ND	8.0	6.8		1	85	4.7	30-130	40	07/07/2020 1548
1,2,4-Trichlorobenzene	ND	8.0	5.2		1	65	7.6	20-90	40	07/07/2020 1548
2,4,5-Trichlorophenol	ND	8.0	6.6		1	82	10	30-123	40	07/07/2020 1548
2,4,6-Trichlorophenol	ND	8.0	6.1		1	76	7.3	30-125	40	07/07/2020 1548

Surrogate	Q	% Rec	Acceptance Limit
2-Fluorobiphenyl		79	37-129
2-Fluorophenol		36	24-127
Nitrobenzene-d5		74	38-127
Phenol-d5		66	28-128
Terphenyl-d14		77	10-148
2,4,6-Tribromophenol		80	35-144

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 DL

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

Montana EPH (screening) - MB

Sample ID: VQ59047-001
Batch: 59047
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
TEH	ND		1	200	200	ug/L	07/07/2020 1627

Surrogate	Q	% Rec	Acceptance Limit
2-Bromonaphthalene (fractionation 2)		87	40-140
1-Chloro-octadecane (aliphatic)		53	40-140
2-Fluorobiphenyl (fractionation 1)		72	40-140
o - Terphenyl (aromatic)		64	40-140

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 DL
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

Montana EPH (screening) - LCS

Sample ID: VQ59047-002
Batch: 59047
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
TEH	1400	1200		1	88	40-140	07/08/2020 1810

Surrogate	Q	% Rec	Acceptance Limit
2-Bromonaphthalene (fractionation 2)		88	40-140
1-Chloro-octadecane (aliphatic)		60	40-140
2-Fluorobiphenyl (fractionation 1)		78	40-140
o - Terphenyl (aromatic)		66	40-140

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 DL

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

Montana EPH (screening) - LCSD

Sample ID: VQ59047-003
Batch: 59047
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
TEH	1400	1300		1	92	4.4	40-140	25	07/08/2020 1840

Surrogate	Q	% Rec	Acceptance Limit
2-Bromonaphthalene (fractionation 2)		95	40-140
1-Chloro-octadecane (aliphatic)		63	40-140
2-Fluorobiphenyl (fractionation 1)		78	40-140
o - Terphenyl (aromatic)		69	40-140

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 DL

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

Montana EPH (aliphatics) - MB

Sample ID: VQ59573-001
Batch: 59573
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
C19 - C36 Aliphatics	ND		1	100	100	ug/L	07/16/2020 2336
C9 - C18 Aliphatics	ND		1	100	100	ug/L	07/16/2020 2336
TEH, post-fractionation	ND		1	200	100	ug/L	07/17/2020 0000

Surrogate	Q	% Rec	Acceptance Limit
1-Chloro-octadecane (aliphatic)		69	40-140

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 DL

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

Montana EPH (aliphatics) - LCS

Sample ID: VQ59573-002
Batch: 59573
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
C19 - C36 Aliphatics	400	310		1	78	40-140	07/17/2020 0007
C9 - C18 Aliphatics	300	180		1	59	40-140	07/17/2020 0007
TEH, post-fractionation	1600	1200		1	76	40-140	07/17/2020 0000

Surrogate	Q	% Rec	Acceptance Limit
1-Chloro-octadecane (aliphatic)		72	40-140

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 DL

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

Montana EPH (aliphatics) - LCSD

Sample ID: VQ59573-003
Batch: 59573
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
C19 - C36 Aliphatics	400	360		1	90	15	40-140	25	07/17/2020 0038
C9 - C18 Aliphatics	300	180		1	59	0.21	40-140	25	07/17/2020 0038
TEH, post-fractionation	1600	1300		1	85	12	40-140	25	07/17/2020 0000

Surrogate	Q	% Rec	Acceptance Limit
1-Chloro-octadecane (aliphatic)		79	40-140

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 DL

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

Montana EPH (aromatics) - MB

Sample ID: VQ59574-001
Batch: 59574
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
C11 - C22 Aromatics	ND		1	100	100	ug/L	07/17/2020 0239

Surrogate	Q	% Rec	Acceptance Limit
2-Bromonaphthalene (fractionation 2)		79	40-140
2-Fluorobiphenyl (fractionation 1)		84	40-140
o - Terphenyl (aromatic)		75	40-140

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 DL

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

Montana EPH (aromatics) - LCS

Sample ID: VQ59574-002
Batch: 59574
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
C11 - C22 Aromatics	850	690		1	81	40-140	07/17/2020 0309

Surrogate	Q	% Rec	Acceptance Limit
2-Bromonaphthalene (fractionation 2)		95	40-140
2-Fluorobiphenyl (fractionation 1)		101	40-140
o - Terphenyl (aromatic)		85	40-140

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 DL

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

Montana EPH (aromatics) - LCSD

Sample ID: VQ59574-003
Batch: 59574
Analytical Method: Montana EPH

Matrix: Aqueous
Prep Method: Montana EPH
Prep Date: 07/06/2020 1615

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
C11 - C22 Aromatics	850	790		1	93	13	40-140	25	07/17/2020 0339

Surrogate	Q	% Rec	Acceptance Limit
2-Bromonaphthalene (fractionation 2)		110	40-140
2-Fluorobiphenyl (fractionation 1)		115	40-140
o - Terphenyl (aromatic)		99	40-140

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 DL

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

Montana VPH (aromatics) - MB

Sample ID: VQ58615-001
Batch: 58615
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Benzene	ND		1	5.0	0.51	ug/L	06/30/2020 1334
C9 - C10 Aromatics	ND		1	25	5.0	ug/L	06/30/2020 1334
Ethylbenzene	ND		1	5.0	0.62	ug/L	06/30/2020 1334
Methyl tertiary butyl ether (MTBE)	ND		1	5.0	1.2	ug/L	06/30/2020 1334
Naphthalene	ND		1	5.0	0.70	ug/L	06/30/2020 1334
Toluene	ND		1	5.0	0.53	ug/L	06/30/2020 1334
m+p - Xylenes	ND		1	5.0	1.2	ug/L	06/30/2020 1334
o - Xylenes	ND		1	5.0	0.58	ug/L	06/30/2020 1334

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (PID)		112	70-130

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 DL

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

Montana VPH (aromatics) - LCS

Sample ID: VQ58615-002
Batch: 58615
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Benzene	25	25		1	102	70-130	06/30/2020 1159
C9 - C10 Aromatics	25	26		1	102	70-130	06/30/2020 1159
Ethylbenzene	25	25		1	98	70-130	06/30/2020 1159
Methyl tertiary butyl ether (MTBE)	25	26		1	105	70-130	06/30/2020 1159
Naphthalene	25	25		1	99	70-130	06/30/2020 1159
Toluene	25	25		1	101	70-130	06/30/2020 1159
m+p - Xylenes	50	51		1	101	70-130	06/30/2020 1159
o - Xylenes	25	25		1	99	70-130	06/30/2020 1159

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (PID)		101	70-130

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 DL

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

Montana VPH (aromatics) - LCSD

Sample ID: VQ58615-003
Batch: 58615
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Benzene	25	28		1	110	8.3	70-130	25	06/30/2020 1228
C9 - C10 Aromatics	25	29		1	114	11	70-130	25	06/30/2020 1228
Ethylbenzene	25	28		1	110	11	70-130	25	06/30/2020 1228
Methyl tertiary butyl ether (MTBE)	25	27		1	109	4.1	70-130	25	06/30/2020 1228
Naphthalene	25	27		1	106	6.6	70-130	25	06/30/2020 1228
Toluene	25	28		1	110	8.3	70-130	25	06/30/2020 1228
m+p - Xylenes	50	56		1	112	10	70-130	25	06/30/2020 1228
o - Xylenes	25	27		1	110	10	70-130	25	06/30/2020 1228

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (PID)		112	70-130

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 DL

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

Montana VPH (aliphatics) - MB

Sample ID: VQ58616-001
Batch: 58616
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
C5 - C8 Aliphatics, Adjusted	ND		1	75	15	ug/L	06/30/2020 1334
C9 - C12 Aliphatics, Adjusted	ND		1	75	15	ug/L	06/30/2020 1334

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (FID)		114	70-130

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 DL

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

Montana VPH (aliphatics) - LCS

Sample ID: VQ58616-002
Batch: 58616
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
C5 - C8 Aliphatics, Adjusted	100	100		1	104	70-130	06/30/2020 1159
C9 - C12 Aliphatics, Adjusted	75	71		1	95	70-130	06/30/2020 1159

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (FID)		104	70-130

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 DL

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

Montana VPH (aliphatics) - LCSD

Sample ID: VQ58616-003
Batch: 58616
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
C5 - C8 Aliphatics, Adjusted	100	120		1	117	12	70-130	25	06/30/2020 1228
C9 - C12 Aliphatics, Adjusted	75	82		1	110	15	70-130	25	06/30/2020 1228

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (FID)		116	70-130

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 DL

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

Montana VPH (TPH) - MB

Sample ID: VQ58617-001
Batch: 58617
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
TPH	ND		1	180	35	ug/L	06/30/2020 1334

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (FID)		114	70-130

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 DL

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

Montana VPH (TPH) - LCS

Sample ID: VQ58617-002
Batch: 58617
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
TPH	380	380		1	100	70-130	06/30/2020 1159

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (FID)		104	70-130

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 DL

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

Montana VPH (TPH) - LCSD

Sample ID: VQ58617-003
Batch: 58617
Analytical Method: Montana VPH

Matrix: Aqueous
Prep Method: VPH

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
TPH	380	420		1	113	12	70-130	25	06/30/2020 1228

Surrogate	Q	% Rec	Acceptance Limit
2,5-Dibromotoluene (FID)		116	70-130

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 DL

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

ICP-MS - MB

Sample ID: VQ58605-001
Batch: 58605
Analytical Method: 6020B

Matrix: Aqueous
Prep Method: 3005A
Prep Date: 07/01/2020 0346

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Antimony	ND		1	2.0	0.50	ug/L	07/01/2020 2338
Arsenic	ND		1	2.0	1.3	ug/L	07/01/2020 2338
Barium	ND		1	5.0	1.3	ug/L	07/01/2020 2338
Beryllium	ND		1	0.40	0.15	ug/L	07/01/2020 2338
Cadmium	ND		1	0.50	0.13	ug/L	07/01/2020 2338
Chromium	ND		1	5.0	1.3	ug/L	07/01/2020 2338
Cobalt	ND		1	5.0	1.3	ug/L	07/01/2020 2338
Copper	ND		1	5.0	1.3	ug/L	07/01/2020 2338
Lead	ND		1	1.0	0.25	ug/L	07/01/2020 2338
Nickel	ND		1	5.0	1.3	ug/L	07/01/2020 2338
Selenium	ND		1	5.0	1.3	ug/L	07/01/2020 2338
Silver	ND		1	1.0	0.25	ug/L	07/01/2020 2338
Vanadium	ND		1	5.0	2.5	ug/L	07/01/2020 2338
Zinc	ND		1	10	2.5	ug/L	07/01/2020 2338

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 DL

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

ICP-MS - LCS

Sample ID: VQ58605-002
Batch: 58605
Analytical Method: 6020B

Matrix: Aqueous
Prep Method: 3005A
Prep Date: 07/01/2020 0346

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Antimony	100	96		1	96	80-120	07/01/2020 2345
Arsenic	100	110		1	109	80-120	07/01/2020 2345
Barium	100	100		1	101	80-120	07/01/2020 2345
Beryllium	100	100		1	102	80-120	07/01/2020 2345
Cadmium	100	100		1	104	80-120	07/01/2020 2345
Chromium	100	110		1	106	80-120	07/01/2020 2345
Cobalt	100	110		1	111	80-120	07/01/2020 2345
Copper	100	110		1	111	80-120	07/01/2020 2345
Lead	100	110		1	106	80-120	07/01/2020 2345
Nickel	100	110		1	111	80-120	07/01/2020 2345
Selenium	100	100		1	103	80-120	07/01/2020 2345
Silver	100	110		1	107	80-120	07/01/2020 2345
Vanadium	100	99		1	99	80-120	07/01/2020 2345
Zinc	100	110		1	112	80-120	07/01/2020 2345

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 DL

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

ICP-MS - MB

Sample ID: VQ58723-001
Batch: 58723
Analytical Method: 6020B

Matrix: Aqueous
Prep Method: 3005A
Prep Date: 07/01/2020 1647

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Dissolved Antimony	ND		1	2.0	0.50	ug/L	07/02/2020 1002
Dissolved Arsenic	ND		1	2.0	1.3	ug/L	07/02/2020 1002
Dissolved Barium	ND		1	5.0	1.3	ug/L	07/02/2020 1002
Dissolved Beryllium	ND		1	0.40	0.15	ug/L	07/02/2020 1002
Dissolved Cadmium	ND		1	0.50	0.13	ug/L	07/02/2020 1002
Dissolved Chromium	ND		1	5.0	1.3	ug/L	07/02/2020 1002
Dissolved Cobalt	ND		1	5.0	1.3	ug/L	07/02/2020 1002
Dissolved Copper	ND		1	5.0	1.3	ug/L	07/02/2020 1002
Dissolved Lead	ND		1	1.0	0.25	ug/L	07/02/2020 1002
Dissolved Nickel	ND		1	5.0	1.3	ug/L	07/02/2020 1002
Dissolved Selenium	ND		1	5.0	1.3	ug/L	07/02/2020 1002
Dissolved Silver	ND		1	1.0	0.25	ug/L	07/02/2020 1002
Dissolved Vanadium	ND		1	5.0	2.5	ug/L	07/02/2020 1002
Dissolved Zinc	ND		1	10	2.5	ug/L	07/02/2020 1002

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 DL

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

ICP-MS - LCS

Sample ID: VQ58723-002
Batch: 58723
Analytical Method: 6020B

Matrix: Aqueous
Prep Method: 3005A
Prep Date: 07/01/2020 1647

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Dissolved Antimony	100	100		1	103	80-120	07/02/2020 1007
Dissolved Arsenic	100	100		1	102	80-120	07/02/2020 1007
Dissolved Barium	100	100		1	102	80-120	07/02/2020 1007
Dissolved Beryllium	100	99		1	99	80-120	07/02/2020 1007
Dissolved Cadmium	100	100		1	100	80-120	07/02/2020 1007
Dissolved Chromium	100	99		1	99	80-120	07/02/2020 1007
Dissolved Cobalt	100	97		1	97	80-120	07/02/2020 1007
Dissolved Copper	100	100		1	102	80-120	07/02/2020 1007
Dissolved Lead	100	100		1	102	80-120	07/02/2020 1007
Dissolved Nickel	100	99		1	99	80-120	07/02/2020 1007
Dissolved Selenium	100	99		1	99	80-120	07/02/2020 1007
Dissolved Silver	100	100		1	101	80-120	07/02/2020 1007
Dissolved Vanadium	100	96		1	96	80-120	07/02/2020 1007
Dissolved Zinc	100	100		1	102	80-120	07/02/2020 1007

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 DL

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

ICP-MS - LCSD

Sample ID: VQ58723-003
Batch: 58723
Analytical Method: 6020B

Matrix: Aqueous
Prep Method: 3005A
Prep Date: 07/01/2020 1647

Parameter	Spike Amount (ug/L)	Result (ug/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Dissolved Antimony	100	100		1	101	1.9	80-120	20	07/02/2020 1013
Dissolved Arsenic	100	100		1	101	1.1	80-120	20	07/02/2020 1013
Dissolved Barium	100	99		1	99	2.5	80-120	20	07/02/2020 1013
Dissolved Beryllium	100	97		1	97	2.4	80-120	20	07/02/2020 1013
Dissolved Cadmium	100	98		1	98	2.1	80-120	20	07/02/2020 1013
Dissolved Chromium	100	97		1	97	1.8	80-120	20	07/02/2020 1013
Dissolved Cobalt	100	95		1	95	1.9	80-120	20	07/02/2020 1013
Dissolved Copper	100	99		1	99	3.1	80-120	20	07/02/2020 1013
Dissolved Lead	100	100		1	101	1.4	80-120	20	07/02/2020 1013
Dissolved Nickel	100	97		1	97	1.8	80-120	20	07/02/2020 1013
Dissolved Selenium	100	97		1	97	1.5	80-120	20	07/02/2020 1013
Dissolved Silver	100	98		1	98	2.6	80-120	20	07/02/2020 1013
Dissolved Vanadium	100	95		1	95	1.3	80-120	20	07/02/2020 1013
Dissolved Zinc	100	100		1	100	1.3	80-120	20	07/02/2020 1013

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 DL

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

ICP-MS - MB

Sample ID: VQ58030-001
Batch: 58030
Analytical Method: 7470A

Matrix: Aqueous
Prep Method:
Prep Date: 06/25/2020 1059

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Mercury	ND		1	0.00020	0.000091	mg/L	06/25/2020 1717

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 DL

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

ICP-MS - LCS

Sample ID: VQ58030-002
Batch: 58030
Analytical Method: 7470A

Matrix: Aqueous
Prep Method:
Prep Date: 06/25/2020 1059

Parameter	Spike Amount (mg/L)	Result (mg/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Mercury	0.0020	0.0020		1	99	80-120	06/25/2020 1720

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 DL

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

CVAA - MB

Sample ID: VQ58789-001
Batch: 58789
Analytical Method: 7470A

Matrix: Aqueous
Prep Method:
Prep Date: 07/02/2020 1122

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
Dissolved Mercury	ND		1	0.00020	0.000091	mg/L	07/02/2020 1459

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 DL

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

CVAA - LCS

Sample ID: VQ58789-002
Batch: 58789
Analytical Method: 7470A

Matrix: Aqueous
Prep Method:
Prep Date: 07/02/2020 1122

Parameter	Spike Amount (mg/L)	Result (mg/L)	Q	Dil	% Rec	% Rec Limit	Analysis Date
Dissolved Mercury	0.0020	0.0019		1	97	80-120	07/02/2020 1502

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 DL

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

CVAA - LCSD

Sample ID: VQ58789-003
Batch: 58789
Analytical Method: 7470A

Matrix: Aqueous
Prep Method:
Prep Date: 07/02/2020 1122

Parameter	Spike Amount (mg/L)	Result (mg/L)	Q	Dil	% Rec	% RPD	% Rec Limit	% RPD Limit	Analysis Date
Dissolved Mercury	0.0020	0.0020		1	98	1.9	80-120	20	07/02/2020 1504

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 DL

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

Chain of Custody
and
Miscellaneous Documents

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 097230

Client: Ramboll
Address: 333 W. Wacker Dr. Ste. 2700
City: Chicago | State: IL | Zip Code: 60606
Project Name: ACC-16 Interim Measure Design
Project No.: 1690014124-003
P.O. No.:
Report to Contact:
Sampler's Signature: x Brooks Bailey
Printed Name: Brooks Bailey
Telephone No. / E-mail: 612-209-8676 plindquist@ramboll.com
Quote No.:
Page 1 of 1
Analysis (Attach list if more space is needed)

VF24007

Sample ID / Description (Containers for each sample may be combined on one line)	Date	Time	Grab/Composite	Matrix: Aqueous	Soil	Non Aqueous	No. of Containers by Preservative Type: Unpres.	H2SO4	HNO3	HCl	NaOH	Other Kit	VOCs	SVOCs	VPH	Dissolved Metals	EPH	Remarks / Cooler I.D.
CMR-MW41s-200622	6.22.20	11:18	G	✓			2		1	5			X	X	X	X	X	( )=limited volume
CMR-TW203s-200622	6.22.20	12:21	G	✓			15			5			X	X	X	X		( )=limited volume use amber jars for other metals
CMR-TW202d-200622	6.22.20	13:17	G	✓			2 (1)		1	5			X	X	X	X	X	( )=limited volume
CMR-TW202s-200622	6.22.20	13:56	G	✓			1			5			X	X	X	X		(as)=lab filter metals
CMR-MW59s-200622	6.22.20	15:08	G	✓			2	2	1	5			X	X	X	X	X	
CMR-MW56s-200623	6.23.20	09:20	G	✓			2		1	5			X	X	X	X	X	( )=limited volume, use amber jars
CMR-TB01-200623	6.23.20	—	G	✓						2			X					

See email 6.23.20 @ 12:35 for instructions

Turn Around Time Required (Prior lab approval required for expedited TAT): ☑ 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: Brooks Bailey	6.23.20	12:00	1. Received by: FedEx	6.23.20	12:00
2. Relinquished by:			2. Received by:		
3. Relinquished by:			3. Received by:		
4. Relinquished by: FED EX	10/24/20	1024	4. Laboratory received by: [signature]	10/24/20	1024

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. 3.5, 3.8 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.
Document Number: MB0018C-14

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

Sample Receipt Checklist (SRC)

Client: Ramboll Cooler Inspected by/date: MEC / 06/24/2020 Lot #: VF24007

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: 20-1107 Chlorine Strip ID: 20-1163 Tested by: BMG
Original temperature upon receipt / Derived (Corrected) temperature upon receipt %Solid Snap-Cup ID: 20-302
2.9 / 2.9 °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 # 21552

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: BMG Date: 06/24/2020

Comments: Samples poured up according to attached sheet

Kelly Nance

From: Kelly Nance
Sent: Wednesday, June 24, 2020 10:57 AM
To: Kelly Nance
Subject: RE: Incoming Bottle Shipment + Limited Sample Volume

From: Kit Carson [mailto:kcarson@ramboll.com]
Sent: Tuesday, June 23, 2020 12:35 PM
To: Kelly Nance <knance@shealylab.com>
Cc: Brooks Bailey <BBAILEY@ramboll.com>
Subject: RE: Incoming Bottle Shipment + Limited Sample Volume

Kelly,

Below is the full list of wells and analysis request based on the limited volume collected. Thanks!

Well ID VF24007	Volume	Request	
TW-202S -004	Only 1 – 250 ml amber bottle collected for SVOCs	Analyze SVOCs and lab filter for metals analysis, if possible.	Pour up 100ml for lab filtered diss metals
TW-202D -003	Only 1/8th of 1-L amber jar collected for EPH + both 250 ml amber jars were collected for SVOCs.	Analyze for EPH, if possible.	Pour 2nd SV into EPH jar for extra volume.
TW-203S -002	Collected 1 – 250 ml amber bottle for SVOCs. Second 250 ml amber bottle collected was half full.	First bottle analyze SVOCs; second bottle lab filter and analyze for metals, if possible.	Pour 1/2 full SV up for lab filtered diss metals
MW-41S -001	Collected 2 – 250 ml amber bottles for SVOCs.	First bottle analyze SVOCs; Second bottle analyze for EPH	Pour up 2nd SV for EPH (or preservative)
MW-56S -006	Collected 2 – 250 ml amber bottles for SVOCs.	First bottle analyze SVOCs; Second bottle analyze for EPH	↓

Kit Carson
Consultant 3, Geologist

D 303-382-5482
M 630-849-9291
kcarson@ramboll.com

From: Kit Carson
Sent: Tuesday, June 23, 2020 9:38 AM
To: Kelly Nance <knance@shealylab.com>
Cc: Brooks Bailey <BBAILEY@ramboll.com>
Subject: RE: Incoming Bottle Shipment + Limited Sample Volume

Kelly,

1

APPENDIX C

PASSIVE TREATMENT TRENCH DESIGN CALCULATIONS

C1 – REGENESIS DESIGN CALCULATIONS

C2 – PETROFIX SAFETY DATA SHEET

APPENDIX C1 – REGENESIS DESIGN CALCULATIONS

August 12, 2020

To: Paul Lindquist and Abigail Small – Ramboll
Via email

From: Ryan Moore; Great Lakes District Manager; 219-286-4838
Owen Miller; Senior Design Specialist; 630-277-0855

Proposal #: OwM62057

Subject: **Budgetary Treatment of a Dissolved Petroleum Hydrocarbon plume, Calumet Refinery, MT**

REGENESIS appreciates the opportunity to provide Ramboll this document outlining a remedial solutions and cost evaluations for treatment of a petroleum hydrocarbon (PHC) groundwater plume at the Calumet Refinery located in Great Falls, MT ("the site"). Below we discuss the target treatment zone (TTZ) considered for remediation and applicability of REGENESIS technologies to address the contaminant and provide cost estimates for treatment using these technologies. Please note the following attachments.

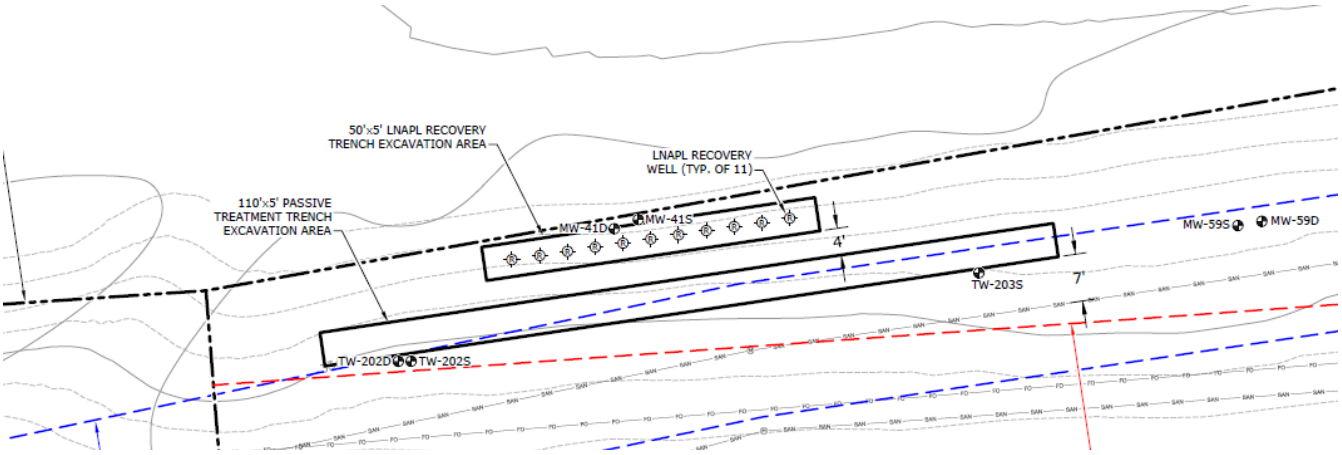
1) Product Specification Sheets
2) REGENESIS Remediation Services Scope of Services and Standard Assumptions

DEFINITION OF TARGET TREATMENT ZONES and REMEDIATION GOALS

The site groundwater is impacted with PHCs resulting from industrial operations. The impacted vertical zone varies across the sites but generally extends from the shallow, overburden aquifer to the top of the underlying bedrock at about 12 feet below ground surface (ft. bgs). The geology is mix of fine sands, silt and various bedrock formation (e.g. siltstone, mudstone and shale). The depth to groundwater across the varies with perched zones encountered across the formation sporadically. The total PHCs primarily consist of BTEX compounds (Benzene, Toluene, Ethylbenzene and Xylene) and TPH-G range compounds. Total PHCs vary across the site, depending on location but are observed to be as high as ~37,000 ppb to less than 1,000 ppb. REGENESIS has focused design efforts exercise on a conservative treatment program which utilizes a treatment trench barrier to apply the remedial chemistry. The purpose behind this treatment trench is to install a permeable reactive barrier (PRB) which allows contaminated groundwater to continually flow through while simultaneously treating the groundwater. The treatment trench should be backfilled with a coarse sand. The intent behind using coarse sand as backfill in the trench is *to engineer flux into the barrier* by using a material that is much more permeable than the native formation. We understand the Ramboll will undertake efforts to address and remove high mass PHCs immediately (i.e., LNAPL) upgradient of this PRB.

The PRB is approximately 110 feet in length with a 5-foot width and a 10 ft vertical treatment thickness transecting the plume. The Site is depicted on Figure 1 below.

Figure 1: Site Map



TREATMENT APPROACH AND DOSING RATIONALE

We propose treatment of the dissolved phase contaminant intercepting the PRB utilizing PetroFix® (PetroFix). PetroFix product data sheet with more information were included as part of our previous Feasibility Designs submitted to Ramboll on November 21, 2019 and June 22, 2020.

PetroFix is a new remedial technology designed to treat petroleum fuel spills in soil and groundwater. This remedial fluid is a highly concentrated water-based suspension consisting of micron-scale activated carbon and biostimulating electron acceptors. PetroFix has a viscosity higher than water and is black in water. PetroFix has a dual function; quickly removing hydrocarbons from the dissolved phase, by adsorbing them onto the activated carbon particles, while added electron acceptors stimulate hydrocarbon biodegradation in place.

The quantity of PetroFix was determined using a finite difference reactive sorption model. At a groundwater velocity of 19 feet per year, a contaminant flux rate of approximately 200 milligrams per square meter per day was estimated based on modeled concentrations of contaminant coming into the barrier (provided by Ramboll).

Benzene – 4,990 micrograms per liter (ug/L)
Toluene – 6,960
Ethylbenzene – 2,740
Xylene and Napthalene – 21,250
TPH substracting BTEX – 2,410

In addition, a 25% safety factor was considered due to the presence of NAPL and potential other non-target compounds intersecting the PRB. Our modeling suggests effective longevity of 23 years at this flux rate assuming no biodegradation (see attached model output). Intrinsic biodegradation through natural attenuation, aided by the PetroFix electron acceptors will increase barrier longevity substantially (greater than 30 years total). Note that as a part of this remedial program, *we have included a contingency application of ORC-A*, in the event LNAPL is detected within the trench PRB. This addition of ORC-A in this scenario will rapidly expedite biodegradation of any LNAPL. Note that the use of ORC-A for this PRB, under predicted and modeled conditions is not required.

APPLICATION MONITORING

Due to the long-term nature of this remedial approach, a monitoring program should be instituted to assess the biodegradation dynamics of the contaminants. Therefore, a monitoring program should capture the relevant bioremediation parameters during the PHC biodegradation process. Below is our recommended list of parameters to collect. Note that the highlighted red parameters are most relevant to this application and thus are recommended to collect.

In-Situ Bioremediation Performance Monitoring Parameters

Analytical Parameter	Method
Contaminants of Concern (COC's)	Varies
pH	Meter reading taken in flow-through cell (DO can also be measured with a Hach kit)
Dissolved Oxygen (DO)	
Oxidation Reduction Potential (ORP)	
Total Fe	Colorimetric Hach Method or EPA 6000 series with filtered and unfiltered samples
Total Mn	
Dissolved Fe	
Dissolved Mn	
Sulfate	EPA 375.3 or EPA 9056
Nitrate	EPA 353.1 or EPA 9056
Total Organic Carbon (TOC)	EPA 415.1 or EPA 9060
Chemical Oxygen Demand (COD)	EPA 410.1-.2
Biological Oxygen Demand (BOD)	EPA 5210B
Alkalinity	EPA 310.2
Methane, CO2	ASTM D1945

PRODUCT QUANTITIES AND COST

Treatment Option –	PetroFix (lbs)	ORC-A (lbs)	Cost ($ - USD)
PetroFix Only	14,000	-	$57,800
ORC-A Contingency Application	-	1,212	$13,400

*Includes estimated freight and tax

APPLICATION

For this treatment, we are recommending the trench PRB be applied using PetroFix during the backfill process in one to two-foot lifts. It is anticipated that the amount of PetroFix without dilution will occupy approximately 10% of the *effective pore volume* (~1,500 gallons/8,250 gallons) assuming a clean sand with 20% effective porosity. This leaves approximately 6,750 gallons for makeup water and/or infiltrating groundwater to fill the remaining effective pore volume in the trench. We recommend the following steps for application:

1) Excavate the trench and remove native soils.
2) Install trench box to open trench and provide stability for mixing.
3) Backfill sand in selected intervals (1-2 ft intervals recommended).
4) Spray PetroFix evenly throughout trench.
5) Mechanically mix to further distribute.
    a. Add additional volume, if needed.
6) Repeat until the top of the target treatment zone is covered.
7) Move onto next segment and repeat steps 1-6.

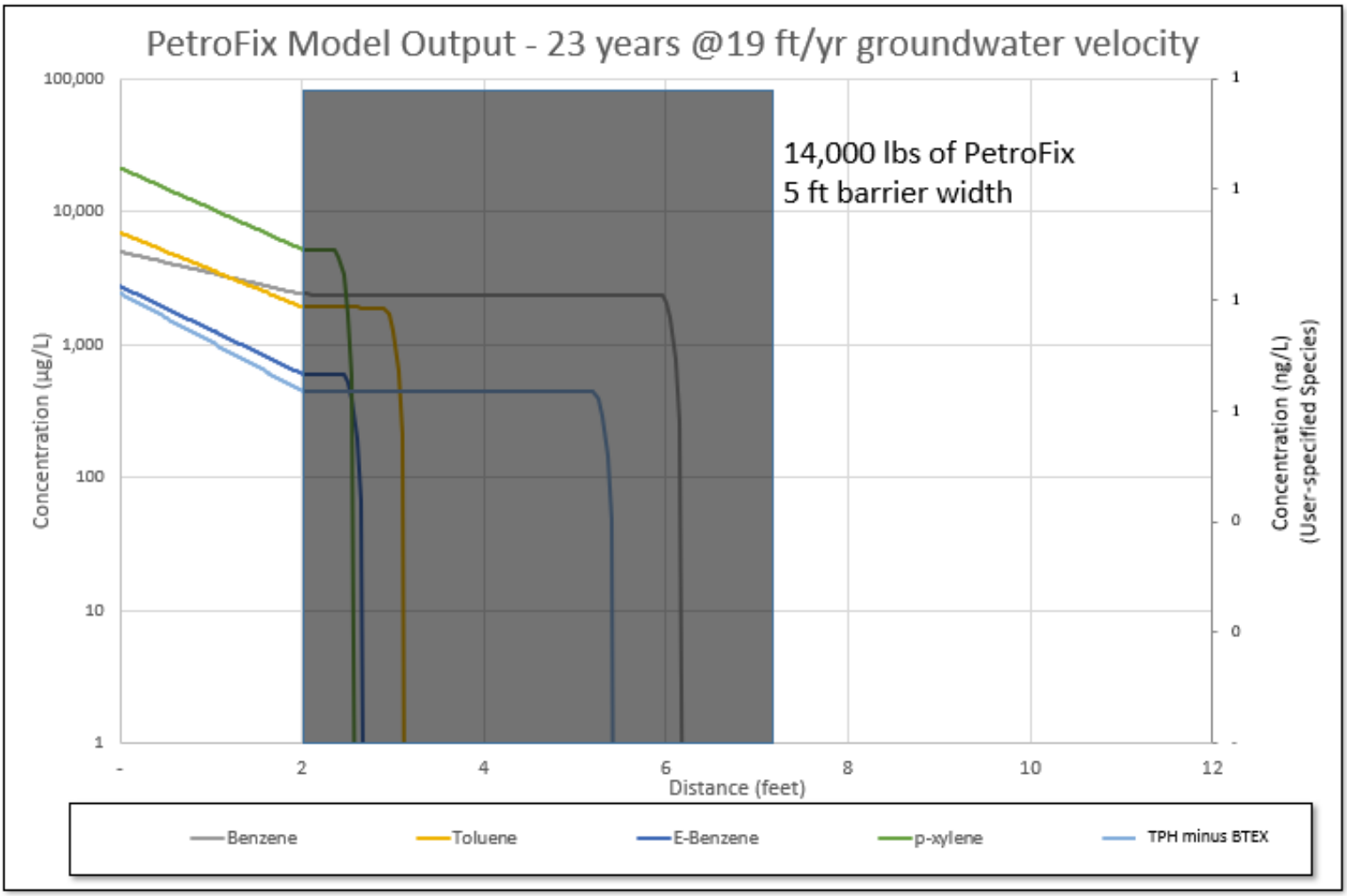
CLOSING

We sincerely appreciate the opportunity to present this budgetary proposal. We are looking forward to working together with you to provide a remedial solution tailored to Ramboll as well as the unique needs of the site. When you want to move forward with a more specific design and cost proposal and receive more site data, we would be happy to revisit our approach to ensure it is in-line with your site-specific needs.

I sincerely appreciate the opportunity to present you with this technical information and look forward to working with you further on this project. Please feel free to contact me with any questions and/or if you would like a formal proposal for the approach presented here.

Sincerely,

Ryan Moore, CHMM-Great Lakes District Manager


PetroFix Model Output - 23 years @19 ft/yr groundwater velocity
14,000 lbs of PetroFix
5 ft barrier width
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
Concentration (ng/L)
(User-specified Species)
1
1
1
1
0
0
-
-
2
4
6
8
10
12
Distance (feet)
Benzene
Toluene
E-Benzene
p-xylene
TPH minus BTEX

REGENESIS

1011 Calle Sombra
San Clemente, CA 92673-6244
Tel: 949.366.8000 • Fax: 949.366.8090

Terms and Conditions
Products and Services

1. PAYMENT TERMS. Net 30 Days. Accounts outstanding after 30 days will be assessed 1.5% monthly interest. Volume discount pricing will be rescinded on all accounts outstanding over 90 days. An early payment discount of 1.5% Net 10 is available for cash or check payments only. We accept Master Card, Visa and American Express.

2. RETURN POLICY. A 15% re-stocking fee will be charged for all returned goods. All requests to return product must be pre-approved by seller. Returned product must be in original condition and no product will be accepted for return after a period of 90 days.

3 FORCE MAJEURE. Seller shall not be liable for delays in delivery or services or failure to manufacture or deliver due to causes beyond its reasonable control, including but not limited to acts of God, acts of buyer, acts of military or civil authorities, fires, strikes, flood, epidemic, war, riot, delays in transportation or car shortages, or inability to obtain necessary labor, materials, components or services through seller's usual and regular sources at usual and regular prices. In any such event Seller may, without notice to buyer, at any time and from time to time, postpone the delivery or service dates under this contract or make partial delivery or performance or cancel all or any portion of this and any other contract with buyer without further liability to buyer. Cancellation of any part of this order shall not affect Seller's right to payment for any product delivered or service performed hereunder.

4. LIMITED WARRANTY. Seller warrants the product(s) sold and services provided as specified on face of invoice, solely to buyer. Seller makes no other warranty of any kind respecting the product and services, and expressly DISCLAIMS ALL OTHER WARRANTIES OF WHATEVER KIND RESPECTING THE PRODUCT AND SERVICES, INCLUDING ALL WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE AND NON-INFRINGEMENT.

5. DISCLAIMER. Where warranties to a person other than buyer may not be disclaimed under law, seller extends to such a person the same warranty seller makes to buyer as set forth herein, subject to all disclaimers, exclusions and limitations of warranties, all limitations of liability and all other provisions set forth in the Terms and Conditions herein. Buyer agrees to transmit a copy of the Terms and Conditions set forth herein to any and all persons to whom buyer sells, or otherwise furnishes the products and/or services provided buyer by seller and buyer agrees to indemnify seller for any liability, loss, costs and attorneys' fees which seller may incur by reason, in whole or in part, of failure by buyer to transmit the Terms and Conditions as provided herein.

6. LIMITATION OF SELLER'S LIABILITY AND LIMITATION OF BUYER'S REMEDY. Seller's liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from the manufacture, sale, delivery, resale, repair or use of any goods or performance of any services covered by or furnished hereunder, shall in no case exceed the lesser of (1) the cost of repairing or replacing goods and repeating the services failing to conform to the forgoing warranty or the price of the goods and/or services or part thereof which gives rise to the claim. IN NO EVENT SHALL SELLER BE LIABLE FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING LOST PROFITS, OR FOR DAMAGES IN THE NATURE OF PENALTIES.

7. INDEMNIFICATION. Buyer agrees to defend and indemnify seller of and from any and all claims or liabilities asserted against seller in connection with the manufacture, sale, delivery, resale or repair or use of any goods, and performance of any services, covered by or furnished hereunder arising in whole or in part out of or by reason of the failure of buyer, its agents, servants, employees or customers to follow instructions, warnings or recommendations furnished by seller in connection with such goods and services, by reason of the failure of buyer, its agents, servants, employees or customers to comply with all federal, state and local laws applicable to such goods and services, or the use thereof, including the Occupational Safety and Health Act of 1970, or by reason of the negligence or misconduct of buyer, its agents, servants, employees or customers.

8. EXPENSES OF ENFORCEMENT. In the event seller undertakes any action to collect amounts due from buyer, or otherwise enforce its rights hereunder, Buyer agrees to pay and reimburse Seller for all such expenses, including, without limitation, all attorneys and collection fees.

9. TAXES. Liability for all taxes and import or export duties, imposed by any city, state, federal or other governmental authority, shall be assumed and paid by buyer. Buyer further agrees to defend and indemnify seller against any and all liabilities for such taxes or duties and legal fees or costs incurred by seller in connection therewith.

10. ASSISTANCE AND ADVICE. Upon request, seller in its discretion will furnish as an accommodation to buyer such technical advice or assistance as is available in reference to the goods and services. Seller assumes no obligation or liability for the advice or assistance given or results obtained, all such advice or assistance being given and accepted at buyer's risk.

11. SITE SAFETY. Buyer shall provide a safe working environment at the site of services and shall comply with all applicable provisions of federal, state, provincial and municipal safety laws, building codes, and safety regulations to prevent accidents or injuries to persons on, about or adjacent to the site.

12. INDEPENDENT CONTRACTOR. Seller and Buyer are independent contractors and nothing shall be construed to place them in the relationship of partners, principal and agent, employer/employee or joint ventures. Neither party will have the power or right to bind or obligate the other party except as may be expressly agreed and delegated by other party, nor will it hold itself out as having such authority.

13. REIMBURSEMENT. Seller shall provide the products and services in reliance upon the data and professional judgments provided by or on behalf of buyer. The fees and charges associated with the products and services thus may not conform to billing guidelines, constraints or other limits on fees. Seller does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where seller may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by seller, it is the sole responsibility of the buyer or other entity seeking reimbursement to ensure the products and services and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, seller does not knowingly present or cause to be presented any claim for payment to the Government.

14. APPLICABLE LAW/JURISDICTION AND VENUE. The rights and duties of the parties shall be governed by, construed, and enforced in accordance with the laws of the State of California (excluding its conflict of laws rules which would refer to and apply the substantive laws of another jurisdiction). Any suit or proceeding hereunder shall be brought exclusively in state or federal courts located in Orange County, California. Each party consents to the personal jurisdiction of said state and federal courts and waives any objection that such courts are an inconvenient forum.

15. ENTIRE AGREEMENT. This agreement constitutes the entire contract between buyer and seller relating to the goods or services identified herein. No modifications hereof shall be binding upon the seller unless in writing and signed by seller's duly authorized representative, and no modification shall be effected by seller's acknowledgment or acceptance of buyer's purchase order forms containing different provisions. Trade usage shall neither be applicable nor relevant to this agreement, nor be used in any manner whatsoever to explain, qualify or supplement any of the provisions hereof. No waiver by either party of default shall be deemed a waiver of any subsequent default.

Remedial Design Assumptions and Qualifications

Cost Estimate Disclaimer: The cost listed assumes conditions set forth within the proposed scope of work and assumptions and qualifications. Changes to either could impact the final cost of the project. This may include final shipping arrangements, sales tax or application related tasks such as product storage and handling, access to water, etc. If items listed need to be modified, please contact Regenesis for further evaluation.

Shipping Estimates: Shipping estimates are valid for 30 days. All shipping charges are estimates and actual freight charges are calculated at the time of invoice. Additional freight charges may be assessed for any accessorial requested at the time of delivery. The estimate included within assumes standard shipping.

Standard delivery is between 8am -5pm Monday –Friday. *accessorial – can include, but not limited to lift gate and pallet jack at delivery, inside delivery, time definite deliveries, and delivery appointments.

Please communicate any requirements for delivery with the customer service department at the time the order is placed.

Return Policy: To initiate a return please contact your local sales manager for an RMA. A 15% re-stocking fee will be charged for all returned goods. Return freight must be prepaid. All requests to return product must be in original condition and no product will be accepted for return after 90 days from date of delivery.

Professional Judgement: In generating this estimate, REGENESIS relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s), and in reliance upon REGENESIS' prior experience on similar project sites. The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, *it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission*. When serving as a supplier or subcontractor to an entity which seeks reimbursement from Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the government.

RRS Assumptions and Qualifications

- Client personnel will take delivery of the remediation chemistry prior to RRS mobilization and arrange for secure storage where the material will not be affected by inclement weather. This may include the use of a pallet jack, forklift (or equivalent), and storage containers given the site circumstances. If material is stored off-site, Client personnel will coordinate the delivery of the material to the site.
- All quoted product rates and delivery dates are based on Standard Delivery Terms, which allow or provide only an estimated date and time of delivery of product to the site. Delivery times will vary per carrier. A guaranteed delivery can be arranged for an additional cost, and must be placed 7 days prior to shipment. Quoted shipping rates are valid for 25 days from date of proposal.
- Cost outlined will be valid for 60 days from date of proposal. If beyond 60 days, REGENESIS reserves the right to update cost.
- Client will locate the product within 10 feet of the RRS injection trailer during application activities.
- RRS will collect project related refuse and empty treatment chemistry containers on a daily basis to keep the site clean. This nonhazardous refuse will be placed in the Client-provided refuse container on-site for disposal. Client is responsible for disposal or recycling of totes, drums and pallets.
- A high volume water source (e.g. hydrant) capable of producing at least 30 gpm will be available to RRS for the duration of the project within 300' of the project staging area, at no cost to RRS. RRS will supply 300 linear feet of 1.5 inch National Standard Thread fire hose.
- RRS will have access to the site for equipment operation and secure storage of materials and equipment throughout the duration of the project.
- Client will provide field water quality meter similar to a YSI 556 with a down-hole sensor, a water level meter, bailers and a technician while on-site for injection activities to assist RRS in assessing groundwater from monitoring wells.
- Client is responsible for securing any permits prior to mobilizing to the site.
- Client is responsible for all soil, air and groundwater sampling and analysis.
- Client is responsible for transportation and disposal of any contaminated waste generated on-site, though we do not anticipate generating any such waste during direct push injection activities.
- For safety reasons, access to the treatment area will be limited to RRS and Client personnel.
- The proposed quantity of reagents can be delivered to the treatment area without significant surfacing/short-circuiting via the prescribed number of injection points. RRS will take precautions to prevent surfacing, but if surfacing occurs, RRS is not responsible for any treatment chemistry infiltration into undesired locations beyond their visual observations.

- RRS will call in a public utility locate for the injection zone area if responsible for providing Direct Push Technology subcontractor. Private utility locates will be the Client's responsibility. RRS is not responsible for damage to unmarked utilities and subsurface structures. If as-built drawings are available for any on-site subsurface features, RRS request the right to review to confirm clearance for the advancement of subsurface drilling and injection.

- RRS personnel will have access to the site for work up to 12 hours per day Sunday through Saturday. However, the standard workday does not exceed 10 hours with travel time Monday through Friday.

- Pricing and work schedule assume union labor and prevailing wages (Davis-Bacon) are not required.

- Proposal assumes standard probing and drilling will begin at ground surface. If hand augering, concrete coring or air knife services will be required, additional charges will apply.

- RRS assumes that Direct Push style drill rig can access all injection point locations and drive injection tooling to the required depth. If site conditions limit the use of the provided Direct Push rig for any injection points and other drilling methods are required to complete the task, additional charges will apply.

- All traffic control requirements will be provided by the client.

- All injection point will be closed/backfilled with bentonite chips to ground surface by RRS. Additional costs associated with restoration of the ground surface have not been included. If restoration of the ground surface is needed, additional charges will apply.

- In generating this estimate, REGENESIS relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

APPENDIX C2 – PETROFIX SAFETY DATA SHEET

SAFETY DATA SHEET

1. Identification

Product identifier PetroFix

Other means of identification None.

Recommended use Remediation of contaminants in soil and groundwater.

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Company Name Regenesis

Address 1011 Calle Sombra
San Clemente, CA 92673 USA

General information 949-366-8000

E-mail CustomerService@regenesis.com

Emergency phone number For Hazardous Materials Incidents ONLY (spill, leak, fire, exposure or accident), call CHEMTREC 24/7 at:

USA, Canada, Mexico 1-800-424-9300

International 1-703-527-3887

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.

Signal word None.

Hazard statement The mixture does not meet the criteria for classification.

Precautionary statement

Prevention Observe good industrial hygiene practices.

Response Wash hands after handling.

Storage Store away from incompatible materials.

Disposal Dispose of waste and residues in accordance with local authority requirements.

Hazard(s) not otherwise classified (HNOC) None known.

Supplemental information None.

3. Composition/information on ingredients

Mixtures

Chemical name	CAS number	%
Activated carbon <10 µm	7440-44-0	>25
Calcium sulfate dihydrate	10101-41-4	<10
Additive	-	<2

Composition comments All concentrations are in percent by weight unless otherwise indicated.
Components not listed are either non-hazardous or are below reportable limits.
Chemical ingredient identity and/or concentration information withheld for some or all components present is confidential business information (trade secret), and is being withheld as permitted by 29 CFR 1910.1200(i).

4. First-aid measures

Inhalation	Move to fresh air. Call a physician if symptoms develop or persist.
Skin contact	Wash off with soap and water. Get medical attention if irritation develops and persists.
Eye contact	Rinse with water. Get medical attention if irritation develops and persists.
Ingestion	Rinse mouth. Get medical attention if symptoms occur.
Most important symptoms/effects, acute and delayed	Direct contact with eyes may cause temporary irritation.
Indication of immediate medical attention and special treatment needed	Treat symptomatically.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2).
Unsuitable extinguishing media	None known.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed. Combustion products may include: carbon oxides, nitrogen oxides, sulfur oxides, calcium oxide.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.
Fire fighting equipment/instructions	Move containers from fire area if you can do so without risk.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	This material will not burn until the water has evaporated. Residue can burn. When dry may form combustible dust concentrations in air.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Avoid prolonged exposure. Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store in original tightly closed container. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-3 (29 CFR 1910.1000)

Components	Type	Value	Form
Activated carbon <10 µm (CAS 7440-44-0)	TWA	5 mg/m3	Respirable fraction.
		15 mg/m3	Total dust.

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
Activated carbon <10 µm (CAS 7440-44-0)	TWA	2 mg/m3	Respirable fraction.

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
Calcium sulfate dihydrate (CAS 10101-41-4)	TWA	10 mg/m3	Inhalable fraction.

Biological limit values No biological exposure limits noted for the ingredient(s).

Appropriate engineering controls Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

Eye/face protection Wear safety glasses with side shields (or goggles).

Skin protection

Hand protection Wear appropriate chemical resistant gloves. Suitable gloves can be recommended by the glove supplier.

Skin protection

Other Wear suitable protective clothing.

Respiratory protection In case of insufficient ventilation, wear suitable respiratory equipment.

Thermal hazards Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance

Physical state Liquid.

Form Aqueous suspension.

Color Not available.

Odor Not available.

Odor threshold Not available.

pH 8 - 10

Melting point/freezing point Not available.

Initial boiling point and boiling range 212 °F (100 °C)

Flash point Not available.

Evaporation rate Not available.

Flammability (solid, gas) Not applicable.

Upper/lower flammability or explosive limits

Flammability limit - lower (%) Not available.

Flammability limit - upper (%) Not available.

Vapor pressure Not available.

Vapor density Not available.

Relative density Not available.

Solubility(ies)

Solubility (water) Not available.

Partition coefficient (n-octanol/water) Not available.

Auto-ignition temperature Not available.

Decomposition temperature Not available.

Viscosity Not available.

Other information

Explosive properties Not explosive.

Oxidizing properties Not oxidizing.

10. Stability and reactivity

Reactivity The product is stable and non-reactive under normal conditions of use, storage and transport.

Chemical stability Material is stable under normal conditions.

Possibility of hazardous reactions No dangerous reaction known under conditions of normal use.

Conditions to avoid Contact with incompatible materials. Avoid drying out product. May generate combustible dust if material dries.

Incompatible materials Strong oxidizing agents. Acids.

Hazardous decomposition products No hazardous decomposition products are known.

11. Toxicological information

Information on likely routes of exposure

Inhalation Spray mist may irritate the respiratory system. For dry material: Dust may irritate respiratory system.

Skin contact Prolonged or repeated exposure may cause minor irritation.

Eye contact Direct contact with eyes may cause temporary irritation.

Ingestion May cause discomfort if swallowed.

Symptoms related to the physical, chemical and toxicological characteristics Direct contact with eyes may cause temporary irritation.

Information on toxicological effects

Acute toxicity Not expected to be acutely toxic.

Components	Species	Test Results
Activated carbon <10 µm (CAS 7440-44-0)		
Acute		
Oral		
LD50	Rat	> 10000 mg/kg

Skin corrosion/irritation Prolonged skin contact may cause temporary irritation.

Serious eye damage/eye irritation Direct contact with eyes may cause temporary irritation.

Respiratory or skin sensitization

Respiratory sensitization Not a respiratory sensitizer.

Skin sensitization This product is not expected to cause skin sensitization.

Germ cell mutagenicity No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.

Carcinogenicity Not classifiable as to carcinogenicity to humans.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

NTP Report on Carcinogens

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not regulated.

Reproductive toxicity This product is not expected to cause reproductive or developmental effects.

Specific target organ toxicity - single exposure Not classified.

Specific target organ toxicity - repeated exposure Not classified.

Aspiration hazard Not an aspiration hazard.

12. Ecological information

Ecotoxicity The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.

Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	No data available.
Mobility in soil	No data available.
Other adverse effects	None known.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not established.

15. Regulatory information

US federal regulations	This product is not known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical	No

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA)	Not regulated.

US state regulations

US. Massachusetts RTK - Substance List

Calcium sulfate dihydrate (CAS 10101-41-4)

US. New Jersey Worker and Community Right-to-Know Act

Not listed.

US. Pennsylvania Worker and Community Right-to-Know Law

Not listed.

US. Rhode Island RTK

Activated carbon <10 µm (CAS 7440-44-0)
Calcium sulfate dihydrate (CAS 10101-41-4)

California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 2016 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins. For more information go to www.P65Warnings.ca.gov.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
Taiwan	Taiwan Chemical Substance Inventory (TCSI)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates this product complies with the inventory requirements administered by the governing country(s).
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 15-February-2018

Revision date -

Version # 01

HMIS® ratings Health: 1
Flammability: 1
Physical hazard: 0

NFPA ratings

Disclaimer Regenesis cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available.

APPENDIX D

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SECTION 01 11 00
SCOPE OF WORK

PART 1- GENERAL

1.1 SCOPE OF WORK

A. The CONTRACTOR shall perform Work in accordance with the Conditions of Contract.

B. The CONTRACTOR shall provide all labor, material, supervision and equipment to perform the Work.

C. All incidental, minor and miscellaneous items, work, and materials for which no payment is specifically provided, and any items, work, and materials not specified or shown which are necessary to complete the indicated work and to maintain and repair the work, or which may be fairly implied as included, shall be done and furnished by the CONTRACTOR at no additional cost.

D. The Technical Specifications will be part of the Contract Documents to be signed between the ENGINEER and the selected CONTRACTOR. These technical specifications make reference to the Design Drawings, entitled "AOC-16 Interim Measure Design Drawings (100%) Dual-Phase Extraction and Passive Treatment Trench Installation", prepared by the ENGINEER (Ramboll) dated September 2020.

E. The CONTRACTOR shall be responsible for executing the work shown on the Design Drawings, called for in the Technical Specifications, Contract Documents and as necessary to perform the site remediation construction and restoration complete in every respect. The CONTRACTOR shall furnish machinery, tools, equipment, material, and labor necessary to make the work satisfactory, complete, neat, and finished. It is the intent of the Technical Specifications to describe a functionally complete Project (or part thereof) to be constructed in accordance with the Contract Documents. Any labor, documentation, services, materials, or equipment that may reasonably be inferred from the Design Drawings and Technical Specifications or from prevailing custom or trade usage as being required to produce the intended result shall be provided whether or not specifically called for at no additional cost to the ENGINEER.

F. The design intent, as determined by the ENGINEER, shall govern in the case of discrepancy in or between the Design Drawings and Technical Specifications. The Technical Specifications are intended to supplement and clarify the Design Drawings, as sometimes work is called for in the Technical Specifications that is not shown on the Design Drawings, and sometimes the Design Drawings indicate work that is not mentioned in the Technical Specifications. Both Design Drawings and Technical Specifications must be complied with in order to fulfill the Contract requirements, and any work called for by either is as binding as though it were called for by both. The CONTRACTOR shall take no advantage of any error or omission in the Design Drawings or of any discrepancy between the Design Drawings and Technical Specifications and shall notify the ENGINEER of such discrepancies immediately upon discovery. In all cases of doubt as to the true meaning of the Design Drawings

and Technical Specifications, the decision of the ENGINEER will be final and conclusive.

1.2 RELATED WORK NOT INCLUDED

(Reserved)

1.3 SUBMITTALS

(Reserved)

1.4 REFERENCES

(Reserved)

1.5 SITE DESCRIPTION

The Calumet Montana Refining, LLC (CMR) refinery (Owner)

is located at 1900 10th Street in Great Falls, Montana. Area of Concern-16 (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 to the east of the active refinery and is owned by CMR.

A CMR two-floored administration office building is in the east portion and an access road, set down area, and vegetation area are in the southern portion of AOC-16. 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 the roadway Right-of-Way (ROW), 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.

The Work will be performed in following two AOC-16 areas:

A. Truck Rack Area

It is the CMR property immediately south of the Truck Rack. This area includes the Primary Recovery Trench (PRT) and native materials north of the PRT.

B. North River Road Area

This area includes the property immediately north of North River Road and south of the railroad bed/loading area.

1.6 PROJECT OBJECTIVES

A. The selected remedy entails dual-phase extraction (DPE) in the existing PRT in the Truck Rack Area and light non-aqueous phase liquid (LNAPL) recovery trench (LRT) and a passive treatment trench (PTT) in the North River Road Area.

B. This section outlines the activities that are associated with the Site. The summary of work to be performed under this contract consists of the following:

a. Extraction and removal of existing vertical culverts, associated equipment, and

electrical connections. Removal of existing fencing.

b. Installation of new dual phase extraction wells located at various points across the existing PRT.

c. Abandonment of temporary monitoring wells TW-202D, TW-202S, and TW-203S located within the PTT construction area.

d. Installation of a dual phase extraction conveyance piping system consisting of main header pipes and several smaller lateral pipes to the various extraction wells.

e. Installation of a gravel foundation pad for pre-engineered enclosures with DPE equipment and a catalytic thermal oxidizer (CATOX).

f. Installation of pre-engineered enclosures with DPE equipment and a CATOX.

g. Installation of piping between the DPE enclosure and the CATOX enclosure.

h. Installation of discharge line to convey extracted fluids from the DPE equipment to the refinery gravity sewer.

i. Electrical service from a pad-mounted transformer to the DPE equipment enclosure and the CATOX enclosure.

j. Installation of security fence around enclosures.

k. Installation of LRT and PTT.

l. Installation of eleven (11) LNAPL recovery wells within and across the LRT and one (1) PTT monitoring well within PTT.

m. All necessary earthwork, including but not limited to, cut/fill, grading, drainage structures, and erosion control measures.

1.7 WORK INCLUDED

A. The listing of work items presented herein, and work sequence presented herein, may not include all specific items. The CONTRACTOR shall complete all work covered by the Design Drawings, and Technical Specifications.

B. Provision of all materials, equipment, labor and facilities required for the work and performance of the work shall be conducted in accordance with the Contract Documents and applicable federal, State, and local regulations.

C. Preparation for and attendance at the pre-construction and scheduled progress meetings.

D. Implementing procedures to ensure protection of soil, surface water, ground water, and air resources.

E. Conduct all waste disposal, dust control, noise control, spill control, and decontamination in accordance with applicable state and federal regulations.

F. Mobilization, including all labor, materials and equipment required to provide the following:

a. Equipment and material staging area;

b. Temporary traffic barrier and fencing;

c. Equipment decontamination facilities;

d. Personnel hygiene facilities;

e. Emergency medical supplies;

f. Installation of soil erosion and sediment controls.

G. Verification of the locations and elevations of all active utilities within the limits of the work area prior to the start of construction.

H. CONTRACTOR will procure applicable state, and local permit equivalencies related to the implementation of the work.

I. Clearing and grubbing at the access and egress roads, at equipment staging areas (where applicable); and at the area where the treatment system enclosure, LRT, and PTT will be located to allow construction activities and for safe vehicular access.

J. Installation of all items indicated on the Design Drawings entitled "AOC-16 Interim Measure Design Drawings (100%) Dual-Phase Extraction and Passive Treatment Trench Installation", prepared by the ENGINEER (Ramboll) dated September 2020 including all items indicated in the associated lists.

K. Excavation and handling of contaminated materials.

L. Transportation and disposal of contaminated materials, if any.

M. Fencing.

N. The CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to perform the following services by a Montana licensed electrician:

a. Coordination with the local utility and local code jurisdiction for electrical service requirements; and

b. Installation of 400-amp, 480 volt, 3-phase, 4-wire electrical conductors from a pad-mounted transformer to the DPE equipment enclosure and CATOX.

O. The CONTRACTOR shall provide electrical service from the pad-mounted electrical transformer to the main distribution panel disconnect located on the exterior of the DPE equipment enclosure. All electrical materials and equipment shall bear the label of Underwriter's Laboratories listed by them in their list of electrical fittings; and approved by them for the purpose for which they are to be used, unless material and equipment is of type for which Underwriter's Laboratories do not list or provide label. The CONTRACTOR is responsible for all fees and all inspections required connecting the new electrical services.

P. Site grading and restoration.

Q. Demobilization.

R. Where construction details in the Design Drawings and Technical Specifications for the above work items are incomplete, the CONTRACTOR will be required to furnish details for ENGINEER's approval, and to perform the construction in accordance with

approved details.

1.8 WORK SEQUENCE

A. The specified work shall be performed to achieve compliance with the Contract Documents and all applicable regulations. Work shall proceed in the approximate stages outlined below, but not necessarily limited to the items that are listed. Some activities may be conducted concurrently.

B. Stage 1 – Utility clearance, clearing and grubbing.

C. Stage 2 – Pre-construction surveying.

D. Stage 3 – Extraction and removal of existing recovery sumps, associated equipment, and electrical connections. Removal of existing fencing.

E. Stage 4 – DPE well installation and temporary monitoring well abandonment in PTT construction area by DRILLING CONTRACTOR.

F. Stage 5 – Installation of DPE well head piping and valves, piping laterals and vacuum headers.

G. Stage 6 - Installation of gravel foundation for the DPE equipment enclosure and CATOX enclosure.

H. Stage 7 – Placement and installation of packaged DPE equipment enclosure and CATOX.

I. Stage 8 - Pipe fitting, installation of ancillary piping, conduit, electrical wiring and motor control centers, instrumentation and controls, and interior plumbing systems.

J. Stage 9 – DPE system functional testing and start-up.

K. Stage 10 – LRT and PPT construction.

1.9 CONTRACTOR'S USE OF PREMISES

A. The CONTRACTOR shall limit on-site operations to the areas within the construction limits shown in the Design Drawings, unless authorized by the ENGINEER. Work in areas outside construction limits shall be coordinated with the ENGINEER.

PART 2– PRODUCTS

(Reserved)

PART 3– EXECUTION

(Reserved)

END OF SECTION

SECTION 01 14 00

WORK RESTRICTIONS

PART 1 GENERAL

1.1 DESCRIPTION

A. The CONTRACTOR shall limit use of the Site to work in the areas indicated on the Construction Drawings. The CONTRACTOR shall not disturb portions of the Site beyond areas in which work is indicated on the Construction Drawings.

B. The CONTRACTOR shall ensure that all personnel of the CONTRACTOR and its subcontractors adhere to all Site regulations including, but not limited to, those established in this Section.

1.2 RELATED WORK NOT INCLUDED

Drawings and general provisions of the Contract and other Division 01 Specification Sections apply to this Section.

1.3 SUBMITTALS

(Reserved)

1.4 REFERENCES

(Reserved)

1.5 DEFINITIONS

(Reserved)

1.6 CONTRACTOR ACCESS AND USE OF PREMISES

A. The Calumet Montana Refining, LLC (CMR) representatives, the ENGINEER and those employed by its Contractors, Subcontractors, or Suppliers shall be allowed on-site. The CONTRACTOR and its subcontractors will be allowed on-site only during their working periods.

B. The CONTRACTOR shall limit its work between the hours of 7:00 a.m. and 6:00 p.m., Monday through Saturday, excluding holidays, unless otherwise indicated. Any other times of work shall be by approval of the ENGINEER at least 48 hours in advance.

C. Only vehicles authorized by the ENGINEER shall be allowed on-site. All others must remain in designated areas, parking areas, or off-site.

D. The CONTRACTOR shall maintain a sign-in/sign-out log for the duration of the Site activities. All personnel must sign-in upon Site entry and sign-out upon Site exit with the CONTRACTOR-designated individual.

E. The CONTRACTOR shall confine operations to within the limits of work specified on the Construction Drawings. The CONTRACTOR shall not extend construction operations to areas outside of the limits of work, expect where noted on the Construction Drawings.

F. Smoking is prohibited on the Site.

1.7 SECURITY REQUIREMENTS

A. The CONTRACTOR shall be responsible for providing Site security and securing all equipment, materials, products and tools until final acceptance by the ENGINEER.

B. The ENGINEER shall not be held responsible for any lost, stolen, or damaged items.

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

(Reserved)

END OF SECTION

SECTION 01 29 00

PAYMENT PROCEDURE

PART 1 GENERAL

1.1 SCOPE

A. Payment for this Contract will be made on a cost reimbursable basis for allowable expenses incurred by the Contractor in the performance of work required by the Contract Documents.

B. The Contractor shall prepare a cost proposal based on the work items identified in this Section and described in other sections of the Technical Specifications and Design Drawings. The Contractor's Cost Proposal, which shall be submitted to Owner and ENGINEER for review, negotiation and approval, will be used to establish the Contract.

C. The work items included in this section and in the Proposal Schedule will serve as the basis for budgeting, cost tracking and progress monitoring. In developing its cost proposal, the Contractor shall identify all activities that are required to perform the specified Work.

1.2 RELATED WORK NOT INCLUDED

Related sections include the following:

A. Section 01 11 00 – Scope of Work.

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

A. Bid Schedule: The Contractor shall follow the format of these specifications, include all items shown in the Design Drawings, and show all general items including mobilization, bonds, and insurance, as applicable.

B. Request for Payment: The Contractor shall submit three copies of Request for Payment. The Contractor shall utilize the Bid Schedule for listing items. An updated construction schedule shall be submitted with each Request for Payment.

1.5 PAYMENT

A. Payment for all Lump Sum Work shown or specified in Contract Document is included in the Contract Price. Payment will be based on a percentage complete basis for line item or work item of the accepted schedule of Work under the Agreement.

1.6 NON-PAYMENT FOR REJECTED OR UNUSED PRODUCTS

A. Payment will not be made for the following:
   1. Loading, hauling, and disposing of rejected material.
   2. Quantities of material wasted or disposed of in manner not called for under Contract Documents.
   3. Rejected loads of material, including material rejected after it has been placed by

reason of failure of Contractor to confirm to provisions of Contract Documents.

4. Material not unloaded from transporting vehicle.
5. Defective work not accepted by ENGINEER or Owner.
6. Material remaining on hand after completion of Work.

1.7 PARTIAL PAYMENT OF STORED MATERIALS AND EQUIPMENT

A. No partial payments will be made for materials and equipment delivered or stored unless Shop Drawings and Preliminary operation and maintenance data is acceptable to ENGINEER.

B. Final payment will be made only for products incorporated in Work; remaining products, for which partial payments have been made, shall revert to Contractor unless otherwise agreed, and partial payments made for those items will be deducted from final payment.

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

3.1 WORK ITEMS

A. The descriptions of work items below are not intended to indicate the actual means of payment under this contract. The work items are to be used by the Contractor as a basis for developing a cost proposal. Actual payment will be made on a "Cost Reimbursable" basis for work performed and allowable expenses.

B. A brief summary of the work for each task is included below. As it is a summary, it is not intended to describe all of the items in detail, but rather to outline the tasks on which the cost proposal is to be based.

3.2 PERMITS (Work Item – 001)

A. This item shall be presented in the proposal as a lump sum amount for each of the anticipated permits and shall include the costs to prepare and submit those permits or permit equivalents. The anticipated permits include the following permits: well installation approval, soil erosion and sediment control permit approval, building permit, encroachment permit, permit to work on a county road or others. The CONTRACTOR's cost proposal shall include the cost of permit fees.

3.3 SUBMITTALS (Work Item – 002)

A. This item shall be presented in the proposal as a lump sum amount, which shall include, but not be limited to, the preparation of the following: preliminary project schedule; initial project schedule; health and safety plan; traffic management plan, material specifications and cut sheets.

3.4 MOBILIZATION/ DEMOBILIZATION (Work Item – 003)

A. This item shall be presented in the proposal as a lump sum amount, which shall include all Mobilization activities required under these Contract Documents, but not limited to, costs for mobilization of labor, equipment, material, and incidentals required for (a) soil erosion and sediment control measures; (b) site preparation for excavation, restricting access to work areas; (c) mobilization of excavation support system, construction equipment, and associated staging areas; (d) mobilization, installation, and operation of temporary facilities such as field office trailer, material storage areas/trailers, and sanitary facilities; (e) mobilization and installation of necessary utility hookups, temporary fencing or site gates; (f) any other requirements or related miscellaneous items specified in the Contract Documents.

B. This item shall also include the costs for all the Demobilization activities required under these Contract Documents, which shall include but not limited to (a) demobilization of labor, materials, equipment, and incidentals from project limits and staging areas; (b) demobilization of all temporary facilities, any installed temporary fencing/gates, and (c) removal of erosion control measures; and (d) cleaning and restoration of site after demobilization of equipment, temporary facilities within the project vicinity. This item shall also include Scheduling the post-construction inspection to review completed work.

3.5 SOIL EROSION AND SEDIMENT CONTROL (Work Item – 004)

A. This item shall be presented in the proposal as a lump sum amount, which shall include all labor, equipment, materials, and incidentals required to implement Soil Erosion and Sediment Control measures within the anticipated area of disturbance during construction. These activities include furnishing, installing, maintaining and removing silt fencing, straw bales, sandbags, diversion berms and other soil erosion and sediment controls, and to implementing dust control for the duration of the project. Erosion control shall be performed in accordance with the requirements of the SECTION 31 25 00 – SOIL EROSION AND SEDIMENT CONTROL.

3.6 CLEARING AND GRUBBING (Work Item – 005)

A. This item shall be presented in the proposal as a lump sum amount, which shall include all labor, equipment, material, and incidentals required to clear and grub any vegetated areas within the proposed construction areas. Costs for cutting trees and chipping vegetation, stump removal, grubbing, and off-site disposal shall be included in this item. The clearing and grubbing shall meet the requirements of SECTIONS 02 11 00 – CLEARING AND GRUBBING.

3.7 HEALTH AND SAFETY (Work Item – 006)

A. This item shall be presented in the proposal as a lump sum amount, which shall include all costs for labor, equipment, material, and incidentals required to prepare and comply with the CONTRACTOR's Health and Safety Plan. Health and safety plan shall meet the requirements of SECTION 01 35 29 – HEALTH AND SAFETY PROCEDURES.

3.8 SURVEYING (Work Item – 007)

A. This item shall be presented in the proposal as a lump sum amount, which shall include all the costs for labor, equipment, material, and incidentals required to: (a) establish surveying benchmarks and points, and (b) document existing grade elevations, and elevations at end of construction and submit all surveys, calculations, and drawings.

3.9 EXCAVATION (Work Item – 008)

A. This item shall be presented in the proposal on a cost-per-in-place-cubic-yard basis. Included under this item are the costs for all labor, equipment, materials, and incidentals necessary to perform excavation, on-site handling, and temporary stockpiling, backfilling, compacting, and grading. This item also includes additional costs associated with segregation; additional excavation required for slope stability; and the design, installation, maintenance and removal of all excavation support systems, if necessary, in accordance with SECTION 31 23 00 – EXCAVATION AND BACKFILL.

3.10 INSTALLATION OF WELLS (Work Item – 009)

A. DRILLING CONTRACTOR will be responsible for dual phase extraction (DPE) well installation. The proposal shall present a lump sum amount, which shall include all the costs for labor, equipment, material, and incidentals required to install eight (8) DPE wells, in accordance with SECTION 13 01 00 – SUBSURFACE DRILLING.

3.11 INSTALLATION OF BELOW GROUND CONVEYANCE PIPING AND PITLESS ADAPTER (Work Item – 010)

A. This item shall include labor, equipment, material, and incidentals required for a) installation of pitless adapters on the side of existing well casing for eight (8) extraction wells; b) installation of belowground polyvinyl chloride (PVC) groundwater conveyance piping from extraction wells to the DPE treatment enclosure, and discharge pipe from DPE treatment enclosure to the refinery gravity sewer; c) heat tracing and insulating belowground piping. The PVC piping shall be installed using by trenching as shown in Design Drawings. The piping installation shall include all below and aboveground valves and fittings, instrumentation, instrumentation electrical conduit and conductors, electrical junction boxes, valve vaults, and tie-in with existing piping.

B. The alignment and profile for piping to be installed is shown in Design Drawings.

C. This item shall also include costs for pipe testing after completion of installation.

D. Costs for removal of existing vegetation within the trench excavation area, excavation and backfilling will be included in Work Item 008.

3.12 INSTALLATION OF PACKAGED SYSTEMS (Work Item – 011)

A. This item shall include labor, equipment, material, and incidentals required for a) installation of gravel foundation, b) off-loading, placement and installation of pre-fabricated DPE system enclosure and catalytic thermal oxidizer (CATOX) on the gravel

foundation, c) completing piping connections between the conveyance piping and the DPE system and between DPE system enclosure and CATOX, and d) providing utility connections to the enclosures. The alignment and profile for piping to be installed is shown in Design Drawings.

3.13 SITE RESTORATION (WORK ITEM 0012)

A. This item shall be presented in the proposal as a lump sum amount, which shall include all labor, equipment, material, and incidentals required for final grading within the construction limits as shown in the Design Drawings. Costs for surveying are to be included in Work Item 007.

END OF SECTION

SECTION 01 31 19

PRE-CONSTRUCTION MEETING

PART 1 - GENERAL

1.1 SCOPE

The Work covered in this Section includes the requirements of the CONTRACTOR to administer and attend pre-construction and pre-work meetings.

1.2 RELATED WORK NOT INCLUDED

(Reserved)

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

(Reserved)

1.5 PRE-CONSTRUCTION MEETING

Following issuance of the Notice to Proceed, the ENGINEER shall meet with the CONTRACTOR for a Pre-Construction Meeting. The purpose of this meeting is to review site logistics, site security, safety protocols, submittal items and procedures, environmental protection, progress schedules, and procurement of materials. The principal features of work will also be reviewed and any questions regarding the Contract and work site will be addressed. Attendance by the Contractor's project manager, superintendent, the Health and Safety Officer and other key personnel will be required.

1.6 PRE-WORK/MEETING SUBMITTALS

A. At least 1 week prior to the Pre-Construction Meeting, the CONTRACTOR shall submit to the ENGINEER electronic copies of the following:
   1. Preliminary Progress Payment Chart;
   2. Health and Safety Plan;
   3. Quality Control Plan;
   4. Traffic Management Plan;
   5. Environmental Protection Plan; and
   6. Submittal Schedule/Register.

B. These will be reviewed prior to the Pre-Construction Meeting to provide the Contractor with a general understanding of the salient points prior to initiating the approval process.

C. Questions concerning the administrative requirements outlined during the Pre-Construction Meeting or any other aspect of the project may also be addressed.

1.7 ADMINISTRATION

A. The Pre-Construction meeting shall be held at the Site.

B. The CONTRACTOR shall take minutes of each meeting and, within three days, distribute copies to all participants of a summary of all pertinent matters arising from the meeting.

PART 2 – PRODUCTS

(Reserved)

PART 3 – EXECUTION

(Reserved)

END OF SECTION

SECTION 01 32 33

PHOTO DOCUMENTATION

PART 1 – GENERAL

1.1 SCOPE

A. The Work covered in this Section includes the taking, processing, and submitting of photographs by the CONTRACTOR.

1.2 RELATED WORK NOT INCLUDED

(Reserved)

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

A. Digital copies of all photographs shall be submitted to the ENGINEER.

1.5 PHOTOGRAPHS

A. Photographs shall be taken throughout the Project of the views identified below, as approved, by the ENGINEER.

PART 2 – PRODUCTS

A. The CONTRACTOR shall furnish its own digital camera with photographic and video capabilities. The camera shall be of at least 10 megapixels in resolution.

PART 3 - EXECUTION

3.1 PHOTOGRAPHS

A. The CONTRACTOR shall provide jpeg images, with date stamp, of the following work tasks and areas. The minimum numbers of individual views are shown in parentheses.

1. Before construction work begins:
   a. Primary Recovery Trench (5)
   b. North River Road Area (5)
   c. Overhead Utilities (5)
   d. Equipment Staging Areas (5)
2. At the completion of site mobilization, two (2) views shall be obtained of each added temporary facility.
3. During construction:
   a. Setup of equipment staging area (5).
   b. Installation of subgrade piping, pitless adapters, and heat tracing (10).

c. Installation of the treatment system enclosure (5).

d. Installation of vapor and liquid treatment systems (5).

e. Installation LNAPL recovery trench and passive treatment trench (10).

4. During operation and monitoring, as directed by the ENGINEER or as required in other Divisions of these project specifications CONTRACTOR shall take photographs as specified or as directed.

B. The photography shall be spaced out, as appropriate, over each activity period to provide views representative of the entire Project work.

END OF SECTION

SECTION 01 35 29

HEALTH AND SAFETY REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. The Work covered in this Section specifies procedures for complying with applicable laws and regulations related to worker safety and health. It is not the intent of the Owner, or ENGINEER to develop, manage, direct, and or administer safety and health for CONTRACTOR's employees. It is required that all CONTRACTORS adhere to applicable Federal, state, local, and CMR health and safety standards and requirements.

B. It is not the intent of the Owner, or ENGINEER to list and identify all applicable safety codes, standards, and/or regulations requiring compliance by all CONTRACTOR groups. Contractor and subcontractors shall be solely responsible for identifying and determining all safety codes, standards, and regulations that are applicable to this work.

C. The CONTRACTOR shall prepare the CONTRACTOR's Health and Safety Plan (HASP) to address all activities to be performed during the Work. The CONTRACTOR shall furnish all labor, materials, equipment, and incidentals required to implement the CONTRACTOR's Health and Safety Plan. At the daily job briefing and/or tailgate conference, the CONTRACTOR shall provide the ENGINEER with all relevant information on the Work to be performed, its location, and the equipment to be used.

1.2 RELATED WORK NOT INCLUDED

Drawings and general provisions of the Contract, including all other Specification Sections, apply to this Section.

1.3 SUBMITTALS

A. The CONTRACTOR shall submit a site-specific HASP addressing health and safety management methods specific to the project.

B. A comprehensive HASP covers all aspects of the Contract scope of work activities related specifically and distinctly to the Scope of Work and site conditions which incorporates the requirements as specified in 29 CFR 1926, Section .65(b) and Section 01.A.07 of EM-285-1-1. The HASP shall be based on a site-specific hazard analysis and any Contract specific safety procedures shall be applied to the identified hazards in the work.

C. HASP shall be organized and bound to readily accept revisions and additions.

D. The Plan shall, at a minimum, include:

1. Hazard Communication

    a. The following information shall be provided for all materials imported to

the Site:

1. Chemical composition of material and Safety Data Sheet (SDS);
2. Description of the method of application;
3. Manufacturer's catalog data for equipment required for use and storage; and
4. Certification that all materials proposed by the CONTRACTOR meet all Federal, State, and local regulations.

b. CONTRACTOR to complete a CMR "New Chemical Request" form for each chemical brought to the Site. A sample form for the "New Chemical Request" is attached as Figure 01 35 29-1. The CONTRACTOR may propose an alternate format, pending approval of the ENGINEER, provided that all required information is included in the CONTRACTOR's proposed format.

c. Hazardous materials or chemicals imported to the Site must be labeled in accordance with OSHA regulations for hazard communication.

d. If no hazardous chemicals are to be used, provide statement to that effect.

2. Emergency Response

   a. Provide procedures to follow in case of an injury.
   b. Provide route maps to the nearest pre-notified medical facility or hospital.

3. Utilities

   a. Provide procedures to follow when working near, around, and/or with utilities.

4. Hazardous Energy Control:

   a. The nature of the work may expose workers to hazardous energy sources that include, but are not limited to, electrical, mechanical, pneumatic, hydraulic, thermal, and computerized systems.
   b. Provide a written plan outlining safe work practices addressing hazardous energy control procedures that meet the requirements of 29 CFR 1910.147.

5. Personal Protective Equipment and Monitoring equipment

   a. Provide a written Personal Protective Equipment (PPE) and monitoring equipment plan outlining safe work practices addressing the use of personal protective equipment and clothing.

6. Flammable Liquids

   a. Provide a written listing of each of the materials flammable materials planned to be used onsite.
   b. Submit a notice prior to arrival on the work site.

7. Respiratory Protection
    a. Provide a written respiratory protection program if any respiratory protection is needed to perform work.
8. Materials Handling Procedures
    a. Provide procedures to be follow in the handling, storage, and disposal of solids and/or liquids associated with the project.
    b. Provide procedures and precautions for handling, storage and disposal of all materials (solids, liquids, and/or deleterious wastes).

E. The CONTRACTOR shall provide the names of the individuals at the jobsite responsible for implementation and compliance with this Plan. All personnel shall have 40- hr HAZWOPER training. All other people admitted to the site who are unlikely to be exposed to over the permissible exposure levels and published exposure limits must have, at a minimum, 24 hours of HAZWOPER training. Proof of training is required prior to doing cleanup work on this Project.

F. The CONTRACTOR shall submit proof of completion of CMR "Go Contractor" safety training prior to mobilizing to the site.

1.4 REFERENCES

A. FEDERAL STANDARDS, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

B. Title 29 Code of Federal Regulations Section 1910 Hazardous Waste Site Worker Operations

C. Title 29 Code of Federal Regulations Section 1926 Excavations.

PART 2 PRODUCTS

A. Multi-gas Detectors for LEL and oxygen monitoring.

B. Photo-Ionization Detectors (PID) for organic vapor monitoring

C. Eye Wash Station

D. PPE

PART 3 EXECUTION

A. The CONTRACTOR shall be solely responsible for the health and safety of its employees, agents, and lower-tier subcontractors for the duration of the services. The CONTRACTOR shall assign a health and safety officer (HSO). The HSO shall:

1. Be capable of identifying all hazards and have the authority to stop work and take immediate action to correct the hazard;
2. Resolve safety-related issues raised by the ENGINEER;
3. Be present on the Site and verify that all work is performed in accordance with the

HASP.

B. ENGINEER will not act as the HSO for the CONTRACTOR or its subcontractors. However, should the ENGINEER observe conditions that would warrant action, the ENGINEER will inform the CONTRACTOR's HSO and may interrupt operations until such conditions are addressed.

C. The ENGINEER shall not be responsible for the creation, content, or implementation of the CONTRACTOR's HASP. The ENGINEER shall not be responsible for the health and safety of the CONTRACTOR's employees.

D. Any information provided by the ENGINEER is without warranty or representation as to its completeness or suitability. The CONTRACTOR shall indemnify and hold the OWNER, the ENGINEER, any subsidiary related and affiliated companies, and the officers, directors, agents, employees, and assigns of each, harmless from and against any and all claims, demands, suits, judgments, losses, or expenses of any nature whatsoever arising directly or indirectly from the CONTRACTOR's noncompliance with the CONTRACTOR's development or implementation of health and safety programs and plans for its employees, agents and lower-tier subcontractors.

E. The CONTRACTOR shall comply with all applicable Federal, State, and local Health and Safety requirements and standards relating to job site and employer safety, including, but not limited to, the Occupational Safety and Health Act of 1970, as amended, and the standards and regulations issued thereunder. The CONTRACTOR shall also comply with CMR health and safety requirements, standards, and policies.

F. The CONTRACTOR shall ensure that necessary air monitoring, protective clothing, hazardous energy control devices, and other specified supplies and equipment are made readily available to employees to facilitate implementation of the HASP.

G. The CONTRACTOR shall ensure all equipment and personnel entering and exclusion zone are decontaminated in accordance with the safety plan. Contractor is responsible to maintain the personal decontamination facilities used by their employees in a sanitary and safe condition.

H. ACCIDENT REPORTING

1. Notify the Owner or ENGINEER immediately of all incidents involving personal injury and/or property damage. Provide a written report known as the Incident Report within 24 hours of any incident. Report for each incident occurrence shall include:

    a. Description of event.
    b. Names of personnel involved.
    c. Description of injuries and treatment required (short term and long term).
    d. Description of property damage.
    e. Site visits and inspections of other agencies as a result of an incident.
    f. Include names of the persons, purpose of the visit, and any other pertinent information.

2. A copy of each incident report, which the CONTRACTOR or subcontractors have submitted to their insurance carriers, shall be forwarded to the ENGINEER and Owner as soon as possible, but in no event later than seven (7) calendar days after the accident occurred.
3. CONTRACTOR may be subject to mandatory drug testing at CMR's discretion.

I. Use of intoxicants or of illegal or debilitating drugs while working on an Owner contract is prohibited.

J. Failure to comply with safety and health regulations will result in work suspension until adequate safety and health measures are implemented.

END OF SECTION

FIGURE 01 35 29

Appendix B Chemical Request Form (Pg 1 of 2)

Part A -- Originator completes this section. Attach two (X2) SDS of Chemical being requested.

1	Originator's Name		Originator's Company		
2	Chemical TRADE Name		Manufacturer		
	What will the chemical be used for?		Chemical Storage Location		
3	Unit Name/Unit No. where chemical will be used		Equipment/vessel name and number (if applicable)		
	Unit Name/Unit No. where chemical will be used		Equipment/vessel name and number (if applicable)		
4	Is the chemical replacing an existing ▶	☐ No ☐ Yes ▶	Trade Name	Manufacturer	Product Code Number
5	What will be the usage status of this new chemical? ▶	☐ Temporary ☐ Permanent	Is this a process chemical? ☐ No ☐ Yes ▶	MOC No.	
6	When will Chemical arrive ▶		Projected Inventory		
7	Transfer Method (Check only one) ☐ Closed ☐ Open ☐ Manual	**Closed** = No exposure potential, example - pumping into closed process. **Open** = Moderate exposure potential, example .- pumping into open hatch **Manual** = High exposure potential, example - dumping 5 gallon pails			
8	Originator's Signature X		Date	Forward form to Environmental Manager upon completion of Part A	
	Originator's Manager Signature X		Date		

Part B -- Environmental Completes

1	Special Disposal Requirements ☐ No ☐ Yes ▶	Explain		
2	Release/Spill Trigger Reporting ☐ No ☐ Yes ▶	Explain		
3	Is this an Extremely Hazardous Substance (EHS) or contain an EHS? ☐ No ☐ Yes ▶	Explain		
4	Other Remarks			
5	Reviewed by X	Date	Forward to Safety Manager upon completion	

Part C -- Safety Department Completes

1	Reviewed by X	Date		
2	Approved for use ☐ Yes ☐ No ▶	Explain		
	Training Required ☐ Yes ☐ No	PPE Procedure Updated ☐ Yes ☐ NA		
	Comments			

The Originator is responsible for the completion of the Chemical Request Form; obtaining all necessary signatures, providing 2 copies of the SDS, ensuring all information is given to the training department and training is completed, initiating an MOC if necessary and providing 2 finalized copies of the Chemical Request Form to both the Purchasing Manager and the PSM Coordinator.

Appendix B **Chemical Request Form (Pg 2 of 2)**

For all Manager Approvals, sign below. If the chemical is not approved please refer to section 5.5.6 for instructions.

Maintenance Manager _____ Date _____

Operations Manager _____ Date_____

Logistics Manager_____ Date_____

Engineering Manager_____ Date_____

Purchasing Manager_____ Date_____

Warehouse _____ Date_____

Storage Location of Chemcial_____

Environmental Manager_____ Date_____

(Final Signature) Safety Manager_____ Date_____

The Originator is responsible for the completion of the Chemical Request Form; obtaining all necessary signatures, providing 2 copies of the SDS, ensuring all information is given to the training department and training is completed, initiating an MOC if necessary and providing 2 finalized copies of the Chemical Request Form to both the Purchasing Manager and the PSM Coordinator.

SECTION 01 41 00

PERMITS AND FEES

PART 1 – GENERAL

1.1 SCOPE

A. This section includes applicable permits, approvals, and associated fees required for completion of the Work.

1.2 RELATED WORK NOT INCLUDED

A. Section 13 01 00 – Subsurface Drilling

B. Section 31 23 00 - Excavation and Backfill

C. Section 31 25 00 – Soil Erosion and Sedimentation Controls

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

A. Copies of permits obtained by the CONTRACTOR shall be provided to the Owner and the ENGINEER.

PART 2 – PRODUCTS

(Reserved)

PART 3 – EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall obtain following permits:

1. A City of Great Falls Planning and Community Development Department, Building Division Building Permit for installation of the dual phase extraction (DPE) System.
2. A City of Great Falls Erosion Control Plan.
3. Montana Department of Transportation Encroachment Permit for installation of passive treatment trench (PTT).
4. Approval by the Board of Water Well Contractors prior to installation of light non-aqueous phase liquid (LNAPL) recovery wells and PTT performance monitoring well.
5. A Cascade County permit to Work on a County Road or right of way permit.

B. The CONTRACTOR shall pay for fees associated with all permits and approvals of their responsibility.

END OF SECTION

SECTION 01 43 00

CONTRACTOR QUALITY CONTROL

PART 1 - GENERAL

1.1 SCOPE

A. The Work included in this Section includes the requirements of the CONTRACTOR's quality control program.

1.2 RELATED WORK NOT INCLUDED

A. Section 01 31 19 – Preconstruction Meeting

B. Section 01 75 00 – Equipment Testing and Startup

C. Section 40 05 01 – Process Piping

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

(Reserved)

1.5 GENERAL

A. The quality of all work shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall implement and maintain an effective quality control program that complies with manufacturer's specifications/requirements and the contract documents.

B. The CONTRACTOR shall furnish qualified personnel, appropriate facilities, instruments, and testing devices necessary to demonstrate compliance with standard construction and testing requirements and shall cover the identified construction quality control activities where required.

C. Inspections and testing shall be performed in accordance with the project specifications where specified, including work performed by subcontractors, to ensure conformance to applicable Specifications and Design Drawings with respect to the quality of materials, workmanship, construction, finished product and functional performance.

PART 2– PRODUCTS

(Reserved)

PART 3 – EXECUTION

3.1 QUALITY CONTROL ORGANIZATION

A. Quality Control Manager

1. The CONTRACTOR shall appoint a Quality Control Manager from within its organization whose responsibility is the overall management of quality control to assure the work is performed in compliance with the Specifications and Design Drawings and who has the authority to act in all quality control matters for the CONTRACTOR.
2. The Quality Control Manager shall be experienced and knowledgeable in construction methods as it relates to the installation of in dual phase extraction (DPE) systems and passive treatment trench. They shall also be experienced in mechanical, electrical and process systems. The Quality Control Manager shall be approved by the ENGINEER.

B. Quality Control Staff

1. The Quality Control Staff shall be employed under the direction of the Quality Control Manager to perform all quality control inspections and testing activities.
2. Staff shall be fully qualified by experience and technical training to perform their assigned responsibilities and shall be directly hired by and work for the CONTRACTOR.

C. The Quality Control Manager shall be responsible for certifying that all inspections and tests are in compliance with the Design Plans and Specifications, ASTM, and NEC requirements.

D. The Quality Control Manager or his designated representative shall be physically on-site when work specified in the project specifications is in progress.

3.2 INSPECTION AND TESTS

A. The CONTRACTOR's quality control program shall consist of inspections and tests to ensure that each feature of the work is carried out in accordance with applicable codes, construction methods, ASTM and NEC requirements, and the Specifications and Design Drawings.

1. Initial inspections shall be performed prior to beginning each work activity requiring inspection, testing and/or certification. Quality control inspections for the work shall include:
   a. A review of submittal and all other Contract requirements, (particularly Activity Hazard Analyses and other Health and Safety Requirements) with the foremen or supervisors directly responsible for the performance of the work;
   b. Checks to assure that provisions have been made to provide required field control testing;
   c. Examination of each work area to ascertain that all preliminary work has been completed;
   d. Verification of all field dimensions and notice to the ENGINEER of any discrepancies;
   e. Physical examination of materials and equipment to assure that they conform to approved shop drawings or submittal data and that all materials and/or equipment are on hand.

2. Work activity inspections shall be performed as soon as work begins on a representative portion of each feature of work and shall include examination of the quality of workmanship as well as a review of control testing to assure compliance with applicable requirements.
3. Follow-up or post work activity inspections including control testing and analysis shall be performed as each feature of work progresses, until completion, to assure compliance with the project requirements.

B. All inspections and test results shall be recorded and provided to the ENGINEER.

C. The CONTRACTOR shall submit a "Construction Quality Control Report" (CQCR) to show the results of all inspections, tests and results as required by these Specifications. The CQCR shall be submitted to the ENGINEER on the first work day following the date covered by the report. A sample form for the CQCR is attached as Figure 01 43 00-1. The CONTRACTOR may propose an alternate format, pending approval of the ENGINEER, provided that all required information is included in the CONTRACTOR's proposed report format.

3.3 DEFICIENCIES

A. The CONTRACTOR shall stop work on any item or work feature, pending satisfactory correction of any deficiency noted by the Quality Control Manager, their staff or the ENGINEER.

B. If recurring deficiencies in an item or items indicate that the quality control program is inadequate, corrective actions shall be taken as approved by the ENGINEER.

C. If the CONTRACTOR fails or refuses to take such corrective actions promptly, the ENGINEER may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to any such stop work orders shall be made the subject of a claim for extension of time or for excess costs or damages by the CONTRACTOR.

3.4 MANUFACTURER’S CERTIFICATE OF COMPLIANCE

A. When so specified, a manufacturer’s Certificate of Compliance shall be completed in full, signed by the entity supplying the product, material, or service, and submitted prior to shipment of product or material or the execution of the services.

B. The ENGINEER may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance, certifying that the proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.

END OF SECTION

Figure 01 43 00-1

DAILY QUALITY CONTROL REPORT (CONTRACTOR)

REPORT NO._____CONTRACT NO._____DATE_____

LOCATION OF WORK: _____

DESCRIPTION:_____

WEATHER: _____

RAINFALL _____INCHES, TEMP: MIN _____ MAX _____

1. Work Performed Today by Contractor (Include Labor Breakdown):

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

2. Work Performed Today by Lower Tier Subcontractors (Include Labor Breakdown):

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

3. List Specific Inspections Performed and Results of these Inspections. (Include Corrective Actions):

_____

_____

_____

_____

_____

_____

_____

_____

4. List Types and Locations of Tests Performed and Results of these Tests:

_____

_____

_____

_____

_____

_____

_____

_____

5. Verbal Instructions Received from ENGINEER's Inspector on Construction Deficiencies or Re-testing Required:

_____

_____

_____

_____

_____

_____

_____

_____

6. Chemical Sampling Locations, Matrix and Analytical Results:

_____

_____

_____

_____

_____

_____

_____

_____

7. Remarks:

_____

_____

_____

_____

_____

_____

8. CERTIFICATION: I certify that the above report is complete and correct and that I, or my authorized representative, have inspected the work performed this day by the Contractor and each subcontractor and have determined that all materials, equipment, and workmanship are in strict compliance with the Design Drawings and Specifications except as may be noted above.

_____
Contractor's Quality Control Manager

SECTION 01 51 00

TEMPORARY FACILITIES

PART 1 - GENERAL

1.1 SCOPE

A. The Work covered in this Section includes provisions to furnish, operate and maintain the following temporary facilities and services and their removal on completion of the Project:

1. Facilities:

   a. CONTRACTOR's temporary equipment/materials storage containers, sheds, or shelters.

2. Services

   a. Wastewater disposal;

   b. Sanitary waste system; and

   c. Traffic control.

1.2 RELATED WORK NOT INCLUDED

A. Section 01 11 00 – Work Requirements

B. Section 01 57 30 – Traffic Safety and Regulations

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

A. The following submittals shall be submitted to and approved by the ENGINEER or Owner prior to mobilization of temporary facilities at the site:

1. Provide copies of permits and approvals for construction as required by Laws and Regulations and governing agencies.

2. Provide plans for temporary CONTRACTOR’s field office and equipment storage facilities.

3. Provide plans for staging areas, storage areas, and parking.

4. Provide fencing and protective barrier locations and details.

5. Provide plans for disposal of waste materials and intended haul routes in agreement with the project Traffic Control Plan.

PART 2– PRODUCTS

2.1 FIELD OFFICES

A. Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading.

B. The CONTRACTOR shall provide a trailer for their own use and for use by ENGINEER.

2.2 STORAGE AREAS

A. Provide shed sizes, furnished, and equipped to accommodate materials and equipment for construction operations.

B. Store combustible materials apart from building.

2.3 EQUIPMENT

A. Provide portable fire extinguishers, UL rated, with class and extinguishing agent as required by locations and classes of fire exposures.

B. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.

PART 3 – EXECUTION

3.1 TEMPORARY FACILITIES REQUIREMENTS

A. All facilities specified shall be located as shown in the Contract Drawings. Prior to installation of offices and sheds, the CONTRACTOR shall consult with the ENGINEER/owner in regard to location, access, and related facilities. As required, coordinate additional staging area with the ENGINEER/Owner.

B. Living quarters shall not be established at the Site.

C. Relocate facilities as required by progress of the Work with approval from ENGINEER/Owner.

D. Maintain in good repair and appearance and provide cleaning service and replenishment as required.

3.2 TEMPORARY FACILITIES

A. Sanitary Facilities

1. Provide and maintain facilities for CONTRACTOR and its subcontractors, and all other onsite personnel. Service: clean and maintain facilities and enclosures.

2. Waste from sanitary facilities shall be collected by a sanitation pumping truck for subsequent transfer to an off-site wastewater treatment facility.

B. Fire Protection

1. Furnish and maintain on-site adequate firefighting equipment capable of extinguishing incipient fires.

3.3 TEMPORARY STORAGE AREAS

A. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored.

3.4 TEMPORARY CONTROLS

A. Air Pollution Control

1. Minimize air pollution from construction operations.
2. Burning: Of waste materials, rubbish, or other debris will not be permitted on Site.

B. Water Pollution Control

1. Do not dispose of volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

C. Erosion and Sediment Control

1. Provide, maintain, and operate temporary facilities to control erosion and sediment releases, and to protect the Work and existing facilities from flooding during construction period

D. Storm Water Control:

1. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of storm water from heavy rains.

3.5 TRAFFIC CONTROL AND PARKING

A. All onsite traffic shall follow the Site-specific Traffic Management Plan.

B. The CONTRACTOR shall provide and install traffic signage before commencing the construction work.

C. The CONTRACTOR shall control vehicular traffic on the Site and ensure safe and efficient operations.

D. Access road from the North River Road to the BNSF railroad property should be blocked with barricades with reflective tape. The barricades should be placed on the Northwestern Energy area.

E. When flaggers and guards are required by regulation or when deemed necessary for safety, furnish them with approved orange wearing apparel and other regulation traffic control devices.

F. Comply with Laws and Regulations regarding closing or restricting use of public streets or highways. No public or private road shall be closed, except if mentioned in the specifications or by written permission of proper authority. Assure the least possible obstruction to traffic and normal commercial pursuits.

G. Temporary parking areas for construction personnel shall be regulated to ensure free and safe entry and egress to and from the Site. Comply with the Site-specific Traffic Management Plan for designated temporary parking areas.

H. Notify ENGINEER of all deliveries scheduled to the site at least one week in advance of scheduled shipment.

3.6 SECURITY AND PROTECTION

A. General on-site security will be provided by Calumet Montana Refining's (CMR) contractor Securitas Security Services USA. Routine security patrols are completed at the facility.

B. Before construction operations begin, furnish and install temporary fence around the construction areas as shown in the Design Drawings.

C. All CONTRACTOR equipment, materials, and supplies must be located within existing fenced area or temporary fenced areas installed by CONTRACTOR. Reactive media for the passive treatment trench will be stored in a lockable, intermodal container (i.e., CONEX box) or stored in a weather protected location within the CMR facility specified by CMR.

D. The excavations shall be protected overnight using engineering controls preventing workers or the public from gaining access. Engineering protections include but are not limited to steel plates, flowable fill, or fencing.

END OF SECTION

SECTION 01 57 30

TRAFFIC SAFETY

PART 1 – GENERAL

1.1 SCOPE

A. The Work covered in this Section includes the CONTRACTOR's obligations with respect to use of public roads and private driveways within and adjacent to the Project Site.

1.2 RELATED WORK NOT INCLUDED

A. Section 01 51 00 - Temporary Facilities and Utilities

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

(Reserved)

PART 2 – PRODUCTS

(Reserved)

PART 3 – EXECUTION

3.1 GENERAL

A. All onsite traffic shall follow the CONTRACTOR developed Site-specific Traffic Management Plan.

B. The CONTRACTOR shall comply with all rules and regulations of the State, County, and City authorities regarding closing or restricting the use of public streets or highways. No public or private road shall be closed, except by express permission of the appropriate authorities.

C. The CONTRACTOR shall comply with all CMR mandated traffic flow requirements and restrictions.

D. The work shall be conducted to assure the least possible obstruction to traffic and normal commercial pursuits. All obstructions shall be protected by installing approved signs, temporary traffic barriers, barricades, and lights where necessary for the safety of the public. The convenience of the general public, site employees and residents, and the protection of persons and property shall be provided in an adequate and satisfactory manner.

E. When flagmen and guards are required by regulation or when deemed necessary for safety, they shall be furnished with approved orange wearing apparel and other regulation traffic control devices.

3.2 POLICE AND FIRE SERVICE

A. The Police and Fire Departments having jurisdiction in the area shall be notified before closing any roadway or portion of a roadway. No closing shall be made without ENGINEER's prior approval. Closure shall be made with the least interference to fire equipment access, which shall not be prevented under any circumstances.

END OF SECTION

SECTION 01 61 13

HANDLING OF CONTAMINATED MATERIAL

PART 1 GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall follow all required State and Federal permits, licenses and authorizations for handling contaminated materials at the Site.

B. The work described in this section consists of handling and temporary storage of contaminated soil and water generated during installation of the dual phase extraction (DPE) wells, conveyance piping, light non-aqueous phase liquid (LNAPL) recovery trench, and passive treatment trench (PTT). Other impacted soil and or decontamination water may need to be handled also.

1.2 RELATED WORK NOT INCLUDED

A. Section 01 35 29 – Health and Safety Requirements.

B. Section 13 01 00 – Subsurface Drilling.

C. Section 31 00 00 – Excavation and Fill.

D. Section 40 05 01 – Process Piping.

1.3 SUBMITTALS

A. A plan for handling of contaminated materials shall be submitted as part of the CONTRACTOR's Environmental Protection Plan and adhere to the requirements set forth in CMR's waste handling policies. This plan shall include:

1. Waste sampling procedures and laboratory analysis methods;
2. Handling procedures;
3. Management of waste material staging area(s); and
4. Transportation of waste material to on-site staging area(s) (if necessary) and off-site disposal facility.

B. The CONTRACTOR to complete waste manifests, as needed and submit to the ENGINEER for signature and provide signed copies from the landfill.

1.4 REFERENCES

(Reserved)

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

3.1 WASTE MANAGMENT

A. DPE WELL INSTALLATION

1. Soil cuttings generated during well installation activities shall be containerized

in properly labeled US Department of transportation (DOT)-compliant 55-gallon drums or roll-off boxes and disposed of off-site along with other soil waste.

2. Fluid generated as part of well development activities shall be disposed of at Calumet Montana Refining's (CMR) wastewater treatment facility.

B. PIPING INSTALLATION

1. Soil generated during excavation activities for DPE transfer piping installation shall be stockpiled immediately next to the trench.
2. The soil shall be reused as backfill, if no visible impacts or elevated PID readings are noted in the stockpiled material. Excess material will be graded into the surrounding area.
3. If soils excavated during transfer pipe installation are visibly impacted as identified by the ENGINEER, soil will be placed on plastic sheeting and characterization for disposal.

C. LNAPL RECOVERY TRENCH AND PTT INSTALLATION

1. The excavated material shall be directly loaded into covered, US DOT-compliant dump-trucks or roll-off boxes and transported by a licensed transporter as profiled non-hazardous special waste under manifest to a licensed landfill.
2. During the excavation, if groundwater is encountered or stormwater enters the excavation, the CONTARCTOR shall collected the accumulated water by appropriate means and dispose it at CMR's wastewater treatment facility.

D. MISCELLANEOUS CONSTRUCTION DEBRIS

1. Miscellaneous construction debris shall be placed in a dumpster dedicated for this project for off-site disposal. CONTRACTOR is responsible for arrangement of dumpster.

E. DECONTAMINATION

1. The CONTRACTOR should decontaminate all equipment, containers, etc. at project completion and properly dispose of residuals.

3.2 CONTAMINATED MATERIAL SAMPLING AND ANALYSIS

A. Representative samples of stored contaminated soil waste material shall be collected.

B. Analyses for contaminated material to be taken to an offsite treatment facility shall conform to local, state, and federal criteria as well as to the requirements of the treatment and disposal facility.

C. Stored material with contaminant levels that exceed the action levels shall be treated offsite to conform to local, state, and federal criteria as well as to the requirements of the treatment facility.

D. Documentation of all analyses performed shall be furnished to the ENGINEER.

3.3 DISPOSAL

A. The CONTRACTOR shall coordinate the transportation of impacted soils by licensed waste hauler in accordance with local, state, and federal requirements.

1. Impacted soil taken off-site shall be manifested according to state and federal requirements and sent to the landfill chosen by the OWNER/ENGINEER.
2. All waste and/or waste containers must be removed from Site prior to job completion.

B. The OWNER/ENGINEER will complete waste profiles for disposal of contaminated soil at the selected landfill in advance of mobilization.

END OF SECTION

SECTION 01 75 00

EQUIPMENT TESTING AND STARTUP

PART 1 - GENERAL

1.1 SCOPE

A. The Work covered in this Section specifies detailed information for the Vendor to perform equipment functional tests, performance tests, and plant start-up. The CONTRACTOR shall assist the Vendor with these tasks.

B. The Vendor shall complete equipment functional test or validation in presence of the ENGINEER to demonstrate that each installed piece of equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements as specified.

C. The Vendor shall conduct individual equipment performance tests in the presence of the ENGINEER to demonstrate and confirm individual equipment meets performance requirements specified in individual sections.

D. Equipment testing and startup shall be completed within the Contract times. The Vendor shall furnish labor, power, chemicals, tools, equipment, instruments, and services required for and incidental to completing functional testing, performance testing, and operational testing.

1.2 RELATED WORK NOT INCLUDED

(Reserved)

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

A. The Vendor shall submit the following informational submittals to the ENGINEER

1. Functional and performance test results.
2. Completed Startup Form for each equipment, unit, or process (see attached form 01 75 00-1).

1.5 EQUIPMENT TESTING

A. Complete equipment installation before testing.

B. Complete Equipment Startup and Test Report Form for each item of equipment to be tested. Form 01 75 11-1 attached at the end of this section.

C. ENGINEEER will make the ready-to-test determination based on review of the following documents:

1. Adequate completion of work adjacent to, or interfacing with, equipment to be tested, including items or works to be completed by others.
2. Availability and acceptability of Vendor's representative, when specified, to assist in testing of respective equipment.

1.6 FUNCTIONAL TESTING

A. The Vendor shall conduct functional testing as specified by manufacturer.

B. Notify ENGINEER in writing at least 10 days prior to scheduled date of testing.

C. Prior to functional testing, perform the following:

1. Calibrate testing equipment in accordance with manufacturer's instructions.
2. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.
3. Lubricate equipment in accordance with manufacturer's instructions.
4. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
5. Check power supply to electric-powered equipment for correct voltage.
6. Adjust clearances and torque.

D. Functionally test mechanical and electrical equipment and instrumentation and control system.

E. Demonstrate proper rotation, alignment speed, flow, pressure, vibration, sound level, adjustments, and calibration.

F. Demonstrate proper operation of each instrument loop function including alarms, local, and remote controls, instrumentation and other equipment functions, generate signals with test equipment to simulate operating conditions in each control mode.

G. When, in ENGINEER's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to start-up phase. Start-up shall proceed following final inspection of the system by the Vendor.

H. Certificate of Proper Installation

1. At the completion of equipment and functional testing, submit written report certifying equipment:
   a. Has been properly installed, adjusted, aligned, and lubricated.
   b. Is free of any stresses imposed by connecting piping or anchor bolts.
   c. Is suitable for satisfactory full-time operation under full load conditions.
   d. Operates within the allowable limits for vibration.
   e. Controls, protective devices, instrumentation, and control panels furnished as part of the equipment package are properly installed, calibrated, and functioning.
   f. Control logic for start-up, shutdown, sequencing, interlocks, and emergency shutdown have been tested and are properly functioning.

1.7 RECORD KEEPING

A. The Vendor maintain and submit following records generated during start-up and testing phase of Project:

1. Daily logs of equipment testing identifying all tests conducted and outcome.
2. Logs of time spent by Vendor's representatives performing services on the job site.
3. Equipment lubrication records.
4. Data sheets of control loop testing including testing and calibration of instrumentation devices and set points.

PART 2 – PRODUCTS

(Reserved)

PART 3 – EXECUTION

(Reserved)

FORM 01 75 00-1

EQUIPMENT START-UP AND TEST FORM

(to be completed for each piece of equipment)

Date of Inspection and Name of Inspector:_____
Equipment: _____
Model, Serial and P&ID Equipment Numbers: _____

Installed according to manufacturer's specifications: Y N
Comments: _____
_____
_____

Installed free of defects: Y N
Comments: _____
_____
_____

All alarms and controls tested: Y N
Comments: _____
_____
_____

Equipment testing performed according to manufacturer's specifications: Y N
Comments: _____
_____
_____

Equipment start-up performed according to manufacturer's specifications: Y N
Comments: _____
_____
_____

Any operational issues: Y N
Comments: _____
_____
_____

Any required corrective actions: Y N
Comments: _____
_____
_____

END OF SECTION

SECTION 01 77 19

FINAL CLOSEOUT REVIEW AND REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Supplemental requirements to the Conditions of the Contract and Specifications for administrative procedures in closing out the Work apply to this section.

1.2 RELATED WORK NOT INCLUDED

Division 1 Sections pertaining to progress procedures at the Project site, and Division 2 Sections for specific closeout and special requirements for the Work in those Sections.

1.3 SUBMITTALS

(Reserved)

1.4 REFERENCES

(Reserved)

1.5 DEFINITIONS

(Reserved)

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

3.1 CLOSEOUT

A. Complete the Work in accordance with appropriate Sections of the Specifications and approved schedules.

B. The ENGINEER will issue their written recommendation for contract completion upon their determination that the CONTRACTOR has achieved Final Completion. Final Completion has occurred when the following requirements have been fulfilled:

1. Project Record Documents have been submitted;
2. All Warranties and Bonds, including but not limited to special guarantees, workmanship and maintenance bonds, maintenance agreements, final certifications and similar documents have been provided;
3. Terms and requirements of all permits issued by regulatory agencies have been satisfied;
4. All required special testing has been completed and approved;
5. All changes to the Work have been completed and approved by Change Order, with associated changes to contract price and time incorporated in the final pay request; and
6. Dates for Project Completion have been established in writing by the ENGINEER.

C. Inspection and acceptance for a phased closeout will be performed in accordance with the General Conditions of the contract.

D. Submit written certifications that the Contract Documents have been reviewed, the Work has been inspected and is complete in accordance with the Subcontract Documents, and ready for the ENGINEER's Inspection.

3.2 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

3.3 PROJECT RECORD DOCUMENTS

A. Maintain at Site, one copy of:

1. Project Drawings and Manual, including addenda;
2. Change Orders and Field Change Authorization;
3. Other modifications to Contract;
4. Field test records; and
5. Require permits.

B. At Closeout, provide updated project record documents including Design Drawings, Specifications, Addenda, Change Orders and other Modifications to the Subcontract, Reviewed Shop Drawings, product data, samples, test results and final As-built Drawings.

3.4 FINAL ADJUSTMENTS OF ACCOUNTS

A. Submit final statement of accounting to the ENGINEER.

1. Statement shall reflect all adjustments:
   a. Original Contract Price.
   b. Additions and deductions resulting from:
      i. Previous Change Orders;
      ii. Other Adjustments;
      iii. Deductions from uncorrected work; and
      iv. Deductions for Re-inspection Payments.
   c. Total Contract Price, as adjusted.
   d. Previous payments.
   e. Sum remaining due.

B. The ENGINEER will prepare final Change Order, reflecting approved adjustments to Contract Price not previously made by Change Orders.

3.5 FINAL APPLICATION FOR PAYMENT

A. Contractor shall submit the final application for payment in accordance with Contract

Documents.

END OF SECTION

SECTION 01 78 00

CLOSEOUT SUBMITTALS

PART 1 – GENERAL

1.1 SUMMARY

A. Supplemental requirements to the Conditions of the Contract and Specifications for administrative procedures in closing out the Work apply to this section.

1.2 RELATED WORK NOT INCLUDED

A. Division 1 Sections pertaining to progress procedures at the Project site.

1.3 SUBMITTALS

(Reserved)

1.4 REFERENCES

(Reserved)

1.5 DEFINITIONS

(Reserved)

PART 2 – PRODUCTS

(Reserved)

PART 3 – EXECUTION

3.1 CLOSEOUT

A. Complete the Work in accordance with appropriate Sections of the Specifications and approved schedules.

B. ENGINEER or its designated representative will issue their written recommendation for contract completion upon their determination that the CONTRACTOR has achieved Final Completion. Final Completion has occurred when the following requirements have been fulfilled:

1. Project Record Documents have been submitted;
2. All Warranties and Bonds, including but not limited to special guarantees, workmanship and maintenance bonds, maintenance agreements, final certifications and similar documents have been provided;
3. Terms and requirements of all permits issued by regulatory agencies have been satisfied;
4. All required verification testing has been completed;
5. All changes to the Work have been completed and approved by Change Order, with associated changes to contract price and time incorporated in the final pay request; and

6. Dates for Project Completion have been established in writing by the ENGINEER or its designated representative.

C. Inspection and acceptance for a phased closeout will be performed in accordance with the General Conditions of the contract.

D. Submit written certifications that the Contract Documents have been reviewed, the Work has been inspected and is complete in accordance with the Subcontract Documents, and ready for the ENGINEER's Inspection.

3.2 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

3.3 PROJECT RECORD DOCUMENTS

A. Maintain one copy of:

1. Project Drawings and Manual, including addenda;
2. Change Orders and Field Change Authorization;
3. Other modifications to Contract;
4. Field test records; and
5. Required permits.

B. At Closeout, provide updated project record documents including verification testing and performance sampling data, test results and final Record Drawings.

3.4 FINAL ADJUSTMENTS OF ACCOUNTS

A. Submit final statement of accounting to ENGINEER.

1. Statement shall reflect all adjustments:
   a. Original Contract Price.
   b. Additions and deductions resulting from:
      i. Previous Change Orders;
      ii. Other Adjustments;
      iii. Deductions from uncorrected work; and
      iv. Deductions for Re-inspection Payments.
   c. Total Contract Price, as adjusted.
   d. Previous payments.
   e. Sum remaining due.

B. ENGINEER will prepare final progress payment, reflecting approved adjustments to Contract Price previously made by Change Orders.

3.5 FINAL APPLICATION FOR PAYMENT

A. Contractor shall submit the final application for payment in accordance with Contract Documents.

END OF SECTION

SECTION 01 94 00

DECOMMISSIONING

PART 1 – GENERAL

1.1 SCOPE

A. The Work covered in this Section specifies detailed information for CONTRACTOR to provide services to decommission two existing recovery sumps and a discharge line as specified in the Design Drawings.

B. The CONTRACTOR shall furnish labor, power, tools, equipment, instruments, and services required for and incidental to completing the system decommissioning and deconstruction.

1.2 RELATED WORK NOT INCLUDED

(Reserved)

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

A. CONTRACTOR shall submit the following informational submittals to the ENGINEER:

1. System Decommissioning Plan not less than 1 week prior to commencing decommissioning.
2. Waste disposal documentation for all materials sent for off-site disposal or recycling.

PART 2 – PRODUCTS

(Reserved)

PART 3 – EXECUTION

2.1 SCOPE

A. The CONTRACTOR shall excavate and remove the two former product recovery systems by excavating and removing the corrugated steel sumps and equipment and piping within the recovery sump.

B. The two existing polyethylene product recovery tanks shall be salvaged and moved to a location specified by the ENGINEER.

C. The existing 1-inch steel discharge piping from western recovery system to sanitary sewer shall be disconnected on both ends and capped/sealed. Fluids from steel discharge pipe shall be contained and managed as hazardous waste. ENGINEER to coordinate the disposal of any containerized waste generated from the removal of the existing recovery sump equipment/piping.

D. The CONTRACTOR shall cut and leave in-place the 4-inch polyvinyl chloride drainpipe.

E. The CONTRACTOR shall disconnect electricity to electrical connection at each recovery system and remove control panel.

F. The existing fencing around the western recovery system shall be removed.

END OF SECTION

SECTION 02 10 00

SITE PREPARATION AND MAINTENANCE OF EXISTING CONDITIONS

PART 1 GENERAL

1.1 SCOPE

A. The Work covered in this Section includes all labor, material, and equipment necessary to perform the preparatory work and procedures to be followed prior to and during the construction work.

1.2 RELATED WORK NOT INCLUDED:

A. Section 01 41 00 – Permits and Fees

B. Section 01 50 00 – Temporary Facilities and Controls

C. Section 01 35 20 – Site Health and Safety

D. Section 01 61 13 – Handling of Contaminated Material

E. Section 02 11 00 – Clearing and Grubbing

F. Section 31 25 00 – Erosion and Sedimentation Controls

1.3 SUBMITTALS

A. Provide Owner and ENGINEER written notice of construction start date at least 30 working days prior to beginning site activities.

B. Prior to start of construction submit product data and the name and location of all sources that will be used to obtain the materials specified in this Section.

C. Submit for documentation, certificates and/or test results for one sample of each material obtained from on- and off-site sources indicating compliance with Specifications prior to start of construction. ENGINEER may take random samples or request additional information of the material upon delivery or placement to verify compliance with the Specifications.

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

3.1 SITE PREPARATION

A. The CONTRACTOR shall conduct clearing and grubbing in accordance with the requirements of Section 02 11 00 – Clearing and Grubbing.

B. The CONTRACTOR shall install temporary facilities as specified in Section 01 50 00 – Temporary Facilities and Controls.

C. The CONTRACTOR shall install soil erosion and sediment control measures as specified in Section 31 25 00 – Erosion and Sedimentation Control.

3.2 PROTECTION OF STRUCTURES AND UTILITIES

A. Preserve and protect groundwater monitoring wells, benchmarks, and site improvements to remain. If damaged during construction, notify ENGINEER immediately. If determined by ENGINEER that the monitoring well, benchmark, or site improvement integrity is compromised, CONTRACTOR shall repair damage at CONTRACTOR's expense under observation of ENGINEER.

B. Protect, support, and maintain existing utilities (i.e., conduits, wires, pipes) that are to remain in place during work as indicated in the Contract Drawings. If uncharted utilities are encountered during excavation, stop work, place work in a safe condition, and notify Engineer. Locate existing underground utilities by vacuum excavation, as necessary.

3.3 STAGING AND STOCKPILING AREAS

A. Subcontractor shall stockpile clean materials in the clean material staging area at a location approved by the ENGINEER.

B. Stockpiles of non-impacted soil shall not exceed 5 feet in height, unless approved otherwise by the ENGINEER, and shall be surrounded with a 9-inch high berm at the perimeter. Silt fence or other erosion control measures shall be placed around the perimeter of the stockpile areas.

C. Inactive stockpiles shall be covered, anchored, and inspected with plastic, as approved by ENGINEER.

3.4 CONTAMINATED MATERIAL HANDLING

A. Handling, temporary storage, and disposal of contaminated soil and water generated during the construction activities should be done in accordance with the requirements of Section 01 61 13 – Handling of Contaminated Material.

3.5 TRANSPORTATION ROUTES

A. The transportation routes should avoid residential areas and follow posted trucking routes. All routes, including public roads and site entrance, shall be maintained throughout the duration of the project. Clean public rights-of-way and streets as needed with commercial street sweepers, or as approved by the ENGINEER.

END OF SECTION

SECTION 02 11 00

CLEARING AND GRUBBING

PART 1 GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall furnish all labor, materials, equipment, and incidentals required to perform all clearing and grubbing activities.

B. This work shall consist of clearing, grubbing, removal, and satisfactory disposal of all of trees, snags, logs, brush, stumps, and shrubs from the designated areas, except those items designated to remain.

1.2 RELATED WORK NOT INCLUDED

A. Drawings and general provisions of the Contract, and Division 01 Specification Sections, apply to this Section.

B. Section 01 50 00 – Temporary Construction Facilities and Controls.

1.3 SUBMITTALS

(Reserved)

1.4 REFERENCES

(Reserved)

1.5 DEFINITIONS

(Reserved)

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

3.1 MECHANICAL CLEARING AND GRUBBING

A. The CONTRACTOR shall grub out all stumps, roots, and root clusters within the work area having a diameter of one (1) inch or larger to a depth of at least one (1) foot below ground surface. Unsatisfactory material such as brush, hedge, roots, stump, branches and logs of trees, heavy vegetation, etc. shall not be embedded or buried at the site.

B. All trees, stumps, roots, brush, hedge, heavy growth of vegetation, etc., shall be cleared and grubbed within the project limits of disturbance as shown in the Construction Drawings without disturbing soil and to the satisfaction of the ENGINEER.

C. All slopes of cuts, access roads, ditches, channels, waterways and all structures, both old and new, within the project limits of disturbance shall be cleared and cleaned of all brush, hedges, weeds, heavy vegetation, obstruction, rubbish and other objectionable material or growth, and shall be maintained in a neat, serviceable and satisfactory condition until the project is accepted.

3.3 MATERIALS MANAGEMENT

A. Stumps, trees, and root wastes that are generated shall be chipped and left on site in designated area approved by the ENGINEER.

B. All other non-contaminated materials removed as a result of this project shall be disposed of by the CONTRACTOR at an approved licensed sanitary landfill or composting site.

C. The CONTRACTOR shall not burn or bury clearing and grubbing waste on-site.

D. The CONTRACTOR shall comply with all local, State, and Federal rules and regulations and the payment of any and all fees that may result from the off-site disposal of materials.

3.4 CLEARING BEYOND SPECIFIED LIMITS

A. Clearing beyond the specified limits of construction for the CONTRACTOR's convenience is prohibited and shall only be performed with ENGINEER's approval.

END OF SECTION

SECTION 11 00 00

GENERAL EQUIPMENT REQUIREMENTS

PART 1 GENERAL

1.1 SCOPE

A. This section sets forth general requirements related to furnishing, installing and testing of any and all equipment specified under any and all sections of these specifications.

1.2 RELATED WORK NOT INCLUDED

A. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.

B. Section 01 57 30 – Traffic Safety.

C. Section 11 01 00 – Packaged Dual Phase Extraction System.

D. Section 11 15 00 – Packaged Catalytic Thermal Oxidizer System.

1.3 REFERENCES

(Reserved)

1.4 SUBMITTALS

B. The Vendor shall submit all submittals (i.e., shop drawings, descriptive data, performance characteristics, material specifications, spare parts, piping and wiring diagrams, etc., as appropriate) showing conformance of all equipment to the Contract Documents to the ENGINEER for review.

C. Submittals on items requiring performance affidavits will not be reviewed until acceptable performance affidavits are received.

D. Where submittals include information (such as piping and wiring diagrams), which is pertinent to other Vendor/CONTRACTORs on the project, approved copies of these submittals shall be forwarded by the one prime CONTRACTOR to the other prime CONTRACTORs concerned.

E. All submittals must be complete, accurate, and provide sufficient details to indicate item-by-item compliance with the Contract Documents. If the submittal deviates from the requirements of the Specifications in any way, it shall be clearly marked in the submittal with the justifying reason stated for subsequent evaluation by the ENGINEER.

1.5 PERFORMANCE AFFIDAVITS

A. The Vendor shall submit manufacturer's performance affidavits for equipment to be furnished for this project when required in the appropriate equipment Materials and Performance Section and/or the Design Drawings.

B. In the performance affidavit submittal, each Vendor must certify to the CONTRACTOR and the ENGINEER, jointly, that they have examined the Contract Documents and that the equipment, apparatus, process or system they offer to furnish

will meet in every way the performance requirements set forth in the Contract Documents. Equipment design, manufacturing, and assembly specifications are an integral part of the performance requirements. The Vendor must transmit to the ENGINEER one (1) copy of the affidavit provided to them by the manufacturer in conjunction with initial shop drawing submittals. Shop drawings will not be reviewed prior to receipt by the ENGINEER of an acceptable performance affidavit. The performance affidavit must be signed by an officer of the corporation, partnership, or company manufacturing or supplying the equipment.

C. Format for the performance affidavit shall be as follows:

Addressed To:	Ramboll US Corporation and Contractor
Project Reference:	Contract No.:
	Project Title:
	City, State:
Content:	At minimum, a statement shall be made that "(Vendor's Name) has examined the Contract Documents and that the (Equipment/Product) meets in every way, the design specifications and performance requirements set forth in Materials and Performance Section(s) of the Contract Documents."
Signature:	Person signing the affidavit shall be a corporate officer, vice president level or higher, unless a statement authorizing signature by another is attached.

1.6 DELIVERY OF EQUIPMENT

A. The Vendor shall be responsible for equipment shipping.

B. The CONTRACTOR is responsible for providing personnel and the properly rated lifting apparatus to off-load the equipment and place it at the designated location shown in the design drawings.

C. Delivery dates for equipment/products shall be as required by the ENGINEER to meet the finalized project work schedule.

D. Delivery of equipment must adhere to the requirements of Section 01 57 30 – Traffic Safety.

1.7 EQUIPMENT IDENTIFICATION

A. The Vendor is responsible for providing equipment identification tags that correspond to the tags in the design drawings. The Vendor shall submit the list of equipment labels to the ENGINEER prior to the 70 percent completion point of equipment fabrication/construction.

B. Each product, piece of equipment, etc., shall be furnished with a substantial stainless steel or brass nameplate. The nameplate shall be conspicuously located and securely fastened and shall be clearly inscribed with, at minimum, the manufacturer's name,

serial number, model number (when applicable), principal rating data and year of manufacture.

C. In addition, each piece of mechanical equipment (i.e., pumps, flow meters, transmitters, etc.) shall also be identified as to name and tag number by a suitable laminated plastic label attached to the unit; for example "Effluent Transfer Pump (P-200)". The equipment tag numbers shall be obtained from the Design Drawings. Names and tag numbers of mechanical equipment shall be coordinated to match same on remotely located controls, control panels, etc. Labels shall be black plastic with 3/8-inch minimum height white engraved lettering.

D. Special care must be taken to ensure that nameplates and labels shall not be painted over.

1.8 SPARE PARTS AND ACCESSORIES

A. The Vendor shall furnish spare parts and accessories for equipment.

B. Spare parts shall be identical and interchangeable with original parts. Parts shall be supplied in clearly identified containers, except that large or bulky items may be wrapped in polyethylene. Each part (or group of small parts) shall be tagged and each tag shall carry the following information: Identification of the equipment the part is for: identity or name of the part itself; and manufacturer's name and identification number of the part.

C. Spare parts shall be stored separately in a locked area, maintained by the CONTRACTOR and shall be turned over to the ENGINEER in a group at initial operation.

1.9 EQUIPMENT INSTALLATION

A. The CONTRACTOR shall obtain written installation manuals from the approved equipment Vendor prior to installation. Equipment shall be installed strictly in accordance with recommendations of the Vendor. Three copies of all installation instructions shall be furnished to the ENGINEER’s field representative not less than two weeks prior to scheduled installation.

B. The CONTRACTOR shall have on hand sufficient and proper construction equipment and necessary accessories of ample capacity to facilitate the work and to handle any emergencies.

C. Equipment shall be placed in a neat and workmanlike manner on the foundations at the locations and elevations shown on the Design Drawings.

D. The Design Drawings indicate the interconnection piping, wiring, conduit systems and new electrical service to be installed by the CONTRACTOR.

1.10 SHOP TESTING

A. All equipment noted in the Design Drawing shall be tested in the shop of the vendor in a manner which shall conclusively prove that its characteristics, including any specified pressure, duty, capacity, rating, efficiency, performance, function, or other special requirements, comply fully with the requirements of the Contract Documents

and that it will operate in the manner specified.

B. Three (3) certified copies of the vendor's actual test data and interpreted results thereof shall be forwarded to the ENGINEER for review.

1.11 FIELD TESTING

A. Field testing of equipment shall be performed as specified herein.

B. The Vendor shall be solely responsible for the proper operation of all equipment during testing and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to Substantial Completion of the Contract.

1. Preliminary Field Testing.

a. The vendor shall furnish all labor, materials, instruments, gauges, etc., as required, and shall perform preliminary field tests on equipment as soon as conditions will allow. If the preliminary field tests disclose any equipment furnished under this Contract which does not comply with the requirements of the Contract Documents, the vendor shall, prior to the final acceptance tests, make all changes, adjustments and replacements required.

b. At a minimum, preliminary field testing shall include verifying that equipment is installed in the location and orientation specified or shown on the Design Drawings. In addition, equipment shall be prepared for operation in accordance with vendor's recommendations and the Contract Documents.

2. Final/Acceptance Testing.

a. Prior to start-up, all equipment and appurtenances installed under this Contract shall be subjected to final/acceptance tests as specified or required to prove compliance with the Contract Documents. The vendor shall furnish labor, fuel, lubricants, water, air and all other materials, equipment and instruments necessary for all acceptance tests.

b. At a minimum, final/acceptance testing shall include:

i. Verification that equipment has been properly aligned, adjusted and lubricated;

ii. Verification that equipment shall meet all specified performance requirements and shall be performed without any unusual noise, vibration or other signs of possible malfunction;

iii. Verification that all controls (both electrical and mechanical) are properly connected and operating; and

iv. Verification that each mode and/or function is properly performing for multi-mode and/or multi-operation equipment.

c. Unless specifically allowed by the ENGINEER or specified elsewhere in the Contract Documents, all field tests of liquid handling equipment shall be conducted using water. The CONTRACTOR shall be responsible for providing

water for such tests.

1.12 SERVICES OF VENDOR`S REPRESENTATIVE

A. The Vendor shall furnish the services of a qualified representative. The time period for the supervision and instructions is outlined in the respective equipment Technical Specification Section. Where no specific duration of visit is listed, the length of time shall be such to allow the equipment representative ample time to follow out the requirements outlined in this Section.

B. The Vendor’s representative provided shall be trained and fully qualified and capable of performing the services required. The Vendor’s representative shall arrive at the site with all tools, instruments, equipment, documentation or other materials necessary to perform the required services.

C. Time spent in travel to the site shall not be applied toward the required duration of services. Time spent at the site if not properly prepared or equipped to perform the required services shall not be applied toward meeting the specified durations.

D. The Vendor shall be responsible for any additional time required to resolve equipment installation and/or operation problems due to a lack of coordination between the supplied equipment and the Contract Documents such as, but not limited to, dimensions, electrical problems or performance.

E. When the Vendor’s representative is required to visit the facility on occasions after initial startup and during the first year of operation, the purpose of these visits shall be to review equipment operation, assist the operators in correcting operational problems, and equipment.

F. The Vendor's representative shall be present at installation to observe equipment installation and shall be responsible for recommending and/or making (as approved by the ENGINEER) minor adjustments and shall supervise field testing of the equipment.

G. The ENGINEER shall have the right to witness the activities of Vendor’s representative during installation, testing, start-up and adjustment. Furthermore, the ENGINEER reserves the right to video tape at ENGINEER's expense, the on-site activities. Neither the Vendor nor the manufacture shall be entitled to any additional compensation as a result of the ENGINEER's videotaping. It is understood that videotaping, if performed, will be strictly for the ENGINEER's use in training its representatives and that the video tapes will not be made available by the ENGINEER to any other party. The ENGINEER will provide duplicate video tapes of representative's activities, if requested by the Vendor at the Vendor’s expense.

H. Following successful installation and testing of equipment, the Vendor’s representative shall submit one (1) written copy of certification stating that the equipment manufactured or supplied by their company has been installed and tested to their satisfaction and that all required final adjustments have been made. The certification shall also include the date of final/acceptance field testing and a listing of all persons present during testing.

I. The Vendor's representative shall also instruct the ENGINEER's and/or OWNER’s

operating personnel in the proper operation and maintenance of the equipment following issuance of the above referenced certification.

J. The Vendor shall submit to the ENGINEER for review and approval a training outline or lesson plan clearly indicating the subject matter and depth of detail proposed to be presented at the training session. This material shall be sent to the ENGINEER not less than 20 calendar days in advance of the training. No training shall be performed in the absence of a previously reviewed lesson plan or outline. Prior to scheduling training sessions, any and all Equipment Manuals, as specified above, shall be submitted and reviewed by ENGINEER. No training shall be performed in the absence of previously reviewed Equipment Manuals. Training, which is provided that does not follow, reviewed lesson plans or outlines, or where the Vendor's representative is not properly prepared or qualified shall not be accepted by the ENGINEER as meeting the training requirements.

K. Training shall be scheduled at least two (2) weeks in advance so as to provide the ENGINEER and/or OWNER an opportunity to adjust work schedules to permit all necessary personnel to attend.

L. The ENGINEER reserves the right to video tape all training sessions, as noted above.

1.13 OPERATION AND MAINTENANCE INSTRUCTIONS

A. The vendor shall furnish and deliver to the ENGINEER three (3) complete sets of information required for the proper operation, maintenance and repair of equipment supplied for this project. Manuals shall be delivered prior to the 70 percent completion point of the project.

B. All instructions shall be bound into a series of identical heavy-duty, three-ring binders. Information shall be organized by sections, each section covering a specific equipment item. Sections shall be listed in a Table of Contents at the front of each volume. Each section shall contain the following as a minimum:

1. Section Table of Contents;
2. Written instructions, including technical bulletins and diagrams;
3. Complete parts lists and parts diagrams for all equipment, including motors and drive units, showing manufacturer's identification numbers for each part;
4. Copies of shop drawings, where required, to adequately describe interrelation of components within a system;
5. Complete electrical and control schematics with labeled terminations;
6. List of special tools required for operation and maintenance;
7. List of spare parts supplied with the equipment, identified by manufacturer's part numbers; and
8. Source of replacement parts and address and telephone number of Vendor`s service representative.

C. Separate sections shall be clearly marked with dividers. Folded drawings or small

items shall be provided in heavy-duty, three-ring plastic pockets.

D. Information not applicable to a specific piece of equipment installed on this project shall be removed from or crossed off on the submission.

E. At the end of each section, the Vendor shall include a detailed maintenance and lubrication schedule for equipment covered in the section. Schedule shall include the following, as a minimum, for each equipment item:

1. List and frequency of maintenance activities, other than lubrication;
2. Lubrication frequency and application points; and
3. Lubricant type (weight or grade and recommended manufacturers) and method of application.

F. Motors and drive units furnished as part of the equipment shall be included in the schedule.

1.14 FAILURE OF EQUIPMENT TO PERFORM

A. Any defects in the equipment or failure to meet the guarantees or performance requirements of the specifications shall be promptly corrected by the Vendor by replacements or otherwise. If the Vendor fails to make these corrections, or if the improved equipment fails to meet the guarantees or specified requirements, the ENGINEER, notwithstanding his having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Vendor to remove it from the premises at the Vendor's expense.

1.15 GUARANTEE

A. By supplying a product under the Contract, the manufacturer and Vendor jointly agree that all manufacturers' warranties, expressed or implied, pass through the ENGINEER to Calumet Montana Refining, LLC (CMR). This warranty obligation starts on the date of the Substantial Completion and survives any inspection by, delivery to, acceptance by or payment by the ENGINEER for the goods furnished by the manufacturer. Further, this warrants that the equipment designed, manufactured and/or used meets all applicable federal, state and local laws, rules and regulations, including applicable OSHA standards. This requirement does not change or limit the requirements for performance affidavits previously described in 1.05 (PERFORMANCE AFFIDAVITS).

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

(Reserved)

END OF SECTION

SECTION 11 01 00

PACKAGED DUAL PHASE EXTRACTION SYSTEM

PART 1 GENERAL

1.1 SCOPE

A. The Work covered in this Section includes the furnishing of all necessary labor, materials, equipment, engineering and incidentals required to install a packaged dual phase extraction (DPE) system.

B. The DPE systems shall consist of one (1) vapor-liquid separator tank, one (1) effluent transfer pump, one (1) blower inlet filter, one (1) dilution air inlet, one (1) dilution air inlet silencer, two (2) vacuum blowers and motors, two (2) air discharge silencer, all piping necessary to plumb the system, all specified instrumentation and controls, valves, control panel including (8) pressure transmitter for the DPE wells, and one (1) enclosure equipped with an exhaust fan, an air conditioning unit, a warning light to indicate high LEL alarm condition, and cellular wireless internet connection to contain the equipment.

C. The Vendor shall provide packaged DPE system. The CONTRACTOR shall install gravel pad foundation and the DPE system enclosure as specified in the Design Drawings and the technical specifications. The CONTRACTOR is also responsible for making piping and utility connections.

1.2 RELATED WORK NOT INCLUDED

A. Section 01 75 00 – Equipment Testing, Plant Startup and Commissioning.

B. Section 11 00 00 – General Equipment and Requirements.

C. Section 11 15 00 – Catalytic Thermal Oxidizer.

D. Section 26 01 00 – Basic Electrical Materials and Methods.

1.3 REFERENCES

A. In general, the CONTRACTOR shall comply with the applicable provisions of the following standards and codes developed by: ASTM INTERNATIONAL (ASTM), AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME), AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI), NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA), NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) 54, 70, 86 AND 91, Occupational Safety and Health Administration (OSHA), Underwriters Laboratory (UL) and as specified below (Reserved)

1.4 SUBMITTALS

A. Detailed shop drawings, operation and maintenance manual, system controls, shop testing results and certification will be provided by the Vendor.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. DPE System Package shall be designed to meet the following criteria:

1. Inlet air volumetric flow rate: 100 standard cubic feet per minute (SCFM) per vacuum blower (measured at blower inlet flange; standard conditions are 14.7 PSIA, 68 deg. F., and 36% relative humidity). The actual inlet CFM design rating shall be guaranteed with an allowable tolerance of plus or minus four (4) percent.
2. Barometric pressure: 14.4 pounds per square inch absolute (PSIA) (Site elevation is 3,300 ft. above mean sea level).
3. Inlet pressure: Seventeen inches (17") Hg Vacuum at the blower inlet flange.
4. Maximum Inlet temperature: 100° Fahrenheit.
5. Relative humidity: 80%.
6. Discharge pressure: 15.35 PSIA (measured at blower discharge flange). Maximum design capability of blower 15" Hg.
7. Maximum blower speed: 3600 revolutions per minute (RPM).
8. Maximum power requirement: 15 brake horsepower (BHP) at the blower shaft with an allowable tolerance of plus or minus four (4) percent.
9. Motor: 15 HP, 480 Volts, 60 Hz. 3 Phase

PART 3 EXECUTION

3.1 SHIPPING

A. The Vendor shall be responsible for packaged DPE system shipping to the construction site.

B. Upon arrival at the destination, the purchaser and/or their agent shall be responsible for inspection of damage in transit. If damage has occurred, a claim should be filed with the carrier by the purchaser, and the Vendor should be notified prior to the system being put to service.

3.2 SYSTEM INSTALLATION

A. The CONTRACTOR shall install 48 feet by 16 feet gravel foundation for the DPE equipment enclosure as specified in the design drawings. The gravel pad foundation material shall meet Montana Department of Transportation specification for a crushed aggregate course Grade 2A. The minimum thickness of the gravel pad shall be 6-inches and it shall be compacted using a vibratory compactor. The gravel pad foundation shall extend a minimum of four feet from the base of the equipment

B. The CONTRACTOR is responsible for providing personnel to coordinate delivery of the packaged DPE system. The proper rated lifting equipment shall be to off-load the equipment from a semi-trailer truck and onto the designated location shown in the design drawings. CONTRACTOR will coordinate delivery schedule with ENGINEER and be responsible for adhering to the schedule.

C. The system shall be installed in accordance with Vendor's plans, specifications, installation drawings, and written instructions. The CONTRACTOR shall refer to

Vendor's installation check list to ensure that all check list items are completed prior to requesting startup assistance.

D. The CONTRACTOR shall connect the DPE transfer piping to the packaged DPE system.

E. The CONTRACTOR shall connect the effluent discharge pipe to the packaged DPE system.

F. The CONTRACTOR is responsible for making the connections between the DPE system and the CATOX.

G. The CONTRACTOR shall provide electrical service from pole electrical disconnect switch to the DPE equipment enclosure.

H. The CONTRACTOR shall remove all waste including shipping, electrical, and piping scrap generated by CONTRACTOR's activities.

3.3 STARTUP AND TRAINING

A. The Vendor shall supply services of the factory trained representative to start-up and provide operator training for the DPE system.

B. Inspection and startup trips:

1. One (1) day layout assistance (prior to installation); and
2. Three (3) day start-up instruction and operator training.

3.4 FACTORY TESTING

A. All equipment shall be tested in the shop of the Vendor in a manner which shall conclusively prove that its characteristics, including any specified pressure, duty, capacity, rating, efficiency, performance, function, or other special requirements, comply fully with the requirements of the Contract Documents and that it will operate in the manner specified. When specifically required in the detailed equipment specifications, arrangements shall be made for the ENGINEER to witness performance tests in the manufacturer's shop.

B. Three (3) certified copies of the Vendor's actual test data and interpreted results thereof shall be forwarded to the ENGINEER for review.

3.5 FIELD QUALITY CONTROL

A. The CONTRACTOR shall assist the Vendor with startup, testing and calibration of all equipment, instruments, and piping systems.

B. Testing shall be performed on the control system panel at the fabrication facility prior to shipment. The vendor/CONTRACTOR shall perform final field testing to verify all instruments are functioning and data communications are operable.

3.6 FIELD TESTING

A. The Vendor shall be responsible for the proper operation of all equipment during testing and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to Substantial Completion of the Contract.

B. The Vendor/CONTRACTOR shall furnish all labor, materials, instruments, gauges, etc., as required, and shall perform preliminary field tests on equipment as soon as conditions will allow. If the preliminary field tests disclose any equipment furnished under this Contract which does not comply with the requirements of the Contract Documents, the Vendor shall, prior to the final acceptance tests, make all changes, adjustments and replacements required.

C. At minimum, preliminary field testing shall include verifying that equipment is installed in the location and orientation specified or shown on the Design Drawings. In addition, equipment shall be prepared for operation in accordance with manufacturer's recommendations and the Contract Documents.

D. At minimum, the testing shall include:

1. Verification that equipment has been properly aligned, adjusted and lubricated;
2. Verification that equipment shall meet all specified performance requirements and shall perform without any unusual noise, vibration or other signs of possible malfunction;
3. Verification that all controls (both electrical and mechanical) are properly connected and operating;
4. Calibration and loop-checking of all skid-mounted/field-mounted devices;
5. Verification that each mode and/or function is properly performing for multi-mode and/or multi-operation equipment;
6. Motor field testing in accordance with manufacturer’s recommendations; and
7. Unless specifically allowed by the ENGINEER or specified elsewhere in the Contract Documents, all field tests of liquid handling equipment shall be conducted using water. The CONTRACTOR shall be responsible for supplying this water.

END OF SECTION

SECTION 11 15 00

PACKAGED CATALYTIC THERMAL OXIDIZER SYSTEM

PART 1 GENERAL

1.1 SCOPE

A. The Work covered in this Section includes the furnishing of all necessary labor, materials, equipment, engineering and incidentals required to install a catalytic thermal oxidizer (CATOX) package system for removal of volatile contaminants from the extracted soil gas stream.

B. The CATOX system shall consist of one (1) self-recuperating catalytic thermal oxidizer, all piping necessary to plumb the system, all specified instrumentation and controls, valves, control panel and one (1) enclosure to contain portions of the equipment not rated for outdoor exposure.

C. The Vendor shall provide packaged CATOX system. The CONTRACTOR shall install gravel foundation and the CATOX system enclosure as specified in the Design Drawings and the technical specifications. The CONTRACTOR is also responsible for making piping and utility connections.

1.2 RELATED WORK NOT INCLUDED

A. Section 11 00 00 – General Equipment Requirements.

B. Section 26 00 01 – General Provisions for Electrical Systems.

C. Section 40 05 01 – Process Piping.

1.3 REFERENCES

A. In general, the CONTRACTOR shall comply with the applicable provisions of the following standards and codes developed by: ASTM INTERNATIONAL (ASTM), AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME), AMERICAN WELDING STANDARDS (AWS), AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI), NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA), NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) 54, 70, 86 AND 91, Occupational Safety and Health Administration (OSHA), Underwriters Laboratory (UL) and as specified below.

1.4 SUBMITTALS

A. The Vendor shall submit the following with the bid:

1. The Vendor shall submit for approval shop drawings showing complete layout and installation requirements for the CATOX package system;

2. Product data for the selected model, including rated flow capacity, dimensions, weights, structural details, piping details, electrical requirements, accessories, and warranty coverage;

3. Data sheets containing all information necessary to relate the equipment specifications; and

4. List of all instrumentation to be provided with descriptive information for each component.

B. Manufacturer's Design Data.

1. The Vendor shall submit electronic copies of manufacturer's design and operational performance data for all proposed equipment.

C. Operation and Maintenance Manuals.

1. The Vendor shall submit electronic copies of all installation, operation, and maintenance manuals prior to equipment delivery. These manuals shall include copies of all approved design drawings, maintenance and lubrication requirements, recommended spare parts list and other operational data as required for normal operation.

D. Warranty.

1. The Vendor shall furnish manufacturer's warranty for the complete CATOX package system against defects in workmanship and materials for a period of one (1) year beginning from the time the equipment is placed in service. The Contractor shall include a provision for including an additional four (4) years of warranty for the system.
2. All costs for labor (including travel), and replacement parts required to repair defects in workmanship and materials during the guarantee period will be considered to have been included in the bid price.
3. The Vendor shall also guarantee that the equipment will perform the service (meet the specified effluent limitations) for which it is designed, and should it fail to do so will modify or replace the unit at no cost to the OWNER.

E. Maintenance Service.

1. Vendor shall furnish service and maintenance for CATOX package system for one (1) year from the date of substantial completion.
2. List of recommended spare parts.

F. ENGINEER's Review.

1. If the Vendor proposes an alternative piece of equipment or other modification to the package system Vendor shall identify the change and provide specifications, data sheets or any other information along with the submittal information required and request ENGINEER's approval.

PART 2 PRODUCTS

2.1 DESIGN REQUIREMENTS

A. The CATOX package system will be supplied by the Vendor and installed by the CONTRACTOR. The Vendor will supply all necessary equipment, controls and instrumentation to support CATOX operation. The system will be installed in an enclosure. The Vendor shall design the treatment system to operate twenty-four (24)

hours per day, three- hundred & sixty-five (365) days per year for at least 15 years of operation.

B. The CATOX must receive soil vapor provided by the dual phase extraction (DPE) blowers. The CATOX package system shall be designed for a 1,000 standard cubic feet per minute (SCFM) soil vapor stream. The soil vapor stream, at the inlet to the CATOX package system, is expected to have the following characteristics:

1. Up to one hundred (100) percent relative humidity;
2. Temperature of up to 250 degrees Fahrenheit;
3. Influent gauge pressure 1.3 inches of Hg; and
4. The primary soil vapor chemical constituents are following based on soil gas sampling at the Site; however, actual soil vapor chemical constituents may vary during normal operation.

   Benzene – 150.6 parts per million by volume (ppmv)
   Cyclohexane – 848.4 ppmv
   n-Heptane – 47.6 ppmv
   n-Hexane – 1525.85 ppmv
   Toluene – 6.2 ppmv

   The balance of the inlet stream will have a composition similar to ambient air; oxygen concentrations are expected to be greater than 15% necessary for sustained combustion:

5. The concentrations presented above are expected to decrease over expected operation life.

C. The stack discharge from the scrubber shall be a minimum of 13 feet above the surrounding grade at the Site.

D. The CATOX must be designed to safely oxidize process stream and respond to outputs from Lower Explosive Limit (LEL) monitors provided by others as a part of the DPE system. Note, the DPE system provided by other Vendor will provide a means of controlling the inlet concentrations to the CATOX package system. The DPE system provided by others will include a dilution air inlet (see SECTION 11 01 00 for details) and the flow rate from each extraction well providing will be adjustable (see SECTION 40 05 01).

E. CATOX package system must be designed to have balanced airflow at all rates.

2.2 PERFORMANCE REQUIRMENTS

The CATOX shall remove at least 99% by weight of the VOCs, semi volatile organic compounds (SVOCs), and C1-C6 gases (methane, ethene, propane, butane, pentane, and hexane) present in the soil vapor stream.

PART 3 EXECUTION

3.1 SHIPPING

A. The Vendor shall be responsible for packaged CATOX system shipping to the construction site.

B. Upon arrival at the destination, the purchaser and/or their agent shall be responsible for inspection of damage in transit. If damage has occurred, a claim should be filed with the carrier by the purchaser, and the Vendor should be notified prior to the system being put to service.

3.2 SYSTEM INSTALLATION

A. The CONTRACTOR shall install 20 feet by 14 ft gravel foundation for the CATOX equipment as specified in the design drawings. The gravel pad foundation material will meet Montana Department of Transportation specification for a crushed aggregate course Grade 2A. The minimum thickness of the gravel pad is 6-inches and will be compacted prior to placement of CATOX equipment. The gravel pad foundation will extend a minimum of four feet from the base of the equipment.

B. The CONTRACTOR is responsible for providing personnel to coordinate delivery of the packaged CATOX system. The properly rate lifting equipment shall be provided for off-loading from a flatbed truck and to place the equipment at the designated location shown in the design drawings. CONTRACTOR will coordinate delivery schedule with ENGINEER and be responsible for adhering to the schedule.

C. The system shall be installed in accordance with Vendor's plans, specifications, installation drawings, and written instructions. The CONTRACTOR shall refer to Vendor's installation check list to ensure that all check list items are completed prior to requesting startup assistance.

D. The CONTRACTOR is responsible for making the connections between the DPE system and the CATOX.

E. The CONTRACTOR shall provide electrical service from electrical disconnect switch to the CATOX equipment enclosure.

F. The CONTRACTOR shall remove all waste including shipping, electrical, and piping scrap generated by CONTRACTOR's activities.

3.3 STARTUP AND TRAINING

A. The Vendor shall provide onsite training to ENGINEER for operation and maintenance of the CATOX package system.

B. Field testing and startup of the equipment. Service technician will be provided for up to three (3), 8-hour consecutive days to test, start-up, and balance the oxidizer. In the event start-up is not completed due to the fault of the Vendor, the vendor will remain on site at CONTRACTOR's cost until complete and successful start-up is achieved.

C. The 3-day period shall also include at least one day training of operating and maintenance staff.

3.4 FIELD QUALITY CONTROL

A. The CONTRACTOR shall assist the Vendor with startup, testing and calibration of all equipment, instruments, and piping systems.

B. Testing shall be performed on the control system panel at the fabrication facility prior to shipment. The vendor shall perform final field testing to verify all instruments are functioning and data communications are operable.

3.5 FIELD TESTING

A. The Vendor shall be responsible for the proper operation of all equipment during testing and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to Substantial Completion of the Contract.

B. The Vendor shall furnish all labor, materials, instruments, gauges, etc., as required, and shall perform preliminary field tests on equipment as soon as conditions will allow. If the preliminary field tests disclose any equipment furnished under this Contract which does not comply with the requirements of the Contract Documents, the Vendor shall, prior to the final acceptance tests, make all changes, adjustments and replacements required.

C. At minimum, preliminary field testing shall include verifying that equipment is installed in the location and orientation specified or shown on the Design Drawings. In addition, equipment shall be prepared for operation in accordance with manufacturer's recommendations and the Contract Documents.

D. At minimum, final/acceptance testing shall include:

1. Verification that equipment has been properly aligned, adjusted and lubricated;
2. Verification that equipment shall meet all specified performance requirements and shall perform without any unusual noise, vibration or other signs of possible malfunction;
3. Verification that all controls (both electrical and mechanical) are properly connected and operating;
4. Calibration and loop-checking of all skid-mounted/field-mounted devices;
5. Verification that each mode and/or function is properly performing for multi-mode and/or multi-operation equipment;
6. Motor field testing in accordance with manufacturer’s recommendations; and

END OF SECTION

SECTION 13 01 00

SUBSURFACE DRILLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The DRILLING CONTRACTOR shall comply with local and State permit requirements, licenses and authorizations for performing Dual Phase Extraction (DPE) well installation at the locations shown on the Design Drawings.

B. In order to prevent and to provide for abatement and control of any environmental pollution arising from DRILLING CONTRACTOR activities in the performance of the work, the DRILLING CONTRACTOR shall comply with all applicable Federal, State, and local laws, regulations, and ordinances concerning environmental pollution control, and abatement.

C. DPE well installations (8) are planned. The well installations require Modified Level D personal protective equipment (PPE).

D. All borings shall be drilled using Rotosonic methods.

E. The keeping of separate drilling records by the ENGINEER shall not relieve the DRILLING CONTRACTOR of the responsibility for logging the work specified in this specification.

1.2 RELATED WORK NOT INCLUDED

A. Drawings and general provisions of the Contract, and Division 01 Specification Sections, apply to this Section.

B. Section 01 35 29 – Health and Safety.

1.3 SUBMITTALS

A. Upon completion of DPE well installation, unless notified otherwise, the DRILLING CONTRACTOR shall provide:

1. Well Construction Logs; and
2. Soil Boring Logs.

1.4 REFERENCES

(Reserved)

1.5 DEFINITIONS

A. Modified Level D PPE provides minimal skin protection (i.e., hand/glove protection along with standard work clothes with optional coverall) and no respiratory protection. Modified Level D PPE can be used when the following conditions are met:

1. Atmosphere contains no known hazards;
2. Oxygen concentrations are not less than 19.5%; and

3. Work functions include minimal contact with contaminated soil, water, groundwater, and precludes splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

1.6 MEASUREMENT FOR PAYMENT

A. Measurement for payment will be based on linear feet of holes actually drilled, measured from original ground surface or as arranged with the ENGINEER.

PART 2 - PRODUCTS

2.1 WELL MATERIALS

A. DPE Wells

1. Well Screens: Schedule 80 polyvinyl chloride (PVC), 20-slot (0.020-inch), 6-inch diameter
2. Well Riser: Schedule 80 PVC, 6-inch diameter.
3. Well Annulus Fill.
   a. High temperature grout (Class G or H cement mixed with silica flour).
   b. Sand pack (US silica 10-20 mesh or equivalent).
4. Bottom Cap (Schedule 80 PVC, 6-inch diameter) and 6-inch diameter expandable locking top cap (J-plug type).
5. 2-foot by 2-foot by 2-foot flush-mount traffic-rated well compartments (8) are to be provided and installed by CONTRACTOR.

B. LNAPL Recovery Wells and Passive Treatment Trench Monitoring Well

1. 12-inch, diameter, round flush-mount traffic-rated well compartments (11) are to be provided by DRILLING CONTRACTOR and installed by CONTRACTOR.

C. Passive Treatment Trench Monitoring Well

2. 8-inch, diameter, round flush-mount traffic-rated well compartment (1) is to be provided by DRILLING CONTRACTOR and installed by CONTRACTOR.

2.2 Drilling Equipment

A. Furnish equipment and supplies to facilitate installation of wells as described in the Design Report, Drawings and this specification. Rotosonic drilling procedures are required. Rotosonic is a drilling method that employs simultaneous high frequency vibration and low speed rotational motion along with downward pressure to advance the core barrel with the use of drilling fluid or air. Drill cuttings are brought to the surface by removal of the entire core barrel from the borehole and cuttings are vibrated out of the barrel. If needed for logging, the cuttings will be collected in plastic sleeves. If not, they will be placed in a 55-gallon-drum or other appropriate container. An outer casing is washed-down with water to stabilize the borehole from collapse and prevent cross-contamination.

2.3 Drilling Supplies

A. Supplies shall include, but not be limited to, casing, drill stem, drill bits, drill fluid and additives, pumps, and power necessary to accomplish the required boring. Drill casing, if used, shall be of such minimum inside diameter as to allow well installation. The use of 12-inch diameter casing is anticipated.

B. DRILLING CONTRACTOR shall provide their own safety equipment and PPE as required.

C. The ENGINEER will monitor air using portable field instruments for volatile organic compounds, carbon monoxide, and oxygen while drilling is being conducted. The ENGINEER will communicate the air monitoring results to the DRILLING CONTRACTOR/drilling crew as the drilling activities commence.

D. DRILLING CONTRACTOR shall provide all materials necessary for decontamination of equipment, a poly tank for wastewater, and roll-off boxes for soil cuttings and PPE.

PART 3 - EXECUTION

3.1 HEALTH AND SAFETY PRECAUTIONS AND PROCEDURES

A. All on-site staff working on well installations are required to be 40-hour Occupational Safety and Health Administration (OSHA) trained in accordance with CFR 1910.120. For this scope of work, Modified Level D will be the level of protection utilized for all tasks. The DRILLING CONTRACTOR will be responsible for providing their own PPE. The DRILLING CONTRACTOR shall also prepare its own company Health and Safety Plan (HASP), which shall specifically govern the work performed by its employees. The DRILLING CONTRACTOR shall designate a project health and safety officer (HSO).

3.2 DRILLING FOR DPE WELLS

A. Mobilization consists of the delivery to the site of all equipment, materials and supplies to be furnished by the DRILLING CONTRACTOR, the complete assembly in satisfactory working order of all such equipment at the jobsite and the satisfactory storage at the site of all such materials and supplies.

B. Demobilization consists of the removal from the site of all equipment, materials and supplies after completion of the work and also includes, at the direction of the ENGINEER, the cleanup and removal of all scrap, waste material, waste drilling fluid, contaminated soil, backfilling all sumps or excavations resulting from the operations and, in general, returning the site as.

C. Accurate driller's logs and records shall be kept of all work accomplished under this contract and deliver complete, legible copies of these logs and records to the ENGINEER upon completion of the work or at such other time or times as directed. All such records shall be recorded during the actual performance of the work and shall be preserved in good condition and order until they are delivered and accepted. The ENGINEER has the right to examine and review all such records at any time prior to their delivery and has the right to request changes to the record keeping procedure. The following information shall be included on the logs or in the records for each hole.

1. Driller's name and Geologist's name.
2. Make, size, and manufacturer's model designation of drilling equipment.
3. Type of drilling operation by depth.
4. Hole diameter.
5. Dates and time by depths when drilling operations were performed.
6. Time required for drilling each run.
7. Drill action, tool drops, and any other unusual and non-ordinary experience which could indicate the subsurface conditions encountered.
8. Top and bottom depth of each run.
9. Percentage of core recovered per run.
10. Depth at which groundwater is encountered, if applicable.
11. Depth of bottom of hole.

3.3 DPE WELL INSTALLATION

A. The installation of each DPE well will begin once the 10-inch diameter Rotosonic casing reached is target depth. The DPE wells shall be constructed in accordance with the Design Drawings.

B. Wellhead connections details are provided in the Design Drawings

3.4 DECONTAMINATION

A. Down-hole drilling equipment shall be decontaminated before equipment is mobilized to the site, prior to drilling a boring, and prior to leaving the site. Down-hole drilling equipment will be decontaminated by steam cleaning with a high-pressure washer. Water for decontamination will be available on site. Decontamination fluids shall be disposed of at Calumet Montana Refining's wastewater treatment facility.

3.5 SURVEY

A. The CONTRACTOR shall survey dual-phase extraction wells for ground coordinates and elevation.

3.6 INVESTIGATION-DERIVED WASTE (IDW)

A. Wastes anticipated during construction activities included construction debris, soil cuttings, decontamination rinsate, and drilling water.

B. The ENGINEER shall prepare waste profiles for acceptance by the off-site disposal facility.

C. The CONTRACTOR shall be responsible for the waste transportation and off-site disposal of the waste streams in accordance with the Environmental Protection Plan.

END OF SECTION

SECTION 26 01 00

ELECTRICAL SUMMARY & SCOPE OF WORK

PART 1 GENERAL

1.1 SCOPE OF WORK

A. The CONTRACTOR shall provide an Electrical Distribution System, in accordance with the intent of these specifications, the accompanying drawings, Owner requirements and all Utility rules and requirements associated with this project.

B. The work shall include, but not be limited to the following:

1. Complete conduit and wiring system including all appurtenances for final connections to new equipment within the scope of work, as defined by the contract documents. This shall include, but not be limited to: all junction boxes, back boxes, wiring devices, switches, receptacles, switchgear, distribution panelboards, medium voltage switchgear, underground electrical distribution, contactors and starters, and mechanical equipment.
2. Provide all electrical distribution equipment, underground conduits, duct banks, handholes, etc. and all appurtenances.
3. The CONTRACTOR shall install all support structures, fittings, conduit and cable supports, and all appurtenances as required by the contract documents.
4. Install meters and terminate all control wiring and appurtenances.
5. The CONTRACTOR shall be responsible for all final power, controls and communications terminations, complete installation of the equipment per manufacturer's instructions and standby assistance during commissioning for the packaged systems. Note: Actual commissioning (including final check of terminations, start-up and testing of equipment) will be performed by the Vendor's representative.
6. All underground control conduits shall be one-inch rigid non-metallic polyvinyl chloride (PVC) conduits. All conduits shall be equipped with pull strings and mud caps on both ends during backfill.
7. All conduit, power and control wiring, including final power and control terminations with proper connections, and all final connections, including all connections with terminations as shown on shop drawings, but not be limited to the following:
   a. Dual phase extraction (DPE) equipment, including pumps, control panel(s), etc.
   b. Catalytic thermal oxidizer (CATOX).
8. Provide coordination drawings integrated with other trades. Provide all as-built documentation and close out documents as required by the project close out procedures at the completion of the project.
9. Secure all electrical permits as required.

10. Provide assistance for third party testing work. Assist in scheduling.
11. Provide red-line record drawing markups upon completion of the project to the engineer.
12. Provide neat and orderly jobsite at all times. Electrical trash produced shall be disposed of daily in dumpsters provided by the Owner.
13. All electrical equipment including controls panels shall be UL listed. Where equipment cannot be listed; a third-party inspection may be required to satisfy local requirements.
14. The CONTRACTOR shall be responsible for coordination of all Lock-Out Tag-Out (LO-TO) procedures. All Lock-Out Tag-Out procedures shall require a minimum of two locks for each point. The CONTRACTOR shall provide all Lock-Out Tag-Out equipment and accessories.
15. Provide two weeks additional site assistance manpower (1 foreman and 1 journey man) and tooling during commissioning and initial start of process system to assist in troubleshooting and verifications of wiring.

1.2 RELATED WORK

A. Drawings and general provisions of the Contract, and Division 01 Specification Sections, apply to this Section.

B. Section 33 71 01 - Electrical Supply

C. Electrical control systems and interlock wiring as required by mechanical drawings, specifications or manufacturer's schematics.

1.3 QUALITY ASSURANCE

A. Comply with applicable local, state and federal codes.

B. Comply with applicable requirements of recognized industry associations which promulgate standards for the various trades.

C. Employ competent qualified electricians for this work.

1.4 STANDARDS

A. Perform work specified in Division 26 in accordance with standards listed below including amendments or revisions. When these specifications are more stringent, they take precedence. In case of conflict, obtain a decision from the ENGINEER.

B. National Fire Codes (NFPA) including, but not limited to following:

1. NFPA-70 - National Electrical Code. 2014 Edition.
2. NFPA-101 - Life Safety Code.

C. Applicable Codes:

1. International Building Code.
2. Applicable State Energy Code.

D. Should any work be construed as being contrary to or not conforming to aforementioned codes, such alleged confliction to be brought to attention of ENGINEER in writing ten (10) days prior to bid date for review so that such point in question may be resolved. All work to be installed in strict conformity with applicable codes without additional cost to the ENGINEER.

E. CONTRACTOR to submit and/or file with proper authorities all necessary specifications and drawings as required by governing authorities.

1.5 SUBMITTALS

A. Within fifteen (15) days after contract has been awarded, CONTRACTOR to submit to ENGINEER for review a complete list of materials, equipment, and accessories proposed for use, listing the item and manufacturer's name only.

B. Based upon aforementioned approved listing, CONTRACTOR to submit One (1) electronic PDF copy of complete brochures and shop drawings of all materials, fixtures, and equipment to use giving the names of manufacturers, trade name and specific catalog numbers.

C. Brochures to be submitted in time to allow fifteen (15) days from date of receipt in ENGINEER before final approval or disapproval is required to meet construction schedule. Submittals to bear CONTRACTOR's stamp of approval evidencing they have examined and checked same and information contained therein is in accordance with contract requirements, and any deviations to be clearly marked. Approval of shop drawings not to be construed as permitting departure from the contractual documents.

D. Above-mentioned brochures to be submitted and approved before any materials are ordered.

E. In the event that within time stated above CONTRACTOR fails to submit complete list of materials, equipment and accessories in proper form, the ENGINEER reserves the right to select a full line of materials, fixtures, and equipment, which shall be binding upon CONTRACTOR for these materials, fixtures, and equipment as the case may be and which shall be used in his work.

F. Brochures: Submit complete descriptions, illustrations, specification data, etc. of all materials, fittings, devices, fixtures, special systems, etc., including the following:

1. Panelboards.
2. Wiring devices and plates.
3. Motor starters and contactors.
4. Disconnect switches.
5. Enclosed circuit breakers.
6. Lighting, including lamps.

G. Proposed items to be clearly indicated when other items are shown on same sheet. When proposing items other than those specified, brochures to contain both

specified item sheets and proposed item sheets for ease of comparison. On request from ENGINEER, samples shall be submitted and/or set up, as directed, for inspection and approval. Samples will be returned to CONTRACTOR.

H. Shop Drawings: Submit specific shop drawings for major materials including the following:

1. Motor starters and contactors including custom wiring diagrams.
2. Distribution switchboards.
3. Motor Control Centers including schematic wiring diagrams.
4. Dimensional layout of all electrical rooms, drawn to scale, with equipment location shown therein. Clearances to be in accordance with NEC and local codes.
5. Electrical Coordination Study submitted by switchboard manufacturer to include time-current curves and all related breaker data information. Coordination Study must be approved by the ENGINEER prior to order of switchgear.

1.6 DELIVERY AND STORAGE

A. Insofar as possible, deliver items in manufacturers' original unopened packaging. Where this is not practical, cover items with protective materials, to keep them from being damaged. Use care in loading, transporting, unloading, and storage to keep items from being damaged.

B. Store items in a clean dry place and protect from damage.

C. All damaged painted surfaces of equipment to be touched up to match original paint.

1.7 RECORD DRAWINGS

A. Keep a set of blueline prints at the job site exclusively for recording deviations from the drawings.

B. Record locations and depths of buried and concealed conduits from fixed easily identifiable objects.

C. Mark deviations in colored pencils so that work of various systems can be easily identified.

D. When work is completed, record all deviations on clean sepia copies of drawings.

E. Submit three sepia copies of completed "record drawings" to ENGINEER's Representative for distribution.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. All materials and equipment used in carrying out these specifications to be new and have Underwriters Laboratories (UL) listing or listing by other recognized testing

laboratory when such listings are available. Specifications and drawings indicate name, type, and catalog numbers of materials and equipment to be used as "standards" shall not be construed as limiting competition. CONTRACTOR may at their option, use materials and equipment when, in the judgment of the ENGINEER, they are equivalent to that specified.

B. CONTRACTOR to procure a precast concrete pad of 84” by 84” by 8” for the placement of a 225 kilovolt amp electrical transformer. Precast concrete pad can be acquired from The Fagenstrom Company of Great Falls, Montana.

PART 3 EXECUTION

3.1 COORDINATION

A. Intent.

1. These sections of specifications and drawings form a complete set of documents for the electrical work of this project. Neither is complete without the other. Any item mentioned in one shall be as binding as though mentioned in both.
2. The intent of these specifications and drawings is to form a guide for a complete electrical installation. Where an item is reasonably necessary for a complete system but not specifically mentioned, such as pull boxes, fittings, expansion fittings, support hangers, etc., provide same without additional cost to the ENGINEER.
3. Electrical layouts indicated on drawings are diagrammatical only. Exact location of outlets to be governed by project conditions. The ENGINEER reserves the right to make any reasonable changes (approximately 6 feet) in location of junction boxes, or equipment prior to roughing-in of such without additional cost to the ENGINEER.

B. Deviations.

1. No deviations from specifications and drawings to be made without full knowledge and consent of ENGINEER.
2. Should CONTRACTOR find during progress of work that existing conditions make desirable a modification of the requirements of any particular item, report such item promptly to ENGINEER for his decision and instructions.

C. Insofar as it is possible to determine in advance, leave proper chases and openings. Place all outlets, anchors, sleeves, and supports prior to pouring concrete or installation of masonry work. Should CONTRACTOR neglect doing this, any cutting and/or patching required to be done is at this CONTRACTOR's expense.

D. Visit site and be informed of conditions under which work must be performed. No subsequent allowance will be made because of error or failure to obtain necessary information to completely estimate and perform work involved.

E. Coordinate to assure that proper points of service transformer locations, voltage characteristics and capacity of service are in accordance with Contract Drawings.

3.3 TRENCHING, EXCAVATION, BACKFILLING, AND REPAIRS

A. Provide trenching, excavation, and backfilling necessary for performance of electrical work.

B. Backfilling to be carefully done using only clean earth thoroughly tamped and compacted below and above embedded items.

3.4 FOUNDATIONS AND PADS

A. Provide foundations and pads required for equipment provided under this division of specifications. Coordinate proper size and location of foundations, pads, anchor bolts, and other items to be provided.

3.5 TESTS

A. On completion of work, installation to be entirely free from grounds, short circuits, and open circuits. Perform a thorough operational test in presence of the ENGINEER. Balance all circuits so that feeders to panels be not more than 10% out of balance between phases with all available load energized and operating. Furnish all labor, materials and instruments for above tests.

B. Furnish the ENGINEER, as a part of closing file, a copy of such tests including identification of each circuit and readings recorded, also the main service ground test. Test information to be furnished to the ENGINEER includes ampere readings of all panels and major circuit breakers, insulation resistance reading of motors and transformers.

C. Prior to final observation and acceptance test, leave in satisfactory operating condition all electrical systems and equipment including but not limited to the following:

1. Electrical distribution system.
2. Ground fault protection system.
3. Electric motors for all equipment.
4. Electric safety devices.

3.6 INSPECTION FEES AND PERMITS

A. Obtain and pay for all necessary permits and inspection fees required for electrical installation.

3.7 IDENTIFICATION OF EQUIPMENT

A. Properly identify all starters, contactors, relays, safety switches and panels with permanently attached black (normal power) or red (essential systems) phenolic plates with 1/4" white engraved lettering on the face of each attached, with two sheet metal screws.

3.10 WARRANTY-GUARANTEE

A. The ENGINEER reserves right to accept or reject any part of installation which does not successfully meet requirements as set out in these specifications.

B. CONTRACTOR shall and hereby does guarantee all work installed under this division shall be free from defects in workmanship and materials for a period of one year from date of final acceptance, whichever is earliest. The above parties further agree that they will repair and replace any defective material or workmanship which becomes defective within the terms of this warranty-guarantee.

END OF SECTION

SECTION 31 23 00

EXACAVATION AND FILL

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes excavation and backfill as required for pipe installation, light non-aqueous phase liquid (LNAPL) recovery trench and passive treatment trench (PTT) installation or other construction in the excavation or trench as shown on the Design Drawing and specified herein.

B. The CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to perform trenching, including excavation, segregation and handling of contaminated soils, if encountered.

C. If the soils excavated during trenching are unsuitable for reuse, the CONTRACTOR shall be responsible for transportation of all excavated soils to an off-site disposal and/or treatment facility. The CONTRACTOR shall stockpile the excavated soil to allow for testing of the materials after removal, and before disposal, in accordance with the requirements of the disposal and/or treatment facility.

D. The CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to perform all backfilling and compaction.

E. The CONTRACTOR shall be responsible for the design of necessary temporary excavation support by a Professional Engineer, licensed in the State of Montana.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.

1.3 SUBMITTALS

A. Backfill Samples

1. The CONTRACTOR shall submit to the ENGINEER samples of earthen materials weighing approximately 50 pounds along with copies of certified laboratory test results stating that the materials meet the specification requirements.

B. Laboratory and Field Test Results

1. The CONTRACTOR shall submit results of all laboratory and field tests to the ENGINEER at least two weeks prior to the planned delivery of the material to the Site.

C. Certification of Materials

1. All materials used as fill, including imported fill, screened gravel and topsoil, shall be tested to ensure they are free from chemical contamination. A minimum of one laboratory test shall be performed per 2,500 cubic yards of material and no less than one test per borrow area. Additional tests shall be performed at a frequency of one sample per 5,000 cubic yards of material or as requested by the ENGINEER.

Certification from backfill supplier is acceptable if backfill supplier can provide laboratory test results.

2. The following reports from the Soil Testing Laboratory shall be submitted:
   a. Test reports on borrow material as follows:
      1. Mechanical Analysis.
      2. Moisture-density curve determination.
   b. Verification of suitability of backfill or fill material, in accordance with specified requirements.
      1. Field reports; in-place soil density tests.
      2. One optimum moisture-maximum density curve for each type of soil fill or backfill planned to be used.
      3. Include data for samples indicating the exact location and methods of transportation and placement of all materials.

1.4 REFERENCES

A. OSHA Regulations

1. 29 CFR 1926 - Subpart P, Excavations

B. American Society for Testing and Materials (ASTM)

1. D-422 -Method for Particle Size Analysis of Soils.
2. D-698 -Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
3. D 1556 - Density of Soil in Place by the Sand Cone Method
4. D 1557 - Laboratory Compaction Characteristics of Soils Using Modified Method
5. D-6938 -Test Methods for In-Place Density and Water content of Soil and Soil Aggregates by Nuclear Methods (Shallow Depth).

PART 2 PRODUCTS

2.1 Material

A. Backfill material

1. Coarse sand backfill material in compliance with applicable Montana regulations meeting the following gradation.

Sieve Size	Percent Passing by Weight
3/4-inch	>100
No. 4	>95
No. 10	>5
No. 40	>1

B. Reactive media

1. Vendor shall provide Regenesis® product PetroFix™ to be utilized in PTT.

C. LNAPL recovery wells (11)

1. Well Screens: 8-feet of schedule 80 polyvinyl chloride (PVC), 20-slot (0.020-

inch), 6-inch diameter

2. Well Riser: Schedule 80 PVC 6-inch diameter.
3. Well Vault: 12-inch diameter traffic rated flush-mount well compartment.

D. PTT Monitoring well

1. Well Screens: Schedule 80 PVC, 20-slot (0.020-inch), 2-inch diameter
2. Well Riser: Schedule 80 PVC, 2-inch diameter.
3. Well Vault: 8-inch diameter traffic rated flush-mount well compartment.

PART 3 EXECUTION

3.1 EXCAVATION - GENERAL

A. The CONTRACTOR shall take the necessary precautions to prevent damage to existing structures and utilities.

B. The trench excavation shall be located as shown on the Design Drawings or as specified. Trenches shall be excavated to maintain the depths as shown on the Design Drawings.

C. The CONTRACTOR shall perform a pre-construction survey of the area prior to beginning excavation. The CONTRACTOR shall take photographs so that the surfaces may be examined during construction and compared with the pre-work condition. The CONTRACTOR shall retain Montana Licensed Surveyor to perform the following:

1. Survey the area, establishing exact elevations and horizontal locations at four fixed points 50 feet apart to act as benchmarks.
2. Clearly identify benchmarks and record existing elevations. The CONTRACTOR shall locate a reference datum to establish benchmark elevations sufficiently distant from work areas so as not to be affected by movement resulting from excavation operations.
3. Elevations shall be verified from existing benchmarks by the Surveyor.
4. Should benchmark readings indicate displacement, the CONTRACTOR shall halt operations until corrective action is provided and is acceptable to the ENGINEER.

D. The CONTRACTOR shall inspect the Site, examine existing conditions and make all necessary preparations for the safe and proper execution of work. The CONTRACTOR shall provide all necessary shoring and sloping to support the side slopes of the excavation as required by EM 385-1-1. All sloping and shoring shall comply with the requirements of OSHA 1926, Subpart P.

E. The CONTRACTOR shall excavate slopes to a safe angle of repose or utilize temporary excavation support such as sheeting, shoring and bracing as necessary to prevent caving, erosion, or gullying of sides and ends of excavations. All temporary and permanent earth support systems must be designed by a Montana licensed professional engineer. The CONTRACTOR will select the sheeting and shoring type

and submit design calculations for the proposed earth support system to the ENGINEER for review.

F. The CONTRACTOR shall perform the excavation in such a manner which prevent undermining or disturbance of soil surrounding existing structures, floor slabs or utilities when excavations are made nearby. The CONTRACTOR shall brace, shore, and protect existing structures, floor and utilities when excavations are within a distance that they could be potentially affected.

G. The CONTRACTOR shall remove all temporary excavation support structures, forms and all debris of every nature, taking care, upon the removal of temporary supports, not to cause movement of adjacent ground or structures or create the danger of a slide.

H. The bottom of all trenches shall be excavated clean. Bottom of excavations shall be inspected by the ENGINEER to determine of soft or unsuitable soil conditions are encountered. If any soft or unsuitable materials are encountered, they shall be removed and replaced with new compacted fill.

I. For areas where existing fill is encountered within the utility excavations, the subgrade at the bottom of the utility excavation shall be compacted in place with a vibratory drum trench compactor (i.e. Wacker Model RT560), a heavy vibratory plate tamper (i.e. Wacker BPU 3545A or equivalent), or "jumping jack style tamper (i.e. Wacker Model BS 600). The ENGINEER must evaluate these areas for the presence of soft or unsuitable material within the existing fill matrix. If instability is observed, the ENGINEER will determine if portions of the fill will have to be removed and replaced with new compacted fill.

J. In the event that water is encountered in the trench excavations or the if the trench bottom becomes soft due to the inflow of surface or trapped water, the soft soil shall be removed and the excavation filled with a minimum of six (6) inches of 3/4" clean crushed stone to provide a firm base for support of the pipe. Appropriate means shall be used to remove the water from the excavation.

K. Open trenches shall be protected and barricaded as required.

3.2 BACKFILL - GENERAL

A. Bedding material shall be placed across the entire width of the bottom of the trench, to a thickness shown on the Design Drawings. The bedding surface shall be shaped to fit the pipe for a depth of not less than 10 percent of the outside diameter of the pipe. The bedding shall be compacted in layers not exceeding six (6) inches in thickness.

B. Some of the existing fill may be suitable for use as compacted fill at the site provided that it remains relatively dry for optimum compaction and that any debris (i.e. concrete, brick, asphalt, wood) and organic material (i.e. topsoil and roots), have been removed prior to its reuse. The underlying Silty Sand or Silty Sand with gravel is generally suitable for use as compacted fill provided that the material remains relatively dry for optimum compaction.

C. During construction, the contractor shall segregate the potentially re-usable soil from the non-reusable fill (i.e. debris and topsoil). The on-site representative from the

ENGINEER shall evaluate the suitability of the excavated materials for use as structural fill during the excavation and prior to its re-use. Potentially usable fill shall be stockpiled and covered with tarps or plastic sheeting for protection from excess moisture. Any fill material that becomes wet must be dried prior to its reuse.

D. Proper moisture conditioning of the soil is required. On-site material that is too wet at time of placement and cannot be adequately compacted shall be aerated and allowed to dry or the material removed, and drier cleaner fill material used. On-site material that is too dry at time of placement and cannot be adequately compacted may need water added in a controlled manner to increase the soil moisture content for proper compaction. The in-situ soils may become soft and weave if exposed to excessive moisture and construction traffic. The instability will occur quickly, and the subgrade will be difficult to stabilize. Adequate site drainage shall be implemented early in the construction schedule. If the subgrade becomes wet, the contractor shall limit the construction activity until the soil has dried.

E. The fill shall be thoroughly mixed and spread evenly by mechanical equipment or other means above the approved subgrade in lifts not exceeding six (6) inches before compaction (or less, if needed to achieve the specified densities), and shall be built up in horizontal layers as nearly even as practicable unless indicated in the Design Drawings. Grading tolerances shall be plus or minus 0.1 feet for all exposed surfaces of backfill unless indicated in the Design Drawings.

F. Slopes shall be constructed from the bottom-up in controlled lifts and benched into the existing slope for stability. Existing slopes receiving new fill must be properly cleared, grubbed, compacted, inspected and approved by the ENGINEER prior to placing new fill.

G. No fill materials shall be placed when either the fill material or the underlying material on which it is to be placed is frozen. In the event that the subgrade or any fill which has already been placed is frozen, it shall be scarified, thawed, and recompacted or removed, to the approval of the ENGINEER before the new fill is placed. Any soft spots resulting from frost shall be removed or recompacted to the satisfaction of the ENGINEER before new fill material is placed. No frozen material shall be used as fill. No compaction shall be done when there is standing water from rain or from excess applications of water. At such times, work shall be suspended until the previously placed and new materials have dried sufficiently to permit proper compaction.

H. Hand-operated vibratory type plate compactors, wackers, jumping jacks, or other suitable equipment shall be used in areas not accessible to larger rollers or compactors in order to avoid damaging structures, pipes, conduits or ducts.

I. Upon completion of the backfill operations the surface of the fill shall be sloped to facilitate surface drainage. This grade shall be maintained throughout backfilling operations except where controlled by other specified grade and elevations. The final finish grade shall be smooth, free of ruts, terraces and holes, and conform to elevations shown in the Design Drawings.

3.3 SUBGRADE PIPING INSTALLATION

A. The trench excavation for the dual phase extraction (DPE) system conveyance piping and discharge piping shall be as shown in the Design Drawings.

B. The conveyance piping trench width shall vary between 8 inches and 50 inches depending on the number of conveyance pipes within the trench. The conveyance piping trench shall be excavated to 3 feet below ground surface (bgs) and extend approximately 240 feet in length.

C. The trench for effluent discharge line from the DPE enclosure to the refinery gravity sewer shall be 3 feet deep, approximately 1 foot wide and 150 feet long.

D. The CONTRACTOR shall excavate both trenched using a backhoe or other suitable equipment.

E. The excavated material shall be stockpiled immediately next to the trenches and field screened with a PID. If no visible impacts or elevated PID readings are noted in the stockpiled material, CONTRACTOR shall use the trench spoils to backfill the trenches. If stockpile material is impacted or elevated PID readings are noted, soil shall be placed on plastic sheeting, covered, and characterized for disposal separately from the already profiled waste soil as deemed by ENGINEER.

F. The CONTRACTOR shall line the bottom of the trenches with 0.01-inch plastic sheeting prior to installation of pipe bedding material or pipe. Plastic sheeting shall extend a minimum of 12 inches beyond the width of the trench on each edge. Plastic sheeting seams shall be overlapped by a minimum of 4-feet.

G. Pipe bedding shall be placed by hand in maximum 6-inch lifts to the dimensions indicated. each lift shall be compacted using hand tamping or vibratory place device with a minimum of two full passes per lift. the bedding material shall consist of sand fill material.

H. The conveyance piping along with an electrical conduit to supply power to pressure transmitters at each well shall be placed within the bedding material as shown on the Design Drawing and the remaining trench depth shall be backfilled with the native material.

I. The CONTRACTOR shall furnish eight (8) new below grade vaults including necessary piping, appurtenances, and controls. Vaults shall be self-draining and constructed such that bottom intersects sand backfill/pipe bedding material. fine-grained materials (e.g., silts or clays) shall not be placed at bottom of vault.

3.4 LNAPL RECOVERY TRENCH CONSTRUCTION

A. The LNAPL recovery trench will be 5-feet wide by 10-feet deep by 50-feet long.

B. The CONTRACTOR shall employ suitable method to install the LNAPL recovery trench as shown in the Design Drawings.

C. The CONTRACTOR shall directly load the excavated material into US Department of Transportation (DOT)-compliant dump-trucks or roll-off boxes to be transported to a landfill.

D. The LNAPL recovery trench shall be backfilled with coarse sand and native material as

specified in the Design Drawings.

E. The CONTRACTOR shall install eleven (11) 6-inch diameter, 0.020-inch slotted (20-slot) PVC pipes within the trench during backfill activities to serve as LNAPL recovery wells.

1. Each LNAPL recovery well will be driven into a minimum of two feet of backfill material. Remaining backfill material will be placed in the LNAPL recovery trench around each LNAPL recovery well.
2. LNAPL recovery wells will be installed every five linear feet as shown on the Design Drawings.

F. LNAPL recovery wells shall be completed at the surface with a bolt down 12-inch diameter steel flush-mount manhole cover set in a 2-feet by 2-feet square concrete pad.

3.5 PTT CONSTRUCTION

A. The PTT will be 5-feet wide by 12.5-feet deep by 110-feet long.

B. The CONTRACTOR shall employ suitable method to install the PTT as shown in the Design Drawings.

C. The CONTRACTOR shall excavate and backfill the trench in segments. The excavated material will be directly loaded into covered, US DOT-compliant dump-trucks or roll-off boxes and immediately transported to a landfill.

D. The PTT trench shall be backfilled with coarse sand amended with PetroFix™ up to approximately 2.5 feet bgs in one to two-foot lifts. Corse sand and liquid PetroFix™ shall be mixed mechanically. The applied Petrofix™ dosage for a given segment will correspond to the total PetroFix™ quantity (14,000 pounds or 1500 gallons) multiplied by the ratio of the backfill volume being treated to the total trench volume. For example, a 20-foot horizontal segment, 2 foot-sand lift corresponds to 3.6% of the total trench volume. 3.6% of the total PetroFix™ quantity will be mixed into this area or 54 gallons per 200 bank cubic feet of backfill. The top 2.5 feet of the trench shall be backfilled with unamended coarse sand and compacted.

E. The CONTRACTOR shall install one (1) 2-inch diameter, 0.020-inch slotted (20-slot) PVC pipe at the center of the trench during backfill activities to serve as a trench performance monitoring well.

1. PTT monitoring well will be driven into a minimum of two feet of backfill material. Remaining backfill material will be placed in the PTT around the PTT monitoring well.
2. PTT monitoring well will be installed at the location shown on the Design Drawings.

F. The PTT monitoring well shall be completed at the surface with a bolt down 8-inch diameter steel flush-mount manhole cover set in a 3-feet by 3-feet square concrete pad.

END OF SECTION

SECTION 31 25 00

SOIL EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. The Work covered in this Section includes the furnishing of all labor, materials, equipment, tools, and appurtenances required to minimize soil erosion and to provide sediment control, as shown in the Design Drawings, or specified herein.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.

B. Section 02 01 00 – Site Preparation and Maintenance of Existing Conditions

1.3 QUALITY ASSURANCE

A. All Work shall be in accordance with applicable manufacturer's instructions and local, state, and federal codes, regulations, laws, and ordinances.

B. CONTRACTOR shall comply with applicable requirements of Section 404 of Clean Water Act and Navigable Waters Protection.

C. During construction and until final acceptance, CONTRACTOR shall respond to erosion and sediment control maintenance requirements or implement additional measures to control erosion ordered by Owner or ENGINEER within 48 hours, or sooner if required, at no additional cost to the ENGINEER.

1.4 SUBMITTALS

A. Product data: Manufacturer’s information verifying that materials meet the specifications of this section and the Design Drawings.

B. Submit for documentation, certificates, and/or test results for one sample of each material obtained from on- and off-site sources indicating compliance with Specifications and Design Drawings prior to start of construction.

PART 2 PRODUCTS

2.1 MATERIALS

A. Silt fence as specified in the Design Drawings

B. Stabilized construction entrance/exit as specified in the Design Drawings

1. Gravel consisting of 100% passing the 2-inch screen and a minimum of 10% passing the 3/8-inch sieve or other equivalent material.

C. Inlet protection – straw bales, sandbags, and gravel berms.

D. Straw Bale Barriers as specified in the Design Drawings

1. Minimum size requirement: width of 14-inches, height of 18-inches, length of 3-feet, and mass of 50 pounds.

2. Steel wire (16 gauge) or nylon or polypropylene string (minimum 1/16-inch diameter) to bind the bales.

PART 3 EXECUTION

3.1 GENERAL

E. The erosion and sediment control measures shown on the Design Drawings represent a minimum requirement. The CONTRACTOR is responsible for determining additional erosion and sediment control measures needed to prevent the transfer of sediment from the project area and to prevent the erosion of surfaces during construction, as needed to protect adjacent properties and water bodies.

F. The CONTRACTOR shall undertake erosion control measures as shown on the Design Drawings including, but not limited to:

1. Install silt fence as indicated in the Design Drawings.
2. Install stabilized construction entrance/exit for access to Site and management areas as needed.
3. Install storm drain inlet protection such as straw bales, sandbags, and gravel berms.
4. Reduce volume and velocity of water crossing disturbed areas by utilizing diversion dams, straw bales, berms, or other facilities.

G. Cover stockpiles with plastic and secure to prevent wind erosion as directed by the ENGINEER.

H. The CONTRACTOR shall inspect, maintain, and replace above mentioned measures as needed, throughout the duration of project.

I. The Owner or ENGINEER have authority to limit surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow, and placement operations. CONTRACTOR shall provide immediate temporary or permanent erosion control measures when directed. CONTRACTOR shall incorporate all permanent erosion control features into project at earliest practicable time to minimize need for temporary controls.

3.2 MAINTENANCE

A. The ENGINEER shall inspect or arrange for inspection of erosion control measures within 24 hours of the end of each rainfall event of 0.5 inches or more, or daily during periods of prolonged rainfall, and weekly during periods without rainfall. The CONTRACTOR shall immediately repair or replace damaged, failed, or inadequate erosion control measures. ENGINEER shall document condition of erosion control measures during such inspections and maintain copies of inspection records.

B. The CONTRACTOR shall immediately repair or replace damaged, failed, or inadequate erosion control measures, as instructed by ENGINEER.

C. The CONTRACTOR shall remove sediment deposits from erosion controls after each storm event.

D. The CONTRACTOR shall inspect planned entrances and adjacent public streets daily when traffic is occurring and remove tracked and eroded soils as deemed necessary by ENGINEER and Owner. At a minimum, the CONTRACTOR shall clean the streets as necessary during hauling operations.

E. The CONTRACTOR to maintain erosion control measures through completion of the Work and remove materials as directed by the ENGINEER.

END OF SECTION

SECTION 33 71 01

ELECTRICAL SERVICE CONNECTION

PART 1 GENERAL

1.1 SCOPE

A. Within this scope of work section, the following work activities are to be performed.

1. The CONTRACTOR is responsible for installing a new 400-amp, 480 volt, 3-phase, 4-wire electrical service from the pad-mounted electrical transformer (by others) to the treatment enclosure.

2. The CONTRACTOR shall furnish all labor, materials, equipment, and incidentals necessary to perform the task.

B. Details.

1. The local electric utility (Northwestern Energy) will install a new electrical power service from one of their existing 12.47 kV main transmission line to a pad-mounted transformer located adjacent to the DPE system enclosure.

2. An electrical transformer, secondary electric utility pole, electric meter, overhead conductors, and main service disconnect switch will be installed. The electric meter shall be provided and installed by the local electric utility, and the local electric utility shall determine the location of the electric meter based on local and/or national codes and standards. The local electric utility shall be responsible for installing a main service disconnect switch on the load side of the electric meter.

3. The CONTRACTOR shall be responsible for extending the electrical service from the pad-mounted mounted electrical transformer to the main disconnect switch located on the exterior of the DPE equipment enclosure. CONTRACTOR shall also be responsible for extending the electrical conductors from the DPE system main power panel to the catalytic oxidizer.

1.2 GENERAL SPECIFICATIONS

A. The CONTRACTOR shall ensure that the electrical service installation adheres to all local and/or national codes and standards.

B. The CONTRACTOR shall ensure that a Montana licensed electrician perform this scope of work.

C. The CONTRACTOR shall support the installation of the electrical power distribution service and shall provide any additional materials and/or hardware required to properly complete the installation.

1.3 RELATED SECTIONS

A. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.

1.4 SUBMITTALS

(Reserved)

PART 2 PRODUCTS

(Reserved)

PART 3 EXECUTION

A. The CONTRACTOR shall install 84-inch by 84-inch by 8-inch concrete pad for the new electrical transformer as specified in the Design Drawings.

B. The CONTRACTOR is responsible for installing an underground electrical service from the pad-mounted electrical transformer to the DPE system main disconnect switch.

C. The CONTRACTOR shall extend the electrical service to the catalytic oxidizer as specified.

END OF SECTION

SECTION 40 05 01

PROCESS PIPING

PART 1 GENERAL

1.1 SCOPE

The Work covered in this Section includes all labor, equipment and material for the installation of polyvinyl chloride (PVC) and appurtenances for the dual phase extraction (DPE) system as shown in the Design Drawings and as specified herein.

1.2 RELATED WORK NOT INCLUDED

Related sections include the following:

A. Drawings and general provisions of the Contract, and other Division 01 Specifications Sections apply to this Section.

B. Section 40 41 08 – Pipe Insulation.

C. Section 40 41 13 – Electric Heat Tracing.

D. Section 31 23 00 – Excavation and Fill.

1.3 REFERENCES

American Society for Testing and Materials (ASTM)

1.4 SUBMITTALS

A. The Contractor shall submit to the ENGINEER the following:

1. Type of pipe, couplings, bends, contraction and expansion joints or loops, in accordance with the manufacturer's recommendations for the review and approval of the ENGINEER.

2. Prior to delivery, submit certification of materials attesting to compliance with these Specifications.

3. Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the ENGINEER prior to installation.

4. Shop drawings, installation guides and data on pipes, fittings, bolts, nuts and other necessary accessories.

5. Layout drawings showing the location and centerline elevation of the pipe and fittings, including details of the support system, sleeves, coupling and appurtenances.

6. Submit pipe testing procedures, including test medium and pressure, line segments, and equipment included in the test, methods of isolating sections of the system, pressure monitoring techniques, and the certification form to be submitted to ENGINEER.

PART 2 PRODUCTS

2.1 GENERAL

The equipment and materials specified herein are intended to be standard types of PVC and fittings meeting the requirements of applicable ASTM standards to be used to transport fluids.

2.2 PVC PIPE, JOINTS, AND FITTINGS

A. The pipe shall be Spears Schedule 80 PVC or approved equal in characteristics.

B. Couplings and fittings shall be as recommended by the pipe manufacturer and shall be Schedule 80.

C. All PVC pipe fittings and couples shall conform to ASTM D 3034.

D. Fittings, specials, unions and flanges shall be of the same schedule number and manufactured of the same materials as the pipes unless otherwise specified on Design Drawings.

2.3 PITLESS ADAPTER

A. Pitless adapter shall be pitless adapter used to connect PVC drop pipe and DPE PVC conveyance piping at each well head.

B. The pitless adapter fitting shall consist of a discharge spool, a discharge body, and a riser piece. The discharge body shall be constructed from fabricated steel. O-ring seats shall be designed to seal full circumference and be of a non-corrosive material. The spool shall include a threaded inlet of the size indicated on the drawings.

C. The spool shall have O-rings set into the body for sealing to the discharge body. The riser shall be of adequate size to pass the spool.

D. The discharge port shall be of size indicated on the Design Drawings. The discharge outlet and size shall be as shown in the Design Drawings.

E. Acceptable manufacturers are Maass Midwest, Model JD2 SS-6 or Dicken, Model S-20-N Adapter or approved equal.

PART 3 EXECUTION

3.1 GENERAL

All pipe shall be handled and assembled in accordance with the manufacturer's instructions, except as modified on the Drawings or in writing by the Contractor.

3.2 DELIVERY, STORAGE, AND HANDLING

A. On site pipe storage shall meet all manufacturers' requirements.

B. Transport individual pipe lengths to the job site on padded bunks with nylon tie-down straps or padded bonding to protect the pipe. Anchor pipe securely to prevent slippage.

C. Store individual pipe lengths on earth berms or timber cradles in the numerical order of installation. Stack the heaviest series of pipe at the bottom. Do not stack pipe in excess of 20-rows high.

D. Store fittings in their original cartons.

E. Lift pipes with handling beams or wide belt slings near the middle of joints as recommended by the pipe manufacturer. Do not use cable slings, chains, or hooks.

F. Before installation, check pipe and fittings for damages, cuts, scratches, or gouges. Remove any pipe section containing defects by cutting out the damaged section in a complete cylinder.

3.3 PIPING INSTALLATION

A. Install in accordance with submittals favorably reviewed by ENGINEER. Prior to fabrication, verify the required dimensions for instrumentation and equipment with the Equipment Vendor's information.

B. Install pipe, fittings, and specials in accordance with recognized industry practices achieving permanently leak-proof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum of joints. Reduce sizes (where indicated on the Contract Drawings) by use of reducing fittings. Align piping accurately.

C. All below grade piping shall be sloped one vertical foot per 500 linear feet from the wellhead to the DPE remediation system enclosure. All fluids shall gravity drain toward the wellhead.

D. Pitless Adapters: The specified installation shall be completed including fittings and at 3-feet below ground surface. Connect the 2-inch drop pipe and 2-inch horizontal discharge line to the adapter or unit according to the manufacturers' instructions. Connections shall be watertight. The outside section of the adapter shall connect onto the well casing per manufacturer instructions.

E. Store all piping and specialties in area free from dust and moisture. Maintain pipe end caps during storage, handling, and fabrication to prevent pipe end damage and eliminate dirt and moisture from inside.

3.4 DPE EXTRACTION WELL VAULT INSTALLATION

A. The CONTRACTOR shall furnish eight new below grade vaults including necessary piping, appurtenances, and controls.

B. Vaults shall be a minimum dimension of 2 feet by 2 feet square with an access cover or hatch.

C. Vaults shall be able to withstand a load rating of h-20 and a minimum of 300 pounds per square foot.

D. Vaults shall be installed a minimum of one-inch above the ground surface.

E. Vaults shall be self-draining and constructed such that bottom intersects sand backfill/pipe bedding material. fine-grained materials (e.g., silts or clays) shall not be placed at bottom of vault.

3.5 LEAKAGE TESTING

A. Cleaning: Flush clean and test all pipes after installation.

B. Testing: Test pipes for leaks and repair or tighten as required. CONTRACTOR shall furnish all equipment, necessary piping, required labor and expenses to test PVC piping systems.

C. Procedures: All PVC piping and equipment shall be pressure tested before final acceptance. Liquid conveyance lines shall be tested with water.

1. All piping and equipment shall be pressure tested by suitably closing the end of the pipe with a test plug of approved design, suitably braced against internal pressure to prevent blowout and possible injury to personnel.
2. The CONTRACTOR shall furnish all labor, materials, and equipment for testing the pipe, including, but not limited to, water for testing, test pump, pressure gauges with 5 psi gradations or less, test plugs, etc.
3. Testing shall be performed by the CONTRACTOR and witnessed by ENGINEER.
4. The liquid conveyance lines shall be filled with water, taking care to eliminate air from high points. A positive displacement test pump shall be used to pump clean water into the pipe to build up a pressure equal to a minimum of 150% of the design pressure, but not exceeding the pressure rating of the pipe.
5. The pump shall be isolated from the pipe and the pipe shall maintain pressure for a period of one hour without any appreciable pressure loss. Accounting for variations in temperature, the test should show less than 2% loss in test pressure over the one-hour test interval. All joints shall be inspected for leaks.

A. CONTRACTOR shall repair any leaks discovered during the testing sequence. All leaks shall be repaired, whether or not the leakage rate is within allowable limits. All repairs will be observed by ENGINEER.

B. CONTRACTOR shall be responsible, at their own expense, for retesting any piping not satisfactorily tested in the presence of ENGINEER. Testing shall be conducted after laying of the piping systems. CONTRACTOR may test entire pipe system or individually test each segment in the final test.

C. Where the piping system is connected to equipment or components designated for operating pressures less than the test pressure, such equipment or components shall be isolated from the piping system by disconnecting them and capping the outlets.

D. Piping shall be pre-tested by applying a negative pressure test. The piping shall be tested by applying a vacuum and monitoring the vacuum over a one-hour period. If the vacuum is maintained with no detectable pressure loss (accounting for temperature variations during the test) then the tested section of pipe is considered passing.

3.6 HEAT TRACING AND ISOLATION

A. Provide and install electric heat trace and insulation on piping sections as specified in the Design Drawings as well as Section 40 41 13 – Electric Heat Tracing and Section 40 41 08 – Pipe Insulation.

END OF SECTION

SECTION 40 40 00

PROCESS PIPING AND EQUIPMENT PROTECTION

PART 1 - GENERAL

1.1 SCOPE

A. This Section includes the protection mechanisms for the process piping and equipment that is part of the dual phase extraction (DPE) system and catalytic oxidizer (CATOX).

1.2 RELATED SECTIONS

Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

A. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.

B. Section 11 01 00 – Packaged Dual Phase Extraction (DPE) System

C. Section 11 15 00 – Packaged Catalytic Thermal Oxidizer System

D. Section 40 05 01 – Process Piping

1.3 REFERENCES

(Reference)

1.4 SUBMITTALS

(Reserved)

1.5 DELIVERY, STORAGE AND HANDLING

A. Components procured under this Section shall be protected from damage due to impact and point loading. The CONTRACTOR shall not allow extraneous materials to come into contact with components.

PART 2 - PRODUCTS

2.1 UNDERGROUND WARNING TAPE

A. Underground warning tape shall be manufactured from high-grade virgin materials of low grade density polyethylene polymers.

B. Underground warning tape should be resistant to most soil types including alkaline and acidic soils.

C. Underground warning tape shall have a minimum thickness of 0.005-inch (5 mils).

D. Underground warning tape shall have a minimum width of 6-inches and a roll size of 1000 feet.

E. Underground warning tape imprints (text) shall have lead-free, permanent, and overcoated to protect from the environment.

2.2 FENCE

A. Fence shall be installed where indicated in the Design Drawings or specified.

B. Fence shall be 6 feet tall, of chain-link design and manufactured of galvanized steel.

2.3 SECURITY LIGHTING

A. A high-pressure sodium bulb with photocell shall be installed within the fenced area and in proximity of the enclosures. Security light shall adequately illuminate the DPE enclosure and CATOX equipment.

PART 3 - EXECUTION

3.1 UNDERGROUND WARNING TAPE

A. The CONTRACTOR shall install underground warning tape along each length of underground process piping from DPE system enclosure to each DPE well and prior to backfilling each trench. Underground warning tape must be installed at least 1 foot below the ground surface.

3.2 FENCE

A. The CONTRACTOR shall install the chain-link fence around the DPE equipment enclosure and the CATOX enclosure, as indicated in the Design Drawings.

B. Fence support posts shall be installed in concrete at maximum spacing of 10 feet to ensure the structural integrity of the fence.

C. Two (2) gates with an opening width of 10 feet shall be installed as shown in the Design Drawings.

3.3 SECURITY LIGHTING

A. The CONTRACTOR shall install a security light within the fenced area and in proximity of the enclosures.

END OF SECTION

SECTION 40 41 08

PIPE INSULATION

PART 1 GENERAL

1.1 SCOPE

A. The Work covered in this Section includes the labor, equipment, and material for the installation of pipe insulation to provide insulation for electric heat traced pipes.

B. Pipe insulation shall be provided for the following types of process piping, where specified in the Design Drawings: below ground dual phase extraction (DPE) conveyance piping from each DPE well, effluent piping from the effluent transfer pump to a refinery gravity process sewer, and piping from DPE vacuum blower to the catalytic thermal oxidizer (CATOX).

1.2 REFERENCES

(Reserved)

1.3 RELATED SECTIONS

A. Related sections include the following:

1. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.
2. Section 40 05 01 – Piping.
3. Section 40 41 13 – Electric Heat Tracing.

1.4 SUBMITTALS

A. The following shall be submitted:

1. Working drawings showing the layout of the insulation for the specified process piping sections.
2. Manufacturer's catalog data and literature.
3. Installation instructions for pipe insulation

1.5 CODES AND REGULATIONS

A. Insulation materials furnished and installed shall meet the fire hazard requirements of any applicable state and local codes and regulations.

PART 2 PRODUCTS

2.1 MATERIALS

A. Fiberglass Insulation.

1. Fiberglass insulation shall be installed as indicated in the Design Drawings.
2. Pipe insulation shall be Owens Corning Fiberglas™ Pipe Insulation or an approved equal.

B. Jacket.

1. Insulation shall be protected with a polyvinyl chloride (PVC) jacketing with a thickness of 0.02 inches.
2. PVC jacketing shall be installed in strict accordance with the manufacturer's recommendations.
3. PVC jacketing shall be manufactured by ITW Insulation Systems or an approved equal.

PART 3 EXECUTION

3.1 PREPARATION

A. The CONTRACTOR shall ensure that all pipe and fitting surfaces over which insulation is to be installed are clean and dry.

B. The CONTRACTOR shall ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. The CONTRACTOR shall ensure that pressure testing of piping and fittings has been completed prior to installing insulation.

3.2 INSTALLATION

A. The CONTRACTOR shall install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.

B. The CONTRACTOR shall install insulation on piping subsequent to installation of heat tracing and acceptance tests.

C. The CONTRACTOR shall install insulation materials with smooth and even surfaces. Each continuous run of piping shall be insulated with full-length units of insulation, with single cut piece to complete run. Cut pieces or scraps shall not be used abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.

D. The CONTRACTOR shall maintain the integrity of the PVC jacketing on all pipe insulation, protecting it against puncture, tears or other damage.

3.3 FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered under this scope of work, the CONTRACTOR shall visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

END OF SECTION

SECTION 40 41 13

ELECTRIC HEAT TRACING

PART 1 GENERAL

1.1 SCOPE

A. The Work covered in this Section includes the labor, equipment, and material for the installation of a system of electric heater and controls to prevent the freezing of the underground pipes during transferring of fluids.

B. Electric heat tracing shall be provided for the following types of process piping, where specified in the Design Drawings: below ground dual phase extraction (DPE) conveyance piping from each DPE Well to the DPE system and effluent piping from the effluent transfer pump to a refinery gravity process sewer.

1.2 REFERENCES

(Reserved)

1.3 RELATED SECTIONS

A. Related sections include the following:

1. Drawings and general provisions of the Contract, and other Division 01 Specification Sections, apply to this Section.
2. Section 26 01 00 – General Provisions for Electrical Systems.
3. Section 40 05 01 – Piping.

1.4 SUBMITTALS

A. The following shall be submitted:

1. Working drawings showing the layout of the heat tracing for the specified process piping sections, type of heat tapes and heaters, locations and types of controls (e.g. thermostats, etc.), location of power supply for the heaters and details of heat tracing connectors.
2. Manufacturer's catalog data and literature.
3. Installation instructions for heater and components.
4. Type and amount of insulation for use with the electric heat trace systems.

1.5 APPROVALS

A. The heat tracing system listed for this application shall be listed by Underwriters Laboratory and shall meet applicable State and local codes and regulations.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Electrical Heat Trace.

1. The heat trace shall be self-regulating.

2. The heaters shall be capable of delivering an output of 5 watts per foot at 40 degrees F.
3. The heater shall be XL-Trace as manufactured by Raychem Corporation, or approved equal.

B. Components.

1. Power connection, end seal, splice, and tee kits shall be as provided by the manufacturer to make up an Underwriter's Laboratories listed system for this application.
2. Components shall be rated for exterior use.
3. The CONTRACTOR shall install following controls for freeze protection:

C. Thermostatic control-serial purpose for freeze protection.

1. The system shall be controlled by a general-purpose freeze protection thermostat either directly or through an appropriate contactor.
2. The thermostat shall have a nickel-plated copper bulb at the end of 3-foot capillary.
3. The thermostat shall be permanently set at 40 degrees F.
4. The thermostat shall have an electrical rating of 22 amps at 240 volt and 18 amp at 277 VAC.
5. The thermostat shall be in a NEMA-4X enclosure.

D. Contactor.

1. The contactor shall be a three (3) pole contactor with a rating of 40 or 100 amps per pole in a NEMA-4X enclosure.

PART 3 EXECUTION

3.1 DESIGN

A. The heater system shall be designed by the CONTRACTOR using manufacturer's standard procedure in conjunction with the specifications and shall be designed to avoid exceeding the maximum permissible temperature of the pipe wall.

B. The CONTRACTOR shall field verify the location, length, and size of the heat-traced piping and its insulation. Heat tracing of valves and other instruments and piping appurtenances shall be included as specified in the Design Drawings.

C. The CONTRACTOR shall field verify the voltage supply for the selected heaters.

3.2 INSTALLATION

A. The CONTRACTOR shall complete the installation in accordance with the manufacturer's installation instructions and approved working drawings using components supplied by the manufacturer. The instructions shall include methods for installations, bends, valves etc.

B. All heat trace cable shall be installed in continuous lengths, no splices are acceptable.

C. The CONTRACTOR shall run the heater linearly along the lower quadrants of pipe sections once the piping has been successfully pressure tested.

D. The CONTACTOR shall secure the heater to the piping with fiberglass tape.

E. The heater shall be protected from damage.

F. For each 5-feet pipe section, the CONTRACTOR shall apply caution labels and ETL tags on the pipe insulation PVC jacket.

3.3 TESTING

A. Prior to shipment of the heater, the heater shall be subjected to inspection and a high-frequency spark test. All braided product shall be subjected to a dry dielectric test.

B. After installation of piping and before and after installing the thermal insulation, the heat tracing shall be subjected to testing using a 1000 DC multimeter. Minimum insulation resistance shall be 20 to 1000 megaohms regardless of the length.

END OF SECTION

APPENDIX E

DRAFT OPERATIONS, MAINTENANCE, AND MONITORING PLANS

E1 – AOC-16 INTERIM MEASURE DRAFT OPERATION, MAINTENANCE AND MONITORING PLAN

E2 – AOC-16 INTERIM MEASURE DRAFT SELF-RECUPERATIVE CATALYTIC OXIDIZER OPERATION, MAINTENANCE AND MONITORING PLAN

APPENDIX E1 – AOC-16 INTERIM DRAFT MEASURE OPERATION, MAINTENANCE AND MONITORING PLAN

AOC-16 INTERIM MEASURE DRAFT OPERATION, MAINTENANCE AND MONITORING PLAN

CALUMET MONTANA REFINING, LLC
GREAT FALLS, MONTANA

November 2020

Log of Revisions to OM&M Plan			
Revision No.	**Revision Date**	**Section or Pages Revised**	**Description of Revision**

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Attachment E: Field Standard Operating Procedures

ACRONYMNS AND ABBREVIATIONS

AOC-16	Area of Concern-16
ASTM	American Society for Testing and Materials
bgs	below ground surface
CMR	Calumet Montana Refining, LLC
COCs	Constituents of Concern
DEQ-7	Montana Department of Environmental Quality-7
DO	dissolved oxygen
DPE	duel-phase extraction
EPH	extractable petroleum hydrocarbons
F	Fahrenheit
Ft	feet
GOAB	gang operated air break
gpm	gallons per minute
HASP	health and safety plan
HHS	Human Health Standards
HMI	human-machine interface
IM	interim measures
in-Hg	inches of mercury
LEL	lower explosive limit
LNAPL	light non-aqueous phase liquid
µg/L	microgram per liter
MDEQ	Montana Department of Environmental Quality
Mg/L	milligrams per liter
MS/MSD	matrix spike/matrix spike duplicate
NFPA	National Fire Protection Association
OM&M	Operations, Maintenance and Monitoring
ORP	oxidation-reduction potential
PID	Photo Ionization Detector
PLC	programmable logic controller
PM	project manager
ppmv	parts per million by volume
PRT	Primary Recovery Trench
psig	pounds per square inch gauge
PRT	product recovery trench
PTT	Passive Treatment Trench
PVC	polyvinyl chloride
RBSL	Risk-Based Screening Levels
Ramboll	Ramboll US Consulting, Inc.

ROW	Right-of-Way
SAP	sampling and analysis plan
SCFM	standard cubic feet per minute
SOP	standard operating procedure
SRCO	Self-Recuperative Catalytic Oxidizer
SVOC	semi-volatile organic compound
QA/QC	quality assurance/quality control
TBD	to be determined
USEPA	United States Environmental Protection Agency
VFD	variable frequency drive
VLS	vapor/liquid separator
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons
WWTP	wastewater treatment plant

1. INTRODUCTION

1.1 Overview and Purpose

Ramboll US Consulting, Inc. (Ramboll), on behalf of Calumet Montana Refining, LLC (CMR), has prepared this Area of Concern-16 (AOC-16) Interim Measure (IM) Operation, Maintenance, and Monitoring (OM&M) Plan for the Calumet Great Falls Montana Refining facility located at 1900 10th Street NE, Great Falls, Montana.

The purpose of this OM&M Plan is to provide a brief description of the dual-phase extraction (DPE) system and the light non-aqueous phase liquid (LNAPL) Recovery Trench/passive treatment trench (PTT); identify and describe the operation of the DPE components; include as-built (record) drawings of the constructed system, equipment schematics/operation and maintenance manuals, and parts listings; present system startup and operation procedures; provide a system operations/project contact list; and detail system monitoring, maintenance, and record-keeping requirements and schedules.

The DPE System and the PTT have been designed as IM corrective actions to address historic petroleum releases resulting in LNAPL and dissolved phase groundwater impacts in the AOC-16 area of the Calumet Great Falls Montana Refining facility.

This OM&M Plan addresses two interim remedial measures in two areas:

- DPE System in the Product Recover Trench (PRT) in the Truck Rack Area
- LNAPL Recovery Trench and PTT in the area North of River Road.

A Self-Recuperative Catalytic Oxidizer (SRCO) is used to treat the vapors recovered as part of the DPE system. A separate OM&M Manual has been prepared for the SRCO. Operations and maintenance requirements for the SRCO are not included herein. Long-term monitoring and sampling associated with the SRCO is included in this document.

1.2 Site 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 to the east of the active refinery and is owned by CMR. The Public Land Survey System 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. A CMR two-floored office building is in the east portion and an access road, set down area and vegetation area is in the southern portion of AOC-16. 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 gate station.

1.3 Objective of the AOC-16 Interim Measure

Interim measure goals specific to each treatment area include:

- Truck Rack Area - (DPE in PRT)
  - Recover free phase LNAPL mass present in the area south of the Truck Rack to stabilize the LNAPL plume.
  - Reduce LNAPL within the vadose and saturated zone soil matrix to stabilize the dissolved phase plume.
- North River Road Area – (LNAPL Recovery Trench and PTT)
  - Mitigate dissolved phase groundwater impacts migrating from the Truck Rack Area towards the Missouri River. The groundwater concentrations of hazardous constituents downgradient of the PTT must be less than the Montana numeric water quality standards set forth in Circular Department of Environmental Quality-7 (DEQ-7) and/or Montana DEQ Tier 1 Groundwater Risk-Based Screening Levels (RBSLs). The applicable groundwater standards shall be met at compliance monitoring points south of AOC-16 and up-gradient of the Missouri River.

1.4 Key Project Contacts

Key project personnel for the AOC IM OM&M activities are presented in Table 1.

Table 1: Key Project Contacts

Project Title	Company/Organization	Name	Contact Info
Montana Department of Environmental Quality (MDEQ) Project Manager	MDEQ	Denise Kirkpatrick	dkirkpatrick@mt.gov (406) 444-3983
CMR Project Manager	Calumet Montana Refining, LLC	Joe Dauner	joseph.dauner@ calumetspecialty.com (406) 454-9887
Principal in Charge	Ramboll Environment and Health	David Heidlauf	dheidlauf@ramboll.com (312) 288-1377
Project Manager	Ramboll Environment and Health	Scott Tarmann	starmann@ramboll.com (262) 901-0093
Field Team Lead	Ramboll Environment and Health	To be determined (TBD)	TBD
OM&M Contractor	(TBD)	(TBD)	TBD

For overall project purposes a designated on-site Field Team Lead will be present during OM&M activities and will provide on-site supervision required during the project. The on-site Field Team Lead will be in contact with the Project Manager, who will then review compliance with project objectives and sampling protocols outlined in this OM&M Manual. Positions and their responsibilities are outlined briefly below:

MDEQ Project Manager - The MDEQ Project Manager provides regulatory oversight to the project. They provide approval of plans, reports and any deviations from previously approved plans. The MDEQ Project Manager ensures that all project work is compliant with required regulations and Orders.

Ramboll Principal-in-Charge - The Ramboll Principal-in-Charge will provide project direction and provide the primary contact among MDEQ, Ramboll, and CMR.

Ramboll Project Manager (PM)	-	The Ramboll PM will supervise all Ramboll personnel and subcontractors and is responsible for the day-to-day management of the project. They will also serve as the liaison between MDEQ, subcontractors, and CMR.
Field Team Lead	-	The Designated Field Team Lead is the senior Ramboll employee in the field. They are responsible for ensuring that all field personnel adhere to Quality Assurance Project Plan (QAPP) and Sampling and Analysis Plan (SAP) requirements. They will perform routine sampling of the DPE System, routine gauging and groundwater sampling of the PTT and LNAPL Recovery trench. They will aid in scheduling and routine monitoring and maintenance. They will collect field forms and records and will be responsible for ensuring all samples are sent to the laboratory as required.
CMR Operations Manager	-	The CMR Operations Manager is the CMR employee in the field. They will perform routine sampling of the DPE System, routine gauging and groundwater sampling of the PTT and LNAPL Recovery Trench. They will perform routine monitoring and collect and compile field forms and records.
OM&M Contractor	-	The OM&M contractor will conduct routine and non-routine maintenance on the DPE system. The OM&M contractor will be on-call to respond to maintenance requests.

1.5 OM&M Plan Organization

This OM&M Plan is divided into the following sections:

- Section 2 – DPE System Operation and Maintenance
- Section 3 – DPE System Performance Monitoring
- Section 4 – PTT Performance Monitoring
- Section 5 – Sampling and Analysis Methods
- Section 6 – Reporting Requirements
- Section 7 – References

2. DPE SYSTEM OPERATION AND MAINTENANCE

2.1 DPE System Process Equipment

The DPE System is primarily designed to recover LNAPL mass and reduce LNAPL within the vadose and saturated zone soil matrix.

The DPE System consists of the following main components:

- Eight extraction wells (DPE-1 through DPE-8) screened across the shallow groundwater aquifer;
- Header piping and manifold;
- Two rotary claw extraction blowers; and
- Vapor/liquid separator (VLS) and liquid transfer pump.

The extracted vapor is conveyed to a SRCO unit for treatment which is addressed in a separate OM&M Manual. The extracted liquids are conveyed via the liquid transfer pump to the refinery sewer and refinery wastewater treatment plant (WWTP) located approximately 150 feet (ft) north of the system enclosure.

2.1.1 Treatment System Enclosure

The process treatment system is housed in a pre-engineered treatment enclosure (DPE enclosure). As shown on Drawing C5 in Attachment A, the DPE enclosure is located northwest of the existing PRT on a gravel base.

The DPE system aims to recover LNAPL and impacted vapor. The recovered material has the potential to be flammable. To minimize the risk of explosion, combustible composition control will be utilized in accordance with National Fire Protection Association (NFPA) 67 *Guide on Explosion Protection for Gaseous Mixtures in Pipe Systems*, Chapter 6.1.1. The vapor concentration within the system will be maintained at or below 25% of the lower explosive limit (LEL) using LEL monitors and dilution ambient air modulating control valves.

The DPE enclosure is divided into a Class 1, Division 2 hazardous area-rated main equipment room and an unclassified control room (See Drawing M1 in Attachment A). Both areas include heating to prevent freezing and lighting for proper operation of the system. Given the Class 1, Division 2 hazardous area rating of the main equipment room adequate ventilation, defined as at 12 air changes per hour, is required. The main equipment room is outfitted with vent fan and louvers to meet this condition.

The DPE enclosure also includes built-in secondary containment in the event of a leak along with an interlock that will shut down the DPE System in the event of liquid accumulation within the secondary containment.

2.1.2 DPE Well Configuration and Construction Detail

The DPE system consists of eight DPE wells screened across the shallow groundwater aquifer. Drawing C6 in Attachment A shows the location of the DPE wells.

Drawing C7 in Attachment A shows a typical DPE well. Each well is installed to approximately 14 ft-below ground surface (bgs) and constructed utilizing 6-inch diameter Schedule 80 polyvinyl chloride (PVC) with a 5-foot slotted PVC well screen at the base of the well. Coarse sand filter packs extend from the bottom of the borehole to one foot above the top of the well screens. The remaining annular space consists of cement grout on the coarse sand ensuring a secure seal. The DPE wells are protected with a 2-foot by 2-foot bolt-down, flush-mount well vault and traffic-rated access cover.

Each DPE well is equipped with a pitless adapter for a 2-inch diameter drop pipe which is attached to DPE PVC conveyance piping. The pitless adapter is installed approximately 3 ft-bgs. The drop pipes extend from the pitless adapter to approximately one foot from the bottom of each DPE well. The drop pipe can be replaced with other lengths of drop pipe to modify the ratio of groundwater to vapor recovered by the system.

2.1.3 Process Piping and Flow Control

The pitless adapter at each wellhead is connected to horizontal 2-inch diameter, schedule 80 PVC pipe installed in a trench. The soil vapor, groundwater and LNAPL extracted from each extraction well is conveyed below ground in individual 2-inch diameter schedule 80 PVC pipes. Individual DPE

conveyance pipe is run in a dedicated trench which joins with a common trench accommodating all eight DPE well conveyance piping into the DPE system enclosure. The underground piping is heat-traced and insulated.

Within the DPE enclosure, each extraction well pipeline is equipped with a throttling ball valve to allow for individual flow control at each well. The manual throttling valves are used to throttle the flow rate for each individual extraction line and maintain the design flow rate per well.

Sample ports are located on each extraction well suction line to allow vapor or groundwater samples to be taken from the suction line of each well.

Within the treatment enclosure, the eight 2-inch suction lines are manifolded into two 6" Schedule 80 PVC headers. Each header is equipped with a motor-actuated 6-inch butterfly valve used to isolate the flow of fluids from each set of wells in the event of a high-water table condition and to limit the rate of water discharge to the WWTP. After the butterfly valves, the two headers are manifolded into a single 6-inch schedule 80 PVC header which is conveyed to the VLS.

2.1.4 Vapor-Liquid Separator and Transfer Pump

The extracted fluids and vapor are drawn through a 300-gallon VLS to remove entrained fluids. The extracted fluids pass through a vertical, cylindrical vessel through the tangential inlet and top center outlet. A wire mesh pad in the vessel is used to separate the LNAPL and water from the extracted soil gas.

The vapor liquid separator is equipped with a low-level switch, a high-level switch, and a high-level shutoff switch. The low-level switch and high-level switch are used to operate a condensate transfer pump. When the amount of liquid in the tank reaches the high-level switch, the transfer pump will be operated to transfer the recovered liquids to the Refinery's WWTP.

The extracted liquids (water and LNAPL) are pumped via a progressive cavity pump through 1.5-inch PVC effluent piping to a 6-inch refinery gravity process sewer located 150 feet north of the treatment enclosure. The process sewer conveys the liquids to the CMR WWTP for treatment and discharge to the City of Great Falls WWTP. The extracted vapors pass through a filter and SRCO prior to release to the atmosphere.

2.1.5 DPE System Blower

Two rotary claw blowers provide approximately 200 standard cubic feet per minute (SCFM) (100 SCFM per blower) suction capacity at 17 inches of mercury (in-Hg) of vacuum. The motor's speed can be controlled using a variable frequency drive (VFD) controller located in the power control panel. The blowers are connected to 3-inch diameter carbon steel discharge piping that manifolds together and then discharge to the SRCO.

Inlet piping to the vacuum blowers includes dilution ambient air modulating control valves. Each blower includes the provision for the addition of ambient air to be fed into the vacuum header to dilute soil vapor in event of a high LEL explosive condition. The vacuum blower system controls will include automated safeguards to introduce ambient dilution air if an elevated LEL condition is detected and to shut down the vacuum blowers if an alarm LEL condition is detected.

2.1.6 Vapor Treatment System

The soil vapor treatment method for the DPE system is a SRCO. OM&M activities associated with the SRCO are discussed in a separate OM&M manual included in the AOC-16 Interim Measures Final (100%) Design Report.

2.1.7 Instrumentation

The following additional instrumentation is used along the DPE system:

- **DPE Enclosure Combustible Gas Sensor:** The combustible gas sensor is used to continuously monitor %LEL within the ambient air of DPE Process Room during system operation, and to provide automatic system shutdown if potentially hazardous conditions are detected.
- **In-line Combustible Gas Meter**: An in-line combustible gas meter is used to monitor %LEL of the untreated process air entering the blowers. The system is programmed to open a dilution valve to maintain combustible gas concentrations below 25% LEL for the detected gas concentrations.
- **Vacuum Gauges and Transmitters:** The vacuum gauges indicate negative pressures. There are vacuum indicators and transmitters at each wellhead that allow the operator to balance flow. There are also vacuum indicators before the vapor-liquid separator, before and after the inlet blower filter, and after each blower.
- **Pressure Gauges:** The pressure gauge indicates positive pressure and is located on the effluent discharge line.
- **Temperature Gauges:** In-line temperature probes monitor the influent and vapor temperatures. There are temperature gauges located in-line before the vapor-liquid separator, and at the outlet of each blower.
- **Flow Meters (Averaging Pitot Tube):** Averaging pitot tubes are used to measure the cumulative vapor flow rate after the VLS and individual blower vapor flow rates after each blower.
- **Flow Meter (Magnetic):** A magnetic flow meter and totalizer is used to measure liquid flow rates after the condensate transfer pump.
- **Blower Filter:** A blower filter is located in-line before the DPE blowers. It provides particle filtration prior to the extracted soil gas entering the blower. The filter must be manually cleaned and replaced.
- **Discharge Silencers:** The two discharge silencers are located in line after the DPE blowers and are operated continuously to reduce the noise of the output from the blowers.
- **Level Meters:** A level meter is used to measure the condensate level in VLS.

2.1.8 Control Panel and Electrical System

The main control panel, located in the control room, houses the programmable logic controller (PLC) and the human-machine interface (HMI). The PLC provides central control and operating logic (i.e., interlocks and alarms) for the system, which is programmed into the PLC. The system computer records selected system operating data including vacuums, temperatures, fluid levels in the VLS, and flow rates for the DPE system equipment. The system computer is remotely accessible through a cellular internet connection, allowing personnel to remotely access the operator interface terminal and observe the same operating information available to the field staff. If monitoring data exceeds pre-established normal operating ranges, the system operator is notified via visual display elements on the control screen. If the system is shut down due to an alarm condition, the system operator and project

personnel will receive notifications via SMS text message to a cellular device or via electronic message.

The DPE system uses a 480-volt, 3 phase power supply obtained from the Northwestern Energy 12.47 kV electrical transmission line located adjacent to the DPE system. A gang operated air break (GOAB) switch and meter socket is located on the transmission line power pole and the conductors feed a 225 kVA transformer that supplies power to an exterior-mounted secondary disconnect switch that feeds the main power panel inside the DPE enclosure.

The DPE system electrical equipment (including wiring) are constructed in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.2 DPE System Operation

2.2.1 Primary System Operation Parameters/Constraints

The DPE system is typically operated within the following primary parameter ranges:

- Total flow rate of 200 SCFM with flow rates of individual wells less than 25 SCFM
- Total vacuum of 16 to 19 in-Hg
- Blower air discharge temperature prior to the SRCO of less than 250 degrees Fahrenheit (F)
- Inlet volatile organic compounds (VOC) concentrations of less than 2900 parts per million by volume (ppmv).
- Potential explosive VOC concentrations less than 25% of the LEL.
- Maximum liquid flow of 30 gallons per minute (gpm).

2.2.2 System Optimization and Balancing

During initial startup or restart following an extended shutdown, high initial VOC concentrations may be encountered; therefore, the VFD blower may be run at its lowest operational speed while flow and vacuum settings for the extraction wells and system are adjusted (e.g., by adjusting the dilution air control valves and wellhead isolation valves) to balance the flow from each well and to limit vapor concentrations in the process vapor stream such that the operational parameters/constraints are met. Wells may need to be brought on-line individually while monitoring vapor concentrations.

As the initial pore volumes of soil gas are ventilated by the DPE wells and the initial slugs of LNAPL are removed, the concentrations will begin to decrease. Additional flow from the wells and less dilution air will be blended to both achieve optimal process gas concentrations and maintain conditions that meet the system's operational parameters. Subsequent balancing and optimization will be conducted as needed based on observed vacuum pressure readings at DPE wells and influent Photoionization Detector (PID) measurements.

2.2.3 Start-Up

Start-up procedure to be provided by packaged dual phase extraction system vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.4 Routine Operating Procedures

Routine operating procedures to be provided by packaged dual phase extraction system vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.5 Troubleshooting

Troubleshooting details to be provided by packaged dual phase extraction system vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.6 Restart, Shutdown, and Emergency Procedures

Restart, shutdown, and emergency procedures to be provided by packaged dual phase extraction system vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.7 Alarm Responses

Table 2 provides the alarm conditions to provide the operator with a general understanding of DPE system function and operation.

Table 2: Alarm Conditions

Attachment A Drawing No.	Interlock ID	Interlock and Control Logic Description
PID-05	I-01	Building interior temperature is high. Indicate high building temp warning on HMI screen.
PID-05	I-02	Building interior temperature is low. Indicate low building temp warning on HMI screen. Turn on electric heater EH-1.
PID-05	I-03	Building interior LEL is high. Send high LEL (building interior) alarm notification to operator. Shutdown system; close flow valves FV 0101 and FV 0102.
PID-05	I-04	Building floor sump high water level. Send high floor sump water level alarm notification to operator. Shut down system.
PID-05	I-05	Tank T-100 liquid level is high. Close flow valve FV 0101 <u>or</u> flow valve FV 0102. Reopen flow valve FV 0101 or FV 0102 when water level in Tank T-100 is lowered to LSS 0103 (Level Switch Stop) in 10 minutes or less; otherwise, indicate P-200 warning on HMI screen.
PID-05	I-06	Tank T-100 high-high liquid level. Close flow valves FV 0101 and FV 0102. Simultaneously open motor actuated flow valve FV 0302 to >75%. Send T-100 HHL Alarm notification to operator. Reopen flow valves FV 0101 and FV 0102 and close actuated flow valve FV 0302 if water level in Tank T-100 is lowered to LSS 0103 (Level Switch Stop) in 10 minutes or less; otherwise shutdown system. Send T-100 HHL and P-200 fault alarm notification to operator.
PID-05	I-07	Pump P-200 effluent flow rate is high. Send alarm notification to operator.
PID-06	I-08	Influent vapor LEL is >25%. Open flow valve FV 0302 and modulate valve position so AIC 0304 is at a LEL of 20%. Indicate warning on HMI screen.
PID-06	I-09	Blower B-310 discharge pressure is high. Shutdown Blower B-310. Send B-310 high pressure alarm notification to operator.

Attachment A Drawing No.	Interlock ID	Interlock and Control Logic Description
PID-06	I-10	Blower B-320 discharge pressure is high. Shut down blower B-320. Send B-320 high pressure alarm notification to operator.
PID-06	I-11	Blower B-310 and blower B-320 discharge pressure is high. Shut down System. Send blower system B-310/B-320 high pressure alarm notification to operator.

2.3 DPE System Recordkeeping and Maintenance

2.3.1 General

This section covers general maintenance procedures to be followed during operation of the DPE system. The procedures described herein are general in nature. More detailed maintenance instructions are found in the individual system component O&M manuals located in Attachment B. OM&M field log sheets for the routine maintenance activities are provided in Attachment C. Recordkeeping of the maintenance activities performed on the DPE System are to be documented on the OM&M log sheets and in a project logbook kept inside the control room of the DPE building. All entries into the logbook shall be copied/scanned and sent electronically to the Project Manager and Ramboll Field Team Lead.

2.3.2 Weekly/Monthly Inspections and Maintenance

The DPE system is designed to function without the need of an on-site operator. However, routine maintenance and inspection of the equipment will be necessary to ensure optimal performance of the equipment and to maximize runtime of the system. During operation, the following inspections and maintenance tasks are to be conducted weekly during the system startup and monthly thereafter. The monthly recordkeeping and system maintenance activities to be performed are summarized in Table 3.

Table 3: Monthly Maintenance Activities

Description of Activity	Action Performed	
	Yes	No
Maintain good housekeeping practices and keep interior of building and equipment clean and free from dust buildup.	☐	☐
Check for any leaks or sediment in the VLS by inspecting fluid level in sight glass. Schedule sediment removal if required.	☐	☐
Check if well vaults are locked and in good condition.	☐	☐
Check inlet blower filter differential pressure. Replace filter if necessary.	☐	☐
Inspect the DPE motor and mounting brackets to ensure that the bolted connections are secure.	☐	☐
While in DPE blower motors are in operation, observe the motor for abnormal noises, vibrations, excessive heating. While DPE motors are not in operation, check for signs of uneven or excessive wear (i.e., cracked or loose drive belts), misalignment issues, and damaged parts.	☐	☐
Check blower cooling air inlets and outlets to confirm they are not covered or obstructed and that the cooling air flow is not blocked.	☐	☐

Description of Activity	Action Performed	
	Yes	No
Check the oil level in each blower.	☐	☐

The system operations data recordkeeping to be manually recorded on a monthly basis are summarized in Table 4.

Table 4: Monthly System Operations Data Recordkeeping

Instrument/Parameter	Reading
Differential pressure reading on Filter F-300 (PI0303)	inches of water
P-200 Effluent Pressure (PI0200) (while pump is running)	pounds per square inch gauge (psig)

System operating data that are recorded automatically by the PLC and can be downloaded electronically on a weekly/monthly basis are summarized in Table 5.

Table 5: Monthly Automated Data Recordkeeping

Instrument/Parameter	Reading
Vacuum at each wellhead (PT0010 through PT0080)	in-Hg
Vacuum Following Manifold	feet
Pumping rate from P-200	gpm
Total volume pumped from P-200	gallons
Undiluted Vapor Flow Rate (FE0301)	SCFM
LEL entering Blower (AT304)	%LEL
Vapor flow from B-310 (FT0305)	SCFM
Vapor flow from B-320 (FT0306)	SCFM
Vapor Temperature (TE0305) Leaving Blower B-310	°F
Vapor Temperature (TE0306) Leaving Blower B-320	°F
Vapor Pressure (PT0305) Leaving Blower B-310	psig
Vapor Pressure (PT0306) Leaving Blower B-320	psig
Runtime of Blower B-310	Hours
Runtime of Blower B-310	Hours
Vapor Pressure (PT040) Entering Blower B-401	psig
Vapor Temperature Entering catalyst (TE0601A, TE0601B, TE0601C)	°F
Differential Pressure Across Catalyst	psig
Vapor Temperature Leaving Catalyst (TE0602A, TE0602B, TE0602C)	°F

2.3.3 Annual Inspections and Maintenance

The maintenance activities to be performed and documented on an annual basis are summarized in Table 6**.**

Table 6: Annual Maintenance Activities

Description of Activity	Action Performed	
	Yes	No
Check calibration of LEL Meters and liquid flow meter and recalibrate if required.	☐	☐
Replace oil in DPE Blowers (B-310 and B-320) every 20,000 operating hours of in accordance with manufacturers recommendations.	☐	☐
Remove and clean strainer in transfer pump discharge line.	☐	☐
Catalytic Combustion Annual Maintenance.	☐	☐
Lubricate motor bearings as recommended by the manufacturer (refer to O&M Manuals in Appendix B for additional maintenance details).	☐	☐

2.3.4 Inventory of Spare Parts

Effective maintenance depends on the availability of spare parts for all essential equipment. Inventories of spare parts will be kept in the CMR maintenance facility and revised as necessary to ensure the availability of spare parts at all times. A spare parts list is provided in Attachment D. The spare parts will be restocked when the inventory becomes diminished. All spare parts will be stored properly in the CMR maintenance facility to ensure quick access and safekeeping of the equipment.

3. DPE SYSTEM PERFORMANCE MONITORING

3.1 General

DPE system performance monitoring and sampling will be conducted to document system operation effectiveness. Most system operating data (flow, temperature, and pressure) will be recorded automatically by the system PLC while some system monitoring data (vapor concentrations) will be manually recorded as described below. The performance monitoring program includes monitoring of operations data (described in Section 2.3) and periodic vapor sampling to document contaminant mass recovery rates and emission levels for compliance with permitting requirements.

3.2 Contaminant Mass Recovery

Monitoring of contaminant mass removal over time will be the primary metric for optimizing DPE system performance and gauging the AOC-16 Interim Measure objective of free phase LNAPL mass recovery and LNAPL plume stabilization. Vapor/air extraction flow rates will be continuously monitored and recorded by the system PLC and influent vapor sampling will be periodically conducted in order to evaluate mass removal rates over time as discussed below.

3.2.1 Flow Rates

The vapor and liquid flow rates collected from the DPE system are continuously monitored by the DPE system instrumentation. The air flow rates are measured using a pitot tube/differential air flow sensor and the run time of the blowers are monitored via an hour meter. The following system flow rate will be used in order to calculate contaminant mass recovered:

- Undiluted soil vapor flow rate (Instrument Tag No. FE 0301)

Vapor flow rate data measured by FE 0301 will be averaged for calculating mass removal rates. Vapor sampling will be conducted on influent vapors as described in Section 3.2.2.

The cumulative liquid volume extracted and discharged for treatment via the WWTP is measured using a magnetic flow meter. Flow rate and flow volume totalizing data is recorded automatically by the PLC and stored for download and processing as described in Section 2.3. The following system flow rate data will be used in order to calculate the mass of contaminants recovered in the liquid phase:

- Liquid flow rate (Instrument Tag No. FE 0200)

Liquid effluent sampling will be conducted as described in Section 3.4 below to determine the concentration of contaminants recovered.

3.2.2 Influent Vapor Concentrations

The concentrations of VOCs in the vapor phase will be measured on each DPE influent line sampling port in the influent manifold and from sample port SP 301 on the inlet side of the blowers (pre-dilution) in order calculate contaminant mass removal rates over time.

Field measurements using a PID will be conducted on each DPE influent line at sample ports SP-1 through SP-8 to measure relative vapor concentrations from each DPE well. A vacuum pump or a vacuum air sampling box and Tedlar bags will be used to collect the samples to be analyzed for VOCs in the field. Following the collection of a influent samples, the sample will be field-analyzed for VOCs using a PID. Sampling will be conducted as described in standard operating procedure (SOP)-13 included in Attachment E. These measurements will be initially conducted daily for the first three days of operation and weekly for the following three weeks. The frequency and utility of individual wellhead vapor sampling will be conducted monthly thereafter.

Air samples will also be collected and submitted for laboratory analysis from SP-301 to calculate the cumulative mass removal rate over time. Air samples will be collected in 1-liter Summa canisters as described in SOP-13 and analyzed by an off-site laboratory for VOCs by United States Environmental Protection Agency (USEPA) Method TO-15. These samples will be initially collected daily for the first three days of operation and weekly for the following three weeks. After start-up, influent vapor samples for laboratory analysis will be conducted on a monthly basis.

The combination of vapor flow rates, blower runtime, and vapor VOC concentrations will be used to calculate the mass of contaminants removed over time.

When mass recovery rates from individual wells or the combined system reach diminishing returns (a.k.a. asymptotic levels), operational modifications will be considered. The individual wells with low recovery rates should be turned off and the wells with the highest VOC recovery rates should be continuously operated. Pulsing of the system in which individual or groups of wells are shut off will also be considered. Once the DPE system approaches asymptotic levels with full time operations, a request will be submitted to MDEQ describing modifications to discontinue extracting from individual or groups of DPE wells and/or to operate the system in a pulsed manner. Subsequently, once DPE system approaches asymptotic levels with modified / pulsed system operations, a request will be submitted to MDEQ to place the DPE system in standby mode.

3.3 Vapor Discharge Sampling

Air samples will also be collected and submitted for laboratory analysis from the discharge of the SRCO (SP-601) to monitor air treatment efficiency of the SRCO. Air samples will be collected in 1-liter Summa canisters as described in SOP-13 and analyzed by an off-site laboratory for VOCs by USEPA Method TO-15. These samples will be initially collected daily for the first three days of operation and weekly for the following three weeks. After start-up, effluent vapor samples for laboratory analysis will be conducted on a monthly basis or at a frequency specified in the air discharge permit.

3.4 Liquid Phase Effluent Sampling

During startup, an effluent sample will be collected and submitted for laboratory analysis of VOCs (USEPA SW-846 8260B) and semi-volatile organic compounds (SVOCs) (USEPA SW-846 8270D) from the discharge side of the transfer pump (P-200) at sample port SP200. Liquid phase effluent samples will be collected on a monthly basis and submitted for laboratory analysis for VOCs and SVOCs.

3.5 Monitoring Well Sampling

Monitoring well gauging at wells MW-22, MW-64, and MW-104 will be conducted on a monthly basis (Attachment A, Drawing C6). The depth to water and if observed, separate-phase hydrocarbon thickness measurements, will be recorded. Vacuum measurements at these wells (MW-22, MW-64, and MW-104) will also be conducted on a monthly basis.

3.6 Field Monitoring Schedule

The long-term performance monitoring schedule for the DPE System is summarized in Table 7.

Table 7: DPE System Field Monitoring Schedule

Monitoring Activity	Sampling Location	Monitoring Frequency	
		Start-Up (First Month)	Long-Term Monitoring Post Start-Up
Influent Vapor Monitoring with PID	Wells DPE-1 through DPE-8 at sampling ports SP-1 through SP-8	Daily for first three days followed by weekly for first month	Monthly
Influent Vapor Monitoring with laboratory analysis of TO-15	Influent at sample port SP301	Daily for first three days followed by weekly for first month	Monthly
Effluent Vapor Monitoring with laboratory analysis of TO-15	SRCO effluent at sample port SP601	Daily for first three days followed by weekly for first month	Monthly (or at a frequency specified in the air permit)
Liquid phase effluent sample with laboratory analysis of VOCs (USEPA Method 8260B) and SVOCs (USEPA Method 8270B)	SP200	Once during first month of startup	Monthly
LNAPL Thickness	MW-22, MW-64, and MW-104	Weekly for first month	Monthly

Monitoring Activity	Sampling Location	Monitoring Frequency	
		Start-Up (First Month)	Long-Term Monitoring Post Start-Up
Subsurface Vacuum	MW-22, MW-64, and MW-104	Weekly for first month	Monthly

4. PASSIVE TREATMENT TRENCH PERFORMANCE MONITORING

4.1 PTT System Description

The North River Road Area consists of two parallel trenches separated by approximately four feet of native material as shown on Drawing C10 in Attachment A. Both trenches are installed perpendicular to groundwater flow.

The upgradient LNAPL recovery trench is 5-feet wide by 10-feet deep by 50-feet long. The upgradient trench is backfilled with coarse sand intended to recover LNAPL prior to the PTT to limit LNAPL from entering the PTT and overrunning the sorption capacity of the activated carbon. During trench backfilling activities, 11 vertical 6-inch diameter, schedule 80, PVC LNAPL recovery wells were installed into the coarse sand to facilitate LNAPL collection and monitoring.

The downgradient PTT is 5-feet wide by 12.5-feet deep and 110-feet long. The PTT is installed to the top of the aquitard unit/the top of the moderately to strongly cemented very fine sand. The PTT is backfilled with a reactive media (Regenesis® product PetroFix™) incorporated into coarse sand (Attachment A, Drawing C13). Groundwater moves passively through the backfill material partitioning hydrocarbons and benzene, toluene, ethylbenzene and xylenes from the dissolved phase by adsorption to the activated carbon particles. The contaminants are then anaerobically biodegraded through chemical oxidation stimulated by the bio-stimulating electron acceptors.

4.2 Performance Monitoring

The primary goal of the PTT is to mitigate dissolved phase groundwater impacts from migrating towards the Missouri River. In 2019, the petroleum constituents of concern (COCs) detected at or above their respectiveDEQ-7 Human Health Standards (HHS) and/or Tier 1 Risk-Based Screening Levels (RBSLs) in AOC-16 included: VOCs (benzene, ethylbenzene, and toluene), SVOCs (2,4-dimethylphenol, 2-methylnaphthalene, and naphthalene) and volatile petroleum hydrocarbons (VPH) (benzene, ethylbenzene, naphthalene, toluene, aliphatic [C5-C8, C9-C12], and aromatic [C9-C10] hydrocarbon fractions (CMR, 2020). The Montana DEQ-7 numeric quality standards for Petroleum COCs are presented in Table 8.

Table 8: Numeric Water Quality Standards for Petroleum Constituents of Concern North River Road Area

Constituent of Concern	Montana DEQ-7 HHS (µg/L)	Tier 1 RBSLs (µg/L)
VOCs		
Benzene	5	5
Ethylbenzene	700	700

Constituent of Concern	Montana DEQ-7 HHS (µg/L)	Tier 1 RBSLs (µg/L)
Toluene	1000	1000
SVOCs		
2,4-Dimethylphenol	100	NV
2-Methylnaphthalene	NV	36
Naphthalene	100	100
MTDEQ VPH		
C5 – C8 Aliphatics	NV	650
C9 – C12 Aliphatics	NV	1400
C9 – C10 Aromatics	NV	1100

Notes:
DEQ-7 HHS = MQDEQ Human Health Standard
µg/L = micrograms per liter
MDEQ = Montana Department of Environmental Quality
NV = no value
SVOCs = semi-volatile organic compounds
Tier 1 RBSLs = MDEQ Tier 1 Risk-Based Screening Levels
VOCs = volatile organic compounds
VPH = Volatile Petroleum Hydrocarbons

Monitoring well MW-105 located approximately 30 feet downgradient of the PTT is the point of compliance well (Attachment A, Drawing C10).

4.2.1 Groundwater Sampling

Initially, quarterly groundwater sampling will be conducted at upgradient well MW-41S, PTT well MW-106, and compliance well MW-105 (Attachment A, Drawing C10). To confirm compliance with the remediation goals, these monitoring wells will be sampled quarterly for Petroleum COCs including:

- VOCs (USEPA Method SW8260D)
- SVOCs (USEPA Method SW 8270D)
- MDEQ VPH (Method MTDEQ VPH)

MW-106 (PTT well) and MW-105 (compliance well) will also be sampled semi-annually for additional parameters to assess the biodegradation dynamics of the COCs. The wells will be sampled for the following parameters:

- pH, dissolved oxygen and oxidation reduction potential (ORP) (field measured);
- Filtered and unfiltered total iron, total manganese, dissolved iron, and dissolved manganese (Colorimetric Hach Method or USEEPA Method 6000 Series);
- Sulfate and nitrate (USEPA Method 375.3/353.1 or USEPA Method 9056);
- Biological oxygen demand (USEPA Method 5210B);
- Alkalinity (USEPA 310.2); and

- Methane and Carbon Dioxide (American Society for Testing and Materials [ASTM] Method D1945).

4.2.2 LNAPL Trench Monitoring

The eleven LNAPL collection wells located in the LNAPL recovery trench (Attachment A, Drawing C10) will be gauged every week for the first three months of operation to determine if LNAPL has accumulated in the wells. If LNAPL is recorded in a well, an adsorbent sock will be placed in the well and LNAPL recovery via the adsorbent sock will be monitored on a weekly basis. If passive recovery using adsorbent socks is determined to be insufficient to address the quantity/volume of LNAPL present within the recovery trench, the well(s) will be outfitted with active pneumatic pumps. After three months of operation if LNAPL has not accumulated in the recovery wells, the LNAPL gauging frequency will be reduced to monthly.

4.3 Field Monitoring Schedule

The long-term performance monitoring schedule for the LNAPL Recovery Trench and is summarized in Table 9.

Table 9: LNAPL Recovery Trench and Passive Treatment Trench Field Monitoring Schedule

Monitoring Activity	Sampling Location	Monitoring Frequency
Gauging of LNAPL wells in LNAPL Recovery Trench	11 LNAPL Recovery Wells	Weekly for the first three months of operation Monthly if no LNAPL has accumulated after 3 months of operation
LNAPL Recovery Monitoring	LNAPL Recovery Well, if LNAPL accumulates in well	If LNAPL accumulates in a well, adsorbent sock to be monitored on a weekly basis
Groundwater sampling and analysis for petroleum COCs	MW-41S MW-105 MW-106	Quarterly for the first year following PTT installation. Frequency of sampling to be re-evaluated after Year 1.
Groundwater sampling and analysis for biodegradation dynamics of petroleum COCs	MW-105 MW-106	Semi-Annually for the first year following PTT installation. Frequency of sampling to be re-evaluated after Year 1.

As previously stated, the primary goal of the PTT is to mitigate the dissolved phase groundwater impacts from migrating from the Truck Rack to the Missouri River. Accordingly, the primary performance monitoring metric for the PTT will be the reduction is dissolved phase petroleum COCs from the upgradient side of the PTT to the downgradient side of the PTT. After collection and analysis of the first year PTT performance data, a recommendation will be submitted to MDEQ as to the frequency of subsequent PTT groundwater monitoring. The PTT groundwater monitoring program will be discontinued once the groundwater on the upgradient side of the PTT meets the MDEQ-7 Human Health Standards for groundwater.

5. SAMPLING AND ANALYSIS METHODS

5.1 General

The procedures discussed in this section describe the sample collection and documentation activities to ensure that samples are collected to be representative of site conditions, comparable to other samples collected for the same objective, and documented to be defensible and of known and documented quality.

5.2 Sampling Protocols

This section outlines the protocols to be used for the various sampling requirements throughout the duration of remediation activities. The types of sampling protocol covered in this section include the following:

- sample collection and chain-of-custody procedures;
- sample identification;
- field sampling methods;
- laboratory methods;
- sample handling and analysis; and
- quality assurance/quality control measures.

Sampling protocols will be consistent with existing CMR sampling methods and SOPs included as Attachment E.

5.2.1 Sample Collection and Chain-of-Custody Procedures

Sample chain-of-custody procedures are provided in SOP-002 (Attachment E). Sample custody will be maintained from the time and place of sample collection through report preparation. A chain-of-custody record is a record of each person who has had possession of the sample from collection through shipment and laboratory receipt. The chain-of-custody will be initiated in the field and will be maintained until received at the laboratory.

5.2.2 Sample Identification

Sample identification will be consistent with existing CMR sample identification procedures. The format to designate collected samples for analytical analysis will consist of an alphanumeric describer that will identify the site name, sample type, sample location, and sample collection date using the following convention:

- The first three identifiers in the sample name will consist of a three-letter acronym for the study site. In this case, the three-letter acronym for the Calumet Montana Refinery is "CMR."
- Following the site name portion of the sample ID will be a dash and one of the following modifier designating the type of sample:
  - System Sample Influent – IN-SP: Used to designate an influent vapor sample collected at a sample port of the DPE system
  - System Sample Effluent – EF-SP: Used to designate an effluent vapor sample collected at a sample port of the DPE system
  - Monitoring Well (permanent) – MW

- Trip Blank – TB

- Following the sample location code will be a three to five-digit indicating a unique location for that type of sample. For vapor sampling from the DPE system, the numeric designation will be the sample port tag numbers included on the piping and instrumentation diagram (i.e. 07 or 301).
- For aqueous media (i.e., groundwater, surface water, quality assurance/quality control (QA/QC) samples), and soil vapor sampling (i.e., influent or effluent vapor samples), the location code will be followed by a six-digit numeric code indicating the date the sample was collected (yy/mm/dd).

Field duplicates will be labeled as ordinary field samples with a unique identification number.

Duplicate samples should not be identifiable by sample ID alone so as to reduce the potential for bias and allow the laboratory to analyze them as "blind" quality control samples. Thus, in the event that multiple samples are collected on the same day from the same location (i.e., a duplicate sample), the designation "DS" (duplicate sample) will be used in place of the parent sample's sample type code and a sequential numeric designation will be assigned in place of the numeric location code. This sequential numeric designation will be "01" for the first duplicate sample collected that day, "02" for the second duplicate sample collected that day (from another sample location, media, etc.), and so on.

Subsequent duplicate samples collected on multi-day sampling events should be numbered sequentially (e.g., - "03" from the previous day's sampling). Since obvious links between the parent and duplicate samples in the Sample ID are to be avoided, it is very important to document in the field logbook or field notes which sample is the parent sample to each duplicate.

Following are some sample name examples:

- A groundwater sample collected from permanent monitoring well location MW-41S at CMR on March 22, 2020 would be designated as "CMR-MW41S-200322."
- A system vapor sample collected from influent sample port SP301 at CMR on March 22, 2020 would be designated as CMR-IN-SP301-200322.
- A duplicate of the groundwater sample collected from permanent monitoring well location MW-41S at CMR on March 22, 2020 (see example above), which is the second duplicate sample collected that day, would be designated as "CMR-DS02-200322". Document in the field logbook or field notes which sample is the parent sample to each duplicate.

5.2.3 Field Sampling Methods

5.2.3.1 Monitoring Well Gauging

Monitoring well gauging and sampling activities for all monitoring wells at the Site will be conducted following the SOP-004 Water Level and Product Level Measurements (Attachment E). Sampling personnel will record depth to groundwater measurements prior to initiating purging and sampling activities. If observed, separate-phase hydrocarbon thickness measurements will be collected. The total depth of each well will be measured if LNAPL is not present. If an observable thickness of LNAPL is observed in a monitoring well (i.e., the product level interface probe indicates the presence of LNAPL), groundwater sampling will not be conducted during the monitoring event. Groundwater levels will be measured to the nearest 0.01-foot depth.

5.2.3.2 Groundwater Sampling

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry.

This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing. Well sampling will follow SOP-004 Water Level and Product Level Measurements, SOP-010 Equipment Decontamination. SOP-011 Water Quality Parameter Calibration, and MDEQ Groundwater Sampling Guidance DEQ-WMRD-GWM-1 (Attachment E). Monitoring well groundwater purging and sample collection will be performed in accordance with Montana DEQ-WMRD-GWM-1 Groundwater Sampling Guidance procedures using a peristatic pump and low-flow sampling methods. Groundwater samples will not be collected from monitoring wells where LNAPL is observed during the monitoring well gauging event.

During low flow purging activities, the pH, temperature, specific conductance, DO, ORP and turbidity will be used as stabilization parameters. The stabilization of a well will be determined based on three consecutive readings with the following limits:

- pH (± 0.1 units);
- Specific conductance (±3%);
- Dissolved Oxygen (DO) (±10% or <0.5 milligram per liter [mg/L]);
- Oxidation-Reduction Potential (ORP) (±10 millivolt [mV]); and
- Turbidity (±10% for values greater than 5 Nephelometric Turbidity Units).

Stabilization readings and visual observations will be recorded on the sampling field form at an interval of approximately 3 to 5 minutes. Description of the water quality (e.g. turbidity, odor) will be recorded during the purging process. If there is limited amount of water available, then collection of the laboratory sample will take priority over the field parameters. If a monitoring well is purged dry prior to stabilization of parameters, a grab sample will be collected after the well has recharged.

Monitoring well groundwater samples will be collected from monitoring wells in the following order:

1. VOCs
2. VPH
3. SVOCs
4. Unfiltered Metals
5. Filtered Metals
6. Other Constituents

5.2.3.3 Vapor Sampling

Air samples from individual wells for field analysis via a PID will be collected into Tedlar bags using vacuum air sampling box following SOP-13 (Attachment E). Air samples collected from the DPE influent and effluent for laboratory analysis will be collected into pre-cleaned, batch certified 1-liter stainless steel laboratory-provided SUMMA® canisters from sample ports installed at the designated locations in the process piping system. Collected samples will be labeled and shipped at ambient temperature under chain-of-custody procedures to the analytical laboratory.

5.2.3.4 Field Notes and Record Keeping

Field notes associated with the monitoring activities will be recorded in the project field book and/or field forms as prescribed in SOP-001 (Attachment E).

5.2.4 Laboratory Methods

Table 10 summarizes the chemical analyses that will be completed on samples during the investigation including both field and laboratory methods. Laboratory analytical methods have been selected based on commercially available USEPA-approved methods.

Table 10: Laboratory Analytical Methods

Parameter	Analytical Method	Sample Matrix
Laboratory Methods		
VOCs	USEPA SW-846 8260B	Water
	USEPA TO-15	Air
SVOCs	USEPA SW-846 8270D	Water
VPH/Extractable Petroleum Hydrocarbons (EPH)	MT VPH/EPH	Water
Filtered and unfiltered total iron, total manganese, dissolved iron, and dissolved manganese	Colorimetric Hach Method or USEPA Method 6000 Series	Water
Sulfate and Nitrate	USEPA Method 375.3/353.1 or USEPA Method 9056	Water
Biological oxygen demand	USEPA Method 5210B	Water
Alkalinity	USEPA 310.2	Water
Methane and Carbon Dioxide	ASTM Method D1945	Water
Field Methods		
pH, Dissolved Oxygen, Turbidity, Total Dissolved Solids, Oxidation/Reduction Potential	Groundwater Flow Through Cell and Multimeter	Water
Total ambient VOCs	Photoionization Detector	Water
		Soil

Notes:
ASTM: American Society of Testing and Materials
MT: Montana
USEPA: United States Environmental Protection Agency

5.2.5 Sampling Handling and Analysis

Samples will be stored in coolers on ice after sampling and maintained at approximately 4 degrees Celsius. Samples will be accompanied by properly completed chain-of-custody forms. The sample

numbers will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.

Samples for off-site laboratory analysis will be packaged for shipment and shipped to the appropriate laboratory for analysis, with a separate signed custody record secured to the inside top of each sample cooler. Shipping containers will be secured with strapping tape for shipment to the laboratory. The cooler will be strapped shut with strapping tape in at least two locations.

A COC record identifying the contents will accompany all shipments. The original record will accompany the shipment, and the sampler will retain a copy of the record for return to the sampling office.

Air bills or bills of lading will be used when samples are sent by commercial carrier (e.g., FedEx, UPS, Airborne Express, or Express Mail). Receipts of air bills or bills of lading will be retained as part of the project documentation file. If samples are shipped by commercial carrier, the custody forms will be sealed inside the sample cooler and coolers will be sealed; commercial carriers are not required to sign off on the custody form.

5.2.6 Quality Assurance/Quality Control

Quality control samples will be collected during the performance monitoring. Quality control samples will consist of the preparation of field duplicates, trip and equipment blanks.

- Field Duplicates – 1 duplicate per 20 analytical samples (air and water).
- Matrix Spike/Matrix Spike Duplicates (MS/MSD) – 1 MS/MSD per 20 analytical samples (water only).
- Equipment Blanks – 1 equipment blank per 20 analytical samples for which non-dedicated equipment is used in the collection (water only).
- Trip Blanks – 1 trip blank per shipping container containing VOC samples (water only).

6. REPORTING REQUIREMENTS

6.1 Record Keeping

Documentation of monitoring and operations will be maintained including:

- Monitoring and Maintenance Checklists
- Operations Data Downloads
- Laboratory Records
- Maintenance Records
- Quarterly Progress Reports

Site Inspection/Monitoring logs will be maintained for the Site (see Attachment B). The operator will record each visit and a brief description of site activities performed, such as system adjustments or maintenance. Information in these logs will be used to prepare the Quarterly Progress Reports. In

addition, parameters that are continuously monitored and recorded by the PLC will be downloaded and maintained as described in Section 2.3.

Groundwater concentration data and vapor concentration data will be managed in the site database and laboratory analytical reports from each sampling event will be maintained in site records.

Maintenance records will be kept for the Site and will include the date the maintenance was performed and who performed the maintenance.

6.2 Quarterly Monitoring Reports

Ramboll will prepare Quarterly Monitoring Reports and submit the Quarterly Monitoring Report to CMR for review and subsequent submission to the MDEQ. The quarterly report will include a summary of the sampling activities that were completed for the DPE and PTT performance evaluation and will include at a minimum the following information:

- Operational data including flow rates and system runtime for the DPE system.
- Identification of operational problems, the length of any shutdowns, and a summary of actions taken to rectify or prevent these problems.
- Influent vapor and liquid sampling results and estimated contaminant mass removal rates for the DPE system.
- Fluid levels including LNAPL thickness measurements in the LNAPL recovery trench upgradient of the PTT.
- LNAPL recovery rates in the LNAPL recovery trench.
- Groundwater concentrations of COCs and terminal electron acceptors in the PTT point of compliance well and PTT well.

ATTACHMENT A

RECORD DRAWINGS

(To be provided by upon delivery of equipment and included in the final version of the OM&M Plan prior to startup; in-text references refer to design drawings included in Appendix A of the 100% Design Report)

ATTACHMENT B

OM&M FIELD LOG SHEETS

ALARM CONDITION LOG SHEET

Operator: _____

Date: _____

Alarm Condition	Date	Time	Responding Operator	Corrective Action or Repairs

EQUIPMENT PREVENTATIVE MAINTENANCE RECORD

Equipment Description: _____

Preventative Maintenance done by: _____

Item	Work Performed	Reference	Frequency

RAMBOLL

EQUIPMENT INSPECTION AND SERVICE COMPLETION RECORD

Operator: _________________________

Date: _____________________________

Service Record		
Date	**Work Done**	**Signed**

RAMBOLL

MAINTENANCE REPORT

Report Data: _____

Maintenance Type: _____

Work Order No.: _____

Work Order Date: _____

_____

Date Repair Started	Date Repair Completed	Component Repaired	Parts and Materials	Labor Hours	Labor Category

Remarks/Resolutions: _____

_____

_____

Name: _____

Signature: _____

MONTHLY MAINTENANCE LOG

Operator: _____
Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Maintain good housekeeping practices and keep interior of building and equipment clean and free from dust buildup			
Check for any leaks or sediment in the VLS by inspecting fluid level in sight glass. Schedule sediment removal if required.			
Check if well vaults are locked and in good condition			
Check inlet blower filter differential pressure. Replace filter if necessary.			
Inspect the DPE motor and mounting brackets to ensure that the bolted connections are secure.			
While in DPE blower motors are in operation, observe the motor for abnormal noises, vibrations, excessive heating. While DPE motors are not in operation, check for signs of uneven or excessive wear (i.e. cracked or loose drive belts), misalignment issues, and damaged parts			
Check blower cooling air inlets and outlets to confirm they are not covered or obstructed and that the cooling air flow is not blocked			
Check the oil level in each blower			

WEEKLY / MONTHLY FIELD DATA LOG

Operator: _____

Date: _____

Description of Activity	Reading		Comments
		units	
Differential pressure reading on Filter F-300 (PI0303)		inches of water	
P-200 Effluent Pressure (PI0200)		psig	
Depth to Product at MW-22		ft-bgs	
Depth to Water at MW-22		ft-bgs	
Depth to Product at MW-64		ft-bgs	
Depth to Water at MW-64		ft-bgs	
Depth to Product at MW-104		ft-bgs	
Depth to Water at MW-104		ft-bgs	

VALVE OPERATION RECORD

Date	Valves Operated	Signed

ANNUAL MAINTENANCE LOG

Operator: _____

Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Check calibration of LEL Meters and liquid flow meter and recalibrate if required			
Replace oil in DPE Blowers (B-310 and B-320) every 20,000 operating hours of in accordance with manufacturers recommendations			
Remove and clean strainer in transfer pump discharge line			
Catalytic Combustion Annual Maintenance			
Lubricate motor bearings as recommended by the manufacturer (refer to O&M Manuals in Appendix B for additional maintenance details)			

DPE System Sampling Form

Operator: _____

Date: _____

Instantaneous Flow Rate (SCFM) (FI0301): _____

Date	Time	Location	Sample Port	Vacuum Gauge	Vacuum (inHg)	Valve Position (% Open)	PID (ppm)	Lab Sample ID	Comments
		DPE-1	SP1	PI0010					
		DPE-2	SP2	PI0020					
		DPE-3	SP3	PI0030					
		DPE-4	SP4	PI0040					
		DPE-5	SP5	PI0050					
		DPE-6	SP6	PI0060					
		DPE-7	SP7	PI0070					
		DPE-8	SP8	PI0080					
		Influent Header	SP301	PI301		N/A			
		SRCO Effluent	SP601	N/A	N/A	N/A			Instaneous Flow Rate at FI0301 (SCFM):
		Liquid-Phase Effluent	SP200	PI200		N/A	N/A		

RAMBOLL

ATTACHMENT C

OPERATION AND MAINTENANCE MANUALS

(To be provided by upon delivery of equipment and included in the final version of the OM&M Plan prior to startup)

ATTACHMENT D

SPARE PARTS LIST

AOC-16 Dual-Phase Extraction System Spare Parts List

Part	Quantity	Cost
Oil for Blower	4 quarts	$ 52.00
Inline Filter	1 EA	$ 132.00
Dilution Line Filter	1 EA	$ 86.00
Internal Demister Pad	1 EA	$ 284.00
Progressive Cavity Pump Head Kit	1 EA	$ 918.00
Misc. Components and Fuses for Control Panel	1 EA	$ 345.00

ATTACHMENT E

FIELD STANDARD OPERATING PROCEDURES

FIELD GUIDANCE DOCUMENT NO. 6.16

GROUNDWATER SAMPLING – FREE PRODUCT / NAPL

RAMBOLL

FIELD GUIDANCE DOCUMENT NO. 6.16

GROUNDWATER SAMPLING – FREE PRODUCT/NAPL

Prepared By:	Amy Caron
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Approved By:	J. Mark Nielsen
Applicable To:	All North American offices
Effective Date:	May 23, 2016
Revision Notes:	1. Updated Formatting
Documents Used as Reference During Preparation:	Boulding, J. Russell, 1996. EPA Environmental Assessment Sourcebook. Chelsea, Michigan: Ann Arbor Press. Cohen, Robert M., James W. Mercer, and John Matthews, 1993. DNAPL Site Evaluation. Geotrans, Inc. and United States Environmental Protection Agency (USEPA). Collins, Mark, Wray R. Rohrman, and K. David Drake, 1992. Monitoring Well Design and Sampling Techniques at DNAPL Sites. Proceedings from the Sixth National Outdoor Action Conference. National Groundwater Association. General Motors Corporation, 2001. Field Method Guideline FMG 6.5 Non-Aqueous Phase Liquid (NAPL). Newell, Charles. J, Steven D. Acree, Randall R. Ross, and Scott G. Huling, 1995. Light Nonaqueous Phase Liquids. USEPA Groundwater Issue. New Jersey Department of Environmental Protection, 2005. Field Sampling Procedures Manual. USEPA, 1992. RCRA Groundwater Monitoring, Draft Technical Guidance. Office of Solid Waste. USEPA, 1994. DNAPL Site Characterization. Office of Emergency and Remedial Response/Office of Research and Development. USEPA, 2004. Field Guidance Document #1220, Groundwater Well Sampling. USEPA Region 9 Laboratory, Richmond, Virginia.

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1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines established by Ramboll for sampling of free product or non-aqueous phase liquids (NAPLs). NAPLs are defined as hydrocarbons that exist as a separate, immiscible phase when in contact with water and/or air. Differences in the physical and chemical properties of water and NAPL result in the formation of a physical interface between the liquids which prevents the two fluids from mixing (USEPA, 1995). NAPLs which have densities less than that of water are classified as light non-aqueous phase liquids (LNAPLs), whereas NAPLs with densities greater than that of water are classified as dense non-aqueous phase liquids (DNAPLs). Petroleum products are the most common LNAPLs to contaminate groundwater; examples of DNAPLs include chlorinated solvents, coal tar wastes, creosote-based wood treating oils, and some pesticides (USEPA, 1994). NAPL can be sampled for gas chromatography fingerprinting to determine the type of product(s) it consists of and its possible source. NAPL can also be sampled to define its physical and/or chemical properties, which could be used in support of remedial designs, establish the presence of multiple sources or define the age a release. Although this FGD provides guidelines for collection of NAPL samples associated with typical field activities and projects, it should be understood that for certain projects more specific sampling procedures, including state-specific or regulatory program-specific guidelines, requirements or procedures, may be applicable. Specific requirements for these types of projects and activities will be reviewed by the Ramboll Principal-in-Charge / Project Director (PIC) and Project Manager (PM) and any additional requirements will be defined in project-specific Work Plans, sampling plans and/or FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans but rather a general reference for developing project specific requirements.

It should be noted that this FGD does not supersede Ramboll Health and Safety procedures or site-specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. All Ramboll employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP followed by approved site-specific procedures which may include those in this FGD. The Ramboll PIC and PM shall ensure that all project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information are maintained in the project file and available to all site personnel for the duration of the project. The signatures of the PIC and PM indicate approval of the methods and precautions outlined in the HASP.

2. EQUIPMENT/MATERIALS

A general checklist of equipment that may be required for typical NAPL sampling efforts is provided below. This checklist includes an overall summary of general equipment typically required for NAPL sampling and should not be considered exhaustive. More specialized sampling equipment may be required depending on project specific needs (refer to **Section 4.3** of this FGD). Additional equipment may be specified in the project-specific HASP.

1. General NAPL Sampling Equipment Checklist:
   - Electronic interface probe (refer to **FGD 6.04**, Groundwater and Free Product Level Measurements).
   - Peristaltic pump with power source (e.g. portable battery).
   - Disposable or Inertia pump (e.g. Waterra pump®).
   - Disposable Teflon and flexible tubing, as needed.
   - Disposable bailers and dedicated nylon line or tether.
     - LNAPL – Use a double check-valve bailer, or a top-filling bailer if the thickness of NAPL is too small to collect a sample with a double check-valve bailer.
     - DNAPL – Use a double check-valve bailer or bottom check-valve bailer.
   - Sample containers (appropriate for various analysis to be performed).
   - Sample labels.
   - Cooler(s) with ice.
   - Decontamination equipment (refer to **FGD 14.02**, Equipment Decontamination).
   - Trash Bags - used to dispose of gloves and any other non-hazardous waste generated during NAPL sampling (refer to **FGD 15.01**, Waste Handling).
   - 55-gallon steel drums or other appropriate waste containers - used to dispose of any Investigation Derived Wastes (IDW) including NAPL, groundwater, and/or decontamination wastes (refer to **FGD 15.01**, Waste Handling).
   - Plastic sheeting.
   - Well keys.
   - Personal Protective Equipment (PPE) and field screening equipment in accordance with the site-specific HASP, including sterile gloves which must always be worn when handling and utilizing sample equipment.
   - Site information (maps, contact numbers, previous field logs, etc.).
   - Well construction specifications, and diagrams.
   - Field notebook or daily field logs and all-weather or permanent pens as outlined in **FGD 1.01** (Field Notes and Records).
   - Labels for Investigation Derived Waste (IDW) containers as outlined in **FGD 15.01** (Waste Handling).
2. Miscellaneous Additional Suggested Equipment:
   - Extra vehicle keys.
   - Credit card for gas and emergencies.
   - Road and site maps.
   - Camera and extra batteries.
   - Mobile phone.

3. REFERENCED GUIDANCE DOCUMENTS

The following FGDs are related to this FGD and should be reviewed prior to mobilization, as needed:

- **FGD 1.01**, Field Notes and Records.
- **FGD 1.02**, Sample Handling, Shipping and Chain of Custody.
- **FGD 1.03**, Data Management.
- **FGD 1.05**, Field Quality Control Samples.
- **FGD 4.06**, Equipment Calibration.
- **FGD 6.04**, Groundwater and Free Product Level Measurements.
- **FGD 14.01**, Sampling Equipment Decontamination.
- **FGD 15.01**, Waste Handling.

The list above is not intended to be all inclusive. Other FGDs and Standard Practice Instruction (SPI) may need to be referenced based on the specific requirements of the site-specific Work Plan/Sampling Plan (e.g., field screening FGDs, FGDs for sampling of other media, etc.).

4. PROCEDURES

4.1 Planning Considerations

All significant sampling strategy decisions will be approved by the PIC and/or PM before the initiation of associated field activities. The Work Plan/Sampling Plan will be designed for the collection of quality data that will best answer the questions and meet the goals or objectives of the study/monitoring program and will include the number of samples, locations, depths, number of sampling sites, and analyses to be performed on each sample. The Work Plan/Sampling Plan will generally provide some discretion in the field depending on encountered conditions; however, any significant departure from prescribed sampling activities, such as unexpectedly encountering NAPL at a site (e.g. during routine groundwater monitoring), should be discussed with and approved by the PIC and/or PM.

When planning a NAPL sampling event, the following should be considered:

- Common NAPL sampling techniques include the use of disposable bailers, pumps with disposable tubing, or single-use or inertia pumps.
- Sampling techniques should be carefully chosen based on the type of NAPL and its expected depth in the water column. For example, peristaltic pumps can be used for collecting NAPL samples in shallow wells (depth to water of less than approximately 25 feet below top of casing) while inertia pumps are suitable for collecting NAPL samples in deeper wells (up to approximately 300 feet deep).
- Depending on the NAPL sampling method chosen, some states require that only personnel licensed in the State where the work is being performed perform the sampling.

4.2 Pre-Field Work Preparation Guidelines

Before initiating field activities, field staff should review and complete pertinent tasks identified in **FGD 2.02**, Site Preparation, Inspection and Housekeeping. Further, to the extent that non-dedicated sampling equipment is to be used (e.g., water level indicator), to minimize potential cross-contamination of samples among wells, such sampling equipment should be decontaminated between wells as described in **FGD 14.01** (Sampling Equipment Decontamination), project-specific Work Plan/Sampling Plan and/or QAPP. Used dedicated sampling equipment should be considered IDW and should be managed in accordance with **FGD 15.01**, Waste Handling, following the sampling event.

At a minimum, the following tasks should be completed to prepare field staff for what may be expected during implementation of the work:

- Review and sign the a site-specific HASP;
- Coordinate and obtain permission for site access;
- Review project-specific Work Plan/Sampling Plan, where applicable;
- Review project-specific Quality Assurance Project Plan (QAPP), where applicable;
- Review and discuss with the PIC and/or PM the proposed Work Plan/Sampling Plan; and
- Ensure that all equipment/materials required to complete the work have been packed prior to mobilization.

In addition, prior to initiating the NAPL sampling activities, Ramboll oversight personnel should field verify the well identity and construction against available documentation (Site Plans, Well Construction Logs, etc.). It is imperative that a positive well identification be made prior to sampling using well labels, Site Plans, and well construction records to ensure that the correct well is sampled. Further, prior to the commencement of the field effort, Ramboll oversight personnel should inspect, test, and/or calibrate equipment that may be used to take field measurements (refer to **FGD 4.06**, Equipment Calibration). Pre-labeling sample containers in advance of field efforts may increase productivity (refer to **FGD 1.02**, Sample Handling, Shipping and Chain of Custody).

4.3 NAPL Sampling Guidelines

Sampling of the NAPL should be performed cautiously, using the proper equipment and following decontamination procedures outlined in **FGD 14.01**, Sampling Equipment Decontamination. The following provides a recommended list of practices for NAPL sampling activities:

- After removing the well lid and inner casing cap (or water-tight locking cap on the well casing in the case of a flush mounted well), use the field screening equipment as required by the Work Plan/Sampling Plan (refer to field screening FGDs) to measure volatile or explosive gas concentrations in the well. Continue to monitor gas concentrations during NAPL sampling. Record all field screening measurements in the field notebook or field logs in accordance with **FGD 1.01**, Field Notes and Records.

- Prior to sampling, polyethylene plastic sheeting should be deployed around the well casing to contain accidental releases of NAPL during sampling. All equipment that comes in contact with NAPL should be staged on the plastic sheeting.
- Measure and record in the field notebook or field log the depth to water, depth to NAPL, and NAPL thickness using an interface probe (refer to **FGD 6.04**, Groundwater and Free Product Level Measurements). When measuring NAPL and water levels, avoid advancing the equipment past the LNAPL/water interface to the extent practicable, particularly if groundwater sampling is to be performed after NAPL has been purged or removed.
- Define the NAPL sampling target depth. When collecting the sample, the following should be considered:
  - In wells with LNAPL, the surface of the NAPL should be skimmed with the sampling equipment (i.e., bailer, peristaltic pump tubing or inertia pump) taking care not to advance the equipment past the LNAPL/water interface, as determined by the interface probe.
  - If the LNAPL in the well is less than approximately 2 inches thick, a dual-phase water-LNAPL sample can be collected using a top-filling bailer or peristaltic pump. If such sample is collected, the sample should be labeled as two-phase and instructions provided to the laboratory to analyze the non-aqueous part of the sample (USEPA 1992). Do not use an inertia pump to collect LNAPL samples when the thickness is less than approximately 6 inches.
- When collecting DNAPL samples, the sampling equipment (i.e., bailer, peristaltic pump tubing or inertia pump) should be carefully and slowly lowered to the bottom of the well. If using a bailer to sample NAPL,
  - Measure the bailer nylon line or tether so that it may be lowered in the well to a pre-specified depth based on prior measurements. The measurements should account for a few feet of additional tether at the top of the well to allow recovery of the bailer. Tie the tether to the eye hook at the top of the bailer in a manner that will not allow the bailer to slip from the tether.
  - Carefully and slowly lower the bailer to the target depth (top of water column for LNAPL, bottom of water column for DNAPL) while maintaining tension on the tether.
  - To retrieve the bailer, pull on the tether slowly ensuring that the line falls on the polyethylene plastic sheeting.
  - Holding the bailer upright, insert the manufacturer supplied pour spout into bottom of the bailer to allow the NAPL sample to flow into the appropriate laboratory-supplied sample containers. Pouring should be conducted over a Department of Transportation-rated 55-gallon drum or the polyethylene plastic sheeting to minimize NAPL spills to the ground.
- If using a peristaltic pump to sample NAPL,
  - Measure the disposable dedicated tubing so that it may be lowered in the well to a pre-specified depth based on prior measurements. The measurements should account for a few feet of additional of tubing “tail” that arcs over approximately 180 degrees from the wellhead to allow connection to the pump.

  - Connect the pump to the power source in accordance with the pump manufacturer recommendations.
  - Attach the disposable dedicated tubing to the pump and carefully and slowly lower the tubing into the well to the target depth (top of water column for LNAPL, bottom of water column for DNAPL).
  - Keep the pump running until the NAPL is pumped to the surface and can be collected into the appropriate laboratory-supplied sample containers. Pumping should be conducted over a Department of Transportation-rated 55-gallon drum or the polyethylene plastic sheeting to minimize NAPL spills to the ground.

- If using an inertia pump to sample NAPL,
  - Measure the disposable dedicated tubing so that it may be lowered in the well to a pre-specified depth based on prior measurements. The measurements should account for a few feet of additional tubing “tail” that arcs over approximately 180 degrees from the wellhead that will be required to collect the NAPL sample.
  - Assemble the dedicated inertia pump (i.e., tubing and one-way foot valve) in accordance with pump manufacturer recommendations and carefully and slowly lower the tubing into well to the target depth (top of water column for LNAPL, bottom of water column for DNAPL). The one way valve will allow the sample into the tubing.
  - Manually operate the pump in accordance with manufacturer recommendations. Operation begins with a rapid upstroke, which closes the foot valve and lifts the sample column inside the tubing a distance equal to the pumping stroke. At the end of the upstroke, the sample column continues to rise due to its momentum and more sample column is drawn into the tubing. During the subsequent downstroke, sample will continue to flow into the tubing. The upstroke/downstroke process is repeated until the NAPL is pumped to the surface in pulses and can be placed into the appropriate laboratory-supplied sample containers.
  - Care should be taken to minimize the downstroke length or the amount of pumping force applied to minimize/avoid disturbing the NAPL/groundwater interface, to the extent possible.
- Following NAPL sample collection in each well, if required in the project-specific Work Plan or sampling plan, collect groundwater samples in accordance with the pertinent groundwater sampling FGD after all NAPL has been purged or otherwise removed.
- Upon completion of sampling activities in each well, dispose of the dedicated sample collection equipment (e.g., bailer, tether, tubing and/or inertia pump) and other IDW in an appropriate waste container (refer to **FGD 15.01**, Waste Handling), and decontaminate all non-dedicated sampling equipment (e.g., water level indicator) as described in **FGD 14.01** (Sampling Equipment Decontamination), project-specific Work Plan/Sampling Plan and/or QAPP.

4.4 Sample Containers

As outlined in **FGD 1.02** (Sample Handling, Shipping and Chain of Custody), equipment and sample containers that will come into contact with collected NAPL should be constructed of materials that will not affect the concentration of constituents in the sample.

The laboratory will provide appropriate sample containers that fulfill volume requirements to perform necessary testing and achieve data quality objectives. The sampling containers and sample volume is a function of the analytical requirements and will be specified in the Work Plan/sampling plan or QAPP.

4.5 Sample Transport and Storage

Samples shall be handled, transported and stored to maintain structural and chemical qualities of NAPL samples. Sampling jars shall be handled as outlined in **FGD 1.02** (Sample Handling, Shipping and Chain of Custody). All samples should be kept in an ice-filled transport container during fieldwork and covered to limit light penetration. If the cooler size allows for space between sample bottles, bubble wrap should be used to fill annular space and prevent breakage during travel. Glass bottle ware should be wrapped individually in bubble wrap for further protection. If provided, pack glass sample vials in laboratory-issue foam packing cartons.

4.6 QA/QC

Quality Assurance/Quality Control (QA/QC) procedures described in the project-specific Work Plan/Sampling Plan and/or QAPP must be followed throughout the sample collection, processing, handling, and analysis process. In their absence, the QA/QC guidelines of **FGD 1.05** (Field Quality Control Samples) should be reviewed.

5. PRECAUTIONS

Certain precautions should be taken to ensure safety while sampling NAPL. Additionally, implementation of the work may face some difficulties and may require compliance with state-specific or regulatory program-specific requirements. In all cases, field activities require recording sufficiently detailed information throughout the implementation of field work.

- It is important to always remain alert and aware of your surroundings. NAPL sampling is subject to hazards posed by heavy equipment, vehicle traffic, industrial machinery, hazardous chemicals and contaminants, and other physical, mechanical, and chemical hazards.
- Prior to mobilization, determine the location of wells and evaluate the need for security, barricading, and/or traffic control (e.g., when wells are located on the right of way).
- At sites with certain contaminants and/or subsurface conditions, potentially toxic and/or explosive gases may accumulate at and around the well as it is being developed. Stay upwind whenever possible and ensure that air monitoring is conducted and personal protective equipment is used in accordance in the site-specific HASP.
- Keep any hoses or suspension lines untangled.

- When working out of sight of the general public or site employees are in potentially hazardous areas (e.g., wooded habitats), all field staff should utilize the "buddy system" and should ensure that the project-specific HASP includes safety measures and procedures.
- For some wells, well keys may not work with rusted/outdated well locks. Bolt cutters may be used to remove the lock, which should be replaced upon completion of well sampling. Do not use petroleum based solvent sprays to free seized locks as it may impact water quality in the well.
- Wells with a water-tight cap may experience a buildup of pressure. Keep your face and body away from the top of the well when loosening or removing the cap.
- Purging activities should not be performed prior to NAPL sample collection so that an undisturbed sample of the NAPL can be collected;
- Groundwater sampling and chemical analysis should not be performed if NAPL is present unless required in the project-specific Work Plan or sampling plan;
- If the work plan/sampling plan requires volatile organic or metals analysis (or other analysis requiring field preservation), be sure to avoid direct contact with laboratory provided preservative chemicals.
- Peristaltic sampling pumps should not come into contact with the NAPL;
- Water quality measurements should not be made prior to sampling NAPL; and
- Special care should be taken with labeling as some NAPLs could have a deleterious effect on either pre-printed labels or handwritten labels. If practical, labeling following sample containerization may aid in preventing the smearing or smudging of labels by aggressive liquids.

6. RECORDKEEPING

Document all sampling locations in accordance with **FGD 1.04** (Documenting Sampling Locations) and record all information in accordance with **FGD 1.01** (Field Notes and Records) and **FGD 1.03** (Data Management).

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Groundwater Sampling Guidance

Montana Department of Environmental Quality

Contaminated Site Cleanup Bureau

DEQ MONTANA	Department of Environmental Quality Waste Management and Remediation Division **Guidance Document**	Number:	**DEQ-WMRD-GWM-1**
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GROUNDWATER SAMPLING GUIDANCE

Purpose:	The purpose of this document is to provide consistent guidance to individuals or entities that complete groundwater monitoring as part of corrective action overseen by the Contaminated Site Cleanup Bureau.
Scope:	This guidance applies to all groundwater actions taken for Contaminated Site Cleanup Bureau regulated projects.

Revision Date	Revision Description

Executive Summary

The Montana Department of Environmental Quality prepared this guidance to assist responsible parties, environmental professionals, and DEQ technical staff in performing appropriate groundwater sampling activities, including low flow sampling. DEQ uses analytical data in its decision-making processes. The purpose of this document is to ensure consistent collection of groundwater samples that accurately represent site conditions.

Low-flow sampling is the Contaminated Site Cleanup Bureau's preferred sampling methodology for groundwater. However, situations exist where low-flow sampling is either not possible or impractical. This guidance identifies those situations. As with any cleanup decision, DEQ recommends that the responsible party or its representative communicate regularly and openly with the DEQ-assigned project manager.

This guidance document is organized into the following sections:

Section 1.0 Preparing for Sampling Events: This section gives an overview of how to prepare for a sampling event, including required background information, equipment lists, and Sampling and Analysis Plan/Health and Safety Plan preparation.

Section 2.0 Standard Sampling Procedures: This section describes standard sampling procedures that apply to all sampling events, regardless of pump type/purge method.

Section 3.0 Low-Flow Sampling: This section describes additional sampling procedures specific to low-flow methods. This is DEQ's preferred sampling method.

Section 4.0 Multiple Volume Purge Sampling: This section briefly describes the method and its advantages and disadvantages.

Section 5.0 No-Purge Sampling: This section briefly describes the method and its advantages and disadvantages.

Section 6.0 Passive Sampling: This section briefly describes the method and its advantages and disadvantages.

Section 7.0 Special Considerations: This section discusses specific sampling situations that may affect sample collection, including sampling groundwater when free product (LNAPL or DNAPL) is present in a well.

Section 8.0 References: This section contains references cited in this document.

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Acronyms

CSCB	Contaminated Site Cleanup Bureau
DEQ	Department of Environmental Quality
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved Oxygen
DPT	Direct Push Technology
USEPA	U.S. Environmental Protection Agency
FAQ	Frequently asked questions
FID	Flame ionization detector
HASP	Health and Safety Plan
LNAPL	Light non-aqueous phase liquid
NTU	Nephelometric turbidity units
ORP	Oxidation-reduction potential (redox potential)
PCB	Polychlorinated biphenyl
PID	Photoionization detector
PVC	Polyvinyl chloride
SAP	Sampling and Analysis Plan
SI	Site investigation
SVOC	Semi-volatile organic compounds
VOC	Volatile organic compounds

Guidance Overview and Purpose

The Montana Department of Environmental Quality (DEQ) Contaminated Site Cleanup Bureau (CSCB) prepared this guidance to assist responsible parties, environmental professionals, and DEQ staff with the collection of defensible and reliable groundwater samples through the use of low-flow and other accepted groundwater monitoring techniques at DEQ CSCB regulated facilities. Data acquired from groundwater monitoring provides key information used in decision making processes. Therefore, sampling should be designed and implemented to maximize the representativeness of site conditions by using proven, accurate, and reproducible methods (Puls and Barcelona, 1996).

Low-flow sampling is the preferred DEQ sampling method unless site-specific and contaminant-specific conditions require alternate protocols. If alternate protocols are necessary, a written technical justification for deviation from this guidance should be submitted to the appropriate DEQ technical contact for approval prior to the sampling event. If this guidance is not clear or does not answer a specific question, please consult the appropriate DEQ technical contact or visit DEQ CSCB's frequently asked questions (FAQ).

DEQ encourages the use of this guidance in the preparation of sampling plans submitted to DEQ. DEQ has developed this guidance using its scientific and technical expertise, and relevant Montana-specific information, as well as technical documents. DEQ encourages parties to contact DEQ with any questions about this document, or if the party believes that DEQ has incorrectly characterized a particular process or recommendation.

Environmental professionals can collect groundwater samples using several techniques. The four most commonly seen by DEQ for contaminated site cleanup are the following:

- Low-Flow Sampling;
- Multiple Volume Purge Sampling;
- No Purge Sampling; and
- Passive Sampling.

Each method has inherent advantages and disadvantages. Based on the advantages described in this document, low-flow sampling is DEQ's preferred method. Other methods may be approved based on site conditions.

1.0 PREPARING FOR SAMPLING EVENTS

Prior to any sampling event, research should be conducted to fully understand site characteristics, monitoring well construction, and equipment needed. The analytical requirements and sampling schedule should be clearly understood and communicated to all personnel involved including the analytical laboratory, project managers, consultants and property owners. This information should be generated in the preparation of a Sampling and Analysis Plan (refer to Section 1.2 for the information that should be included). A copy of the plan should be available while in the field.

1.1 SITE BACKGROUND

A thorough site background should be compiled prior to the sampling event. Implementing any sampling method requires knowledge of the well construction and lithology surrounding the well and that the well is in good condition. Review well installation information including well depth, length of screen, and depth to top of well screen. If needed, collect well depth data the day before sampling begins (see Section 2.4 for further detail on measuring total depth). Review which wells are to be sampled and check well conditions in the field. The monitoring well screen should be located properly to intercept existing contaminant plumes and this information should be studied prior to sampling in the field to ensure proper pump placement for sampling. If installation information is unavailable, or screen silting/biofouling or other well construction issues have been observed, sampling the well might not be acceptable. Work directly with your DEQ technical contact for direction.

Sampling should not be conducted immediately following well development; the time needed for an aquifer to equilibrate after well development will depend on site conditions and methods of installation, but generally exceeds one week.

Formation lithology, permeability, transmissivity and location of expected contamination within the aquifer should all be known prior to initiating sampling (this helps determine the placement of the pump in the well screen as discussed in Section 2.4).

1.2 SAMPING AND ANALYSIS PLAN

A Sampling and Analysis Plan (SAP) needs to be prepared prior to the initiation of the sampling event. The SAP is intended to document the procedural and analytical requirements for sampling events performed to collect groundwater samples. A basic SAP should include the following elements:

- Introduction/Background: This section should include the site history and current status, location, hydrology and hydrogeology, previous environmental investigations, environmental and/or human impact, reporting, and schedule.

- Project Data Quality Objectives: This section should include the data uses, expected data quality, data quality indicators, accuracy, precision, completeness, representativeness, comparability, lab data QA/QC, and reporting limits (which should be lower than the applicable screening levels).

- Sampling Design: The sampling design should include the number and location of wells sampled, the order the wells will be sampled, sampling methodology, standard operating procedures (SOPs) for all meters and equipment used, including details on the calibration method and frequency, laboratory analysis, groundwater sampling equipment checklist, chain of custody control, decontamination procedures, sample documentation and shipping, field quality assurance/quality control (QA/QC) samples, and data validation procedures.

1.3 HEALTH AND SAFETY PLAN

A site-specific health and safety plan (HASP), should be prepared prior to field activities. Field safety procedures, including safety equipment and clothing, hazard identification, and the location and route to the nearest hospital, will be included in the HASP. The HASP should be kept on site and available at all times to the personnel performing the sampling activities. Please follow the HASP with regard to activities and equipment required to mitigate personnel contact with physical, chemical, or biological hazards.

1.4 EQUIPMENT AND SUPPLIES

Before every sampling event, a maintenance check of all instruments should be performed to ensure equipment is working properly before being used in the field. The following sections provide a list of equipment and supplies necessary for a low-flow sampling event.

1.4.1 Informational Materials

These include health and safety plans (HASP), sampling and analysis plans/quality assurance project plans (SAP/QAPP), monitoring well construction data, location maps, field data from previous events, user manuals for relevant equipment. For detailed descriptions of these items, please refer to Sections 1.1 – 1.3 above.

1.4.2 Pumping Device

Low-flow sampling is the preferred DEQ sampling method unless site-specific and/or contaminant-specific conditions require alternate protocols. An adjustable rate pump capable of achieving flow rates of 0.1 – 0.5 liters per minute (L/min) is typically necessary to conduct low-flow sampling; however, this is dependent on site specific hydrogeology (Puls and Barcelona, 1996; ASTM 2005, NJDEP, 2003). Some extremely coarse-textured formations have been successfully sampled at flow rates up to 1 L/min. Examples of appropriate pumps include bladder, submersible, gas driven, and in rare instances peristaltic (Puls and Barcelona, 1996). DEQ acceptance of the pump type should be obtained prior to the sampling event.

The following sections provide a review of the most commonly used sampling pumps, and list the advantages and disadvantages associated with these pumps, which should be considered when selecting a sampling device. Bailers are also included to demonstrate why they are not suitable for low-flow sampling. The information below is based on Section 7.4 of the USEPA Region 8 Standard Operating Procedures for Groundwater Sampling (USEPA, 2017b).

A. <u>Bladder Pumps</u>
   Bladder pumps are DEQ's preferred method for low-flow sampling.

Advantages	Disadvantages
• Maintains sample integrity • Can sample from discrete locations within the well • Can sample down to depths greater than 200 feet below ground surface	• Requires decontamination as non-disposable equipment is placed in the well • Requires air compressor or pressurized gas source and control box

B. Other Submersible Pumps

If a bladder pump cannot be used, other types of pumps such as gear-drive, helical-rotor, or submersible centrifugal may be used with DEQ approval or when specified in an approved SAP. Other submersible pumps have advantages and disadvantages similar to bladder pumps.

C. Peristaltic Suction Pumps

Suction pumps, such as peristaltic pumps, are typically inappropriate for collecting VOCs, semi-volatile organic compounds (SVOCs), volatile petroleum compounds and some (pH-dependent) metals because of the potential for degassing and associated potential pH changes (Parker, 1994). However, peristaltic pumps may be acceptable for VOC sampling if the sampling is being conducted in conditions where high levels of contamination are present, and where the results are not being used as closure samples.

Peristaltic pumps may be appropriate for the collection of inorganic compound samples. However, peristaltic pumps may affect the stabilization of some water quality indicator parameters including dissolved oxygen (DO), pH, and oxidation-reduction potential (ORP). Due to its effect on water quality parameters, a peristaltic pump should not be used when data will be used to evaluate monitored natural attenuation of groundwater (NJDEP, 2003).

There may be situations where a peristaltic pump is the best alternative for sampling, such as very shallow wells where the water column is not long enough to sustain a submersible pump. If peristaltic pumps are used during the collection of VOCs, DEQ approval should be obtained and caution should be taken: ensure tubing is not pinched resulting in pressure changes that can cause volatilization; ensure tubing is completely filled with water prior to sampling; avoid sunlight on the exposed tube which could result in temperature changes leading to volatilization (USEPA, 2017a). These additional measures required to ensure appropriate data quality is attained may be difficult to demonstrate, making peristaltic pumps a less agreeable option.

Advantages	Disadvantages
• Portable • Inexpensive • Readily available	• Limited to depths of approximately 20 to 25 feet below ground surface • Vacuum can cause loss of dissolved gasses and volatile organics

	• Tubing has the potential to absorb contaminants (see Section 1.4.3 for more detail)

D. Bailers

Bailers should never be used for low-flow sampling because they generate turbulence in the well (ASTM, 2005; Puls & Barcelona, 1996). It may be necessary to use a bailer if groundwater levels in the well are not conducive (minimal volume) to placing a low-flow pump. Bailing cords should be composed of either nylon or coated stainless steel. Use of bailers should be approved by DEQ prior to use in the field.

Advantages	Disadvantages
• No power source needed • Portable • Inexpensive and readily available • Rapid, simple method for removing small volumes of purge water • Decontamination not required if the bailers are disposable	• Not applicable to all sampling methods (e.g., not appropriate for low-flow sampling) • Improper use can cause aeration of sample and cause suspension of sediments • Time and labor intensive to purge deep wells or large water volumes • Transfer of samples to containers may cause aeration • Requires decontamination if bailers are not disposable

E. Dedicated vs. Portable Pumps

Dedicated pumps are preferable to portable pumps. Portable pumps may create disturbance in the water column during installation, and also require decontamination between wells. If a portable pump is used, new or dedicated tubing should be used at each sampling location, and the pump should be lowered gently into the well to minimize disturbance to the water column.

While not required, dedicated equipment is ideal for monitoring wells undergoing frequent, routine sampling over extended periods of time. Dedicated equipment saves the sampler time by reducing the need for decontamination, reducing disturbances in the well casing interfering with parameter stabilization and sample collection, and reduces variability in sampling results.

1.4.3 Tubing and Bladders

Pump tubing and bladders should be appropriate for the sampled analytes. Certain types of plastic tubing and bladders can either sorb contaminants from sample water or contribute contaminants to sample water as it flows through the tubing or bladders (Parker and Ranney, 1997; Parker and Ranney, 1998). Factors to consider when selecting tubing and bladders may

include data quality objectives, the well diameter, the type of pump to be used, the depth to groundwater, and the potential residence time the sample may have within the tubing. DEQ-acceptance of the tubing type should be obtained prior to the sampling event.

- Teflon, Teflon-lined and steel tubing or bladders appear to have the least potential to bias samples collected for organic compounds including VOCs, SVOCs, petroleum, pesticides and polychlorinated biphenyls (PCBs). If other tubing or bladders are used for these analytes, DEQ recommends that an equipment blank be used to check that contaminants are not being added to the water, and DEQ may require that a 'spiked' solution be run through the tubing to check for adsorption; contact the DEQ project manager for specific directions.
- In addition to Teflon and Teflon-lined tubing and bladders, PVC, polypropylene or polyethylene tubing and bladders are also appropriate for metals sampling. Stainless steel tubing is not appropriate for collecting metals samples, although equipment blanks may demonstrate whether or not there is an effect.
- Note that Teflon sampling equipment can interfere with the results when collecting samples for PFOA/PFOS compounds. If sampling for these compounds, please contact the DEQ project manager for specific directions.
- The smaller the diameter of tubing used, the easier it will be to maintain low flows without getting air bubbles in the tubing. It is recommended to use ¼" or ⅜" (inside diameter) tubing to ensure that the tubing remains filled with groundwater when operating at very low pumping rates (USEPA, 2017a).
- In order to minimize diffusion between the water in the tubing and the atmosphere, maximize tubing wall thickness and minimize tubing length.
- Avoid sunlight on any exposed tubing, which could result in temperature changes leading to volatilization (USEPA, 2017a).
- If a peristaltic pump is used for low-flow sampling, pharmaceutical grade ("pharmed") tubing should be used around the rotor head of the pump to avoid diffusion to/from the atmosphere.

1.4.4 Power Source

A power source for operating the pump will be necessary. If a petroleum powered generator is used, the power source should be located at least 30 feet downwind of the well and sampling apparatus so as not to interfere with sampling results (USEPA, 2017a).

1.4.5 Flow Measurement Supplies

A graduated cylinder (or measuring cup), stopwatch, and bucket are appropriate for measuring flow. An in-line flow meter may also be used; however, if using a multi-meter for turbidity and flow rate, turbidity should be collected before the flow meter due to the potential for sediment buildup and interference with turbidity results (Yeskis and Zavala, 2002).

1.4.6 Water Level Measuring Device

An electronic water-level indicator or an electronic interface probe (when LNAPL is present or suspected) capable of measuring to the nearest one hundredth of a foot (0.01 ft) should be used for measuring water table depth ensuring as little disturbance to the water surface as possible. A pressure transducer placed above the pump may be used for tracking water levels during pumping; however, it needs to be calibrated at the start and end of sampling by comparing measurements to those from an interface probe. Procedures for collecting water level measurements are described in Section 2.3.

1.4.7 Multi-Parameter Water Quality Meter

A multi-parameter water quality meter is preferred for monitoring stabilization parameters during sampling. If the multi-parameter water quality meter does not measure for turbidity, a "T" connecter will be necessary for obtaining turbidity readings prior to water entering the flow-through cell. Within the approved SAP (Section 1.2), the type of multi-meter used (if known prior to sampling), along with a list of parameters to be measured, should be specified with details on the calibration method and frequency.

If a multi-parameter water quality meter is not available, individual water quality meters may be used for measuring the different stabilization parameters. The SAP should contain standard operating procedures (SOPs) for all meters used, including details on the calibration method and frequency.

Field notes should contain records of all field calibrations performed during the sampling event. In general, meter calibrations should be performed at the beginning of each day and/or after field conditions change (change in barometric pressure or temperature).

1.4.8 Flow-Through Cell

DEQ recommends using a flow-through cell during low-flow sampling activities. When collecting stabilization parameters, using multiple meters simultaneously to make repeated measurements can be a time-consuming and difficult task. Using a multi-parameter water quality meter with a water-tight seal inserted into a flow-through cell allows for multiple parameters to be recorded simultaneously. Post stabilization, field staff can disconnect the inflow tube to the flow-through cell to collect samples from the tube.

1.4.9 Decontamination Supplies

Decontamination supplies including approved cleaning solutions, paper towels, brushes, etc. as outlined in the approved SAP should be on site during sampling.

1.4.10 Record Keeping Supplies

Logbooks, chain of custody forms, equipment calibration forms, well monitoring forms, sample receipts, etc. will be necessary during sampling.

1.4.11 Sample Bottles/Labels/Preservatives

Sampling vials/bottles, labels, coolers filled with ice, zip-lock bags, and the appropriate preservatives (as outlined in the approved SAP and dictated by the chemical being sampled for and the analytical method) will be necessary during sampling.

1.4.12 Gloves

Appropriate gloves should be worn during sample collection; gloves should be changed between samples and prior to decontamination of equipment.

1.4.13 Miscellaneous Equipment

Supplies to aid in shading during hot weather and inhibit freezing of equipment in winter, drinking water supplies, first aid kit, tools for accessing wells (including keys for locks), well location maps, GPS, camera, cellphone, sunscreen, well construction information, calibration manuals, etc. as dictated by conditions and the nature of the work should be on hand during sampling.

2.0 STANDARD SAMPLING PROCEDURES

The following sections describe sampling procedures that apply to all sampling events, regardless of pump type/purge method. For details on additional procedures for specific pump types, including low-flow pumps, please refer to Sections 3.0 – 6.0.

2.1 SAMPLING ORDER

When previous water quality data is available, begin with the least contaminated wells, and proceed to increasingly contaminated wells. When contaminant distribution is unknown, begin with wells upgradient of likely contaminant source(s), continue with downgradient wells, and finish with wells in or closest to suspected contaminant source(s). Collect any necessary quality control samples as outlined in the SAP, including any equipment blanks.

2.2 INSTRUMENT CALIBRATION

Instruments should be calibrated at the beginning of each day. A calibration check is performed at the end of the day to ensure the instruments remained in calibration. All calibration procedures should be documented.

2.3 WATER LEVEL MEASUREMENTS

The measurement of water levels in monitoring wells provides critical data that can be used to determine groundwater flow direction and gradients, aquifer conditions relative to the well screen, and the effect that purging has on groundwater. Water level measurements should be taken in such a way as to minimize disturbance of the water surface and limit the potential to disturb sediments that may have collected within the well. Because water levels have the potential to be influenced by external factors such as barometric pressure, it is recommended that water level measurements be taken from all facility wells within a relatively short period of time to ensure the measurements are comparable.

Depth to groundwater in the monitoring well should be measured prior to installing the pump and/or tubing (if the monitoring well does not have a dedicated pump). If the well is equipped with a dedicated pump then record the static water level prior to initiating purging. If measuring in an active domestic or irrigation well, ensure the water level is static by measuring at least twice. Record the initial water level to the nearest 0.01 ft in the field logbook or field sampling form. Ensure that the water level probe is decontaminated and wiped clean before measuring another well.

Prior to beginning pumping, measure depth to groundwater again and record in the field logbook or field sampling form. If a pressure transducer is being used to document drawdown during sampling, install before pumping begins. Water level measurements should be collected to the nearest 0.01-foot as measured from a surveyed reference point. Once purging begins, water level measurements and pumping rate should be recorded every three to five minutes (along with stabilization parameters), and pump speeds should be adjusted to minimize drawdown.

Water level measurements should be taken continuously throughout the sampling event. Water level drawdown (Figure 1) provides the best indication of stress placed on the hydrologic system by a given flow-rate during sampling.

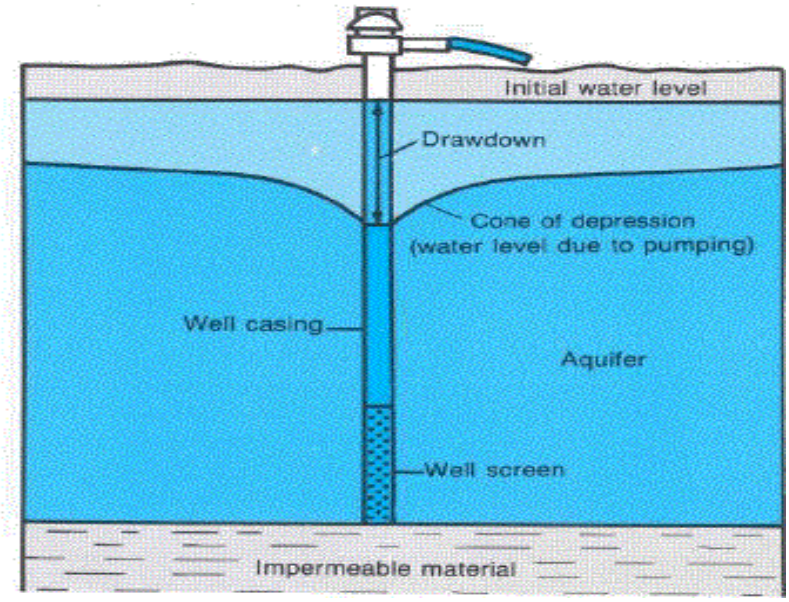

Figure 1: Water level draw down in well (USGS 2016)

2.4 PUMP PLACEMENT IN THE WELL SCREEN

Sampling devices should be lowered slowly and carefully into the well to avoid mixing of stagnant water in the casing above the screen. Sediment and particulates settled at the bottom of the casing can cause interference during sampling activities. Suspending this material will slow down the purge and sampling time and could cause false positives in water quality data. The goal is to minimize the disturbance of water and solids within the well (Figure 2).

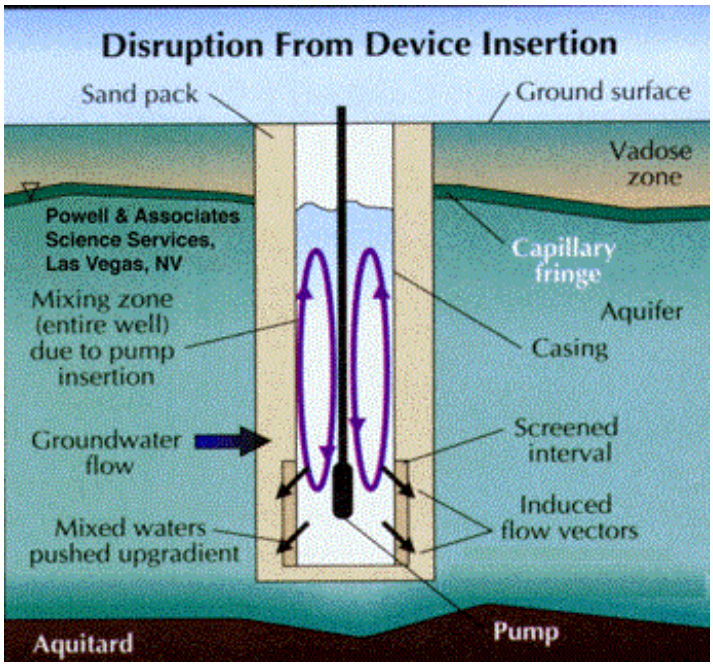

Figure 2: Disruption from device insertion (Powell & Assoc., 2016)

The measurement of the total depth of the well is used to help determine pump placement by assessing the well volume and potential interferences with the screen interval. Total depth is typically included on the well log; however, if changes are suspected due to sediment build-up, the total depth should be confirmed by measuring in the field. If well depth is to be measured, it may be measured the day before sampling or after the sampling event is complete to prevent sediments at the bottom of the well casing from becoming suspended in the water column and interfering with data quality and sample collection time.
Placement of the pump within the well screen may be site or contaminant dependent. If a field specific change is required, ensure that the DEQ technical contact is notified verbally during field activities. Please consider the following field specific needs for pump placement:

- For most sites, and at wells with screens 10 feet long or shorter, the pump intake/inlet should be located at approximately the midsection of the saturated screened interval.

- For wells with screens longer than 10 feet, the primary flow zones and contaminant concentration intervals should be identified and the pump intake location should be determined in consultation with the DEQ technical contact.

- For sites with intervals of different contaminant concentrations within the well screen, the pump intake should be located in the most contaminated interval.

- For monitoring wells with LNAPLs, please see section 7.5.1. Care should be taken to ensure data quality is not affected either by small LNAPL globules in the sample or the inability to properly decontaminate the equipment between sampling locations. If low-flow sampling is proposed for a monitoring well where LNAPL is present, please consult the DEQ technical contact to ensure data quality objectives are being met.

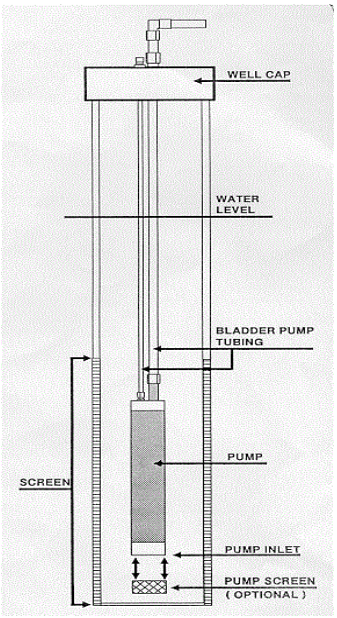

Figure 3: Pump located midsection of well screen (GWSP, 2016)

- For monitoring wells with dense non-aqueous phase liquids (DNAPLs), it may be appropriate to locate the pump intake in the lower portion of the well; however, the pump should not be placed in the lower two feet of the well if possible, so as to avoid disturbing sediment.

- For fractured bedrock sites and other sites with preferential contaminant flow pathways, the pump intake should be placed to sample the most hydraulically conductive interval, unless the sampling objective is to sample a different flow path.

2.5 STABILIZATION PARAMETERS

Water quality indicator parameters should be monitored during purging. Common water quality indicator parameters used to determine stabilization include pH, oxidation/reduction potential (ORP), conductivity, dissolved oxygen (DO), and turbidity. Temperature data can also be collected, but is not necessarily a required indicator of stabilization (Puls and Barcelona, 1996). Measurements should be taken every three to five minutes, and stabilization is considered achieved when three consecutive readings are within the following ranges for the stabilization parameters (NJDEP, 2003; USEPA, 2017a; Puls and Barcelona, 1996):

Water Quality Indicator Parameter	Stabilization Range
pH	± 0.1 units
Specific Conductance	± 3%
Dissolved Oxygen (DO)	± 10%
Turbidity	± 10%
Oxidation/Reduction Potential (ORP)	± 10 millivolts

Turbidity and DO will typically require the longest time for stabilization. It should also be noted that natural turbidity levels in groundwater may exceed 10 nephelometric turbidity units (NTU); therefore, turbidity can be considered stable when three consecutive readings are within 10% for values greater than 5 NTU and if three turbidity values are less than 5 NTU (USEPA, 2017a). For DO, if three consecutive values are less than 0.5 mg/L, consider the values as stabilized (USEPA, 2017a).

Where a flow-through cell is used, complete exchange of water through the flow-through cell is necessary between measurements. If the cell volume cannot be replaced in a five-minute interval, then the time between measurements should be increased accordingly. Stabilization of the indicator parameters allows the sampler to know when formation water has been accessed and sample collection may begin.

If the multi-parameter meter used during the sampling event does not have the capability of testing turbidity, turbidity samples should be collected before water enters the flow-through cell. Transparent flow-through cells can help field personnel monitor for particulate build-up, which can affect indicator field parameter values measured within the cell. If excessive turbidity is encountered during pump start-up, purging may need to continue until particulates settle to avoid build-up during parameter monitoring and sampling.

Depending on facility conditions, parameters may not stabilize during pumping. If parameters do not stabilize, please proceed with one of the following:

- Purge the well for a minimum of four hours prior to sampling if the static water level was stable prior to pumping, or
- Purge three well volumes from the well prior to sampling, or
- Discontinue purging and do not collect a sample.

If a sample is collected, lack of stabilization of parameter values should be documented in the field logbook. Whether to allow sampling when parameter stabilization is unattainable is a site-specific and contaminant-specific decision to be discussed with the DEQ technical contact.

2.6 SAMPLE COLLECTION

Samples should be collected once indicator parameters have stabilized as described in Section 2.5 above. When more than one sample contaminant type is to be collected from the well, samples should be collected in order from most volatile to least volatile analytes. The pump should not be turned off between purging and sampling although the pump rate may be decreased for sample collection in order to fill sample containers (often necessary to fill VOC sampling vials).

However, the rate may not be increased. Prior to collecting samples, disconnect tubing from the monitoring well from any inline-flow devices. Samples should be collected directly from the tube discharging from the monitoring well (unless an inline filter is required for the particular sample analysis). Immediately after a sample bottle has been filled it should be preserved according to the SAP, unless of course the sample container is pre-preserved by the laboratory.

2.7 DECONTAMINATION

Specific decontamination procedures depend on the equipment being used and the contaminants being sampled. Procedures for decontamination should be included in the SAP and purge water should be handled in a manner consistent with DEQ requirements. In general, sampling devices should be decontaminated prior to sampling the first well and then following the sampling of each well. The use of dedicated pumps, bladders, and tubing will reduce the amount of time spent on decontamination. Disposable bladders and tubing should be used only once unless dedicated to the well. Water level probes should be decontaminated between each sampling point by wiping or scrubbing off soil or other foreign material, washing with a laboratory grade detergent (Liquinox or equivalent)/clean-water solution, and rinsing with tap water followed by a final rinse with distilled or deionized water. If the probe comes in contact with free product or highly contaminated groundwater, wash equipment using a desorbing agent (e.g. dilute solution of water and isopropanol or methanol) followed by a detergent wash, a thorough tap water rinse, and a final distilled or deionized water rinse. The interior and exterior of the pump, tubing, support cables, electrical wires, and any other equipment which was in contact with the well should be decontaminated in a similar manner as well.

2.8 POST SAMPLING ACTIVITIES

After sampling, record the depth to groundwater again prior to ending the pumping event. If using dedicated pump tubing, hang it inside of the monitoring well or place within a dedicated container for storage until the next sampling event to avoid cross-contamination. Ensure the tubing is dry prior to long-term storage to avoid issues with mold. Secure the monitoring well. At the end of the sampling event, or end of day event, a calibration check of instruments should be performed and recorded.

3.0 LOW-FLOW SAMPLING

Low-flow sampling is when groundwater samples are collected with a pump set at a low flow rate. The measurement of water levels and stabilization parameters is used to determine when groundwater representative of the aquifer is being collected. This method minimizes disturbance of the well and formation water, and allows for groundwater sampling without purging multiple well volumes of water.

The procedure and considerations for low-flow sampling are described in *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (Puls and Barcelona, 1996).

Low-flow, also called "minimum drawdown" and "low stress" purging and sampling refers to the velocity with which water enters the pump intake; it does not necessarily refer to the flow rate of water discharged at the surface (Puls and Barcelona, 1996). Groundwater generally flows horizontally through a monitoring well screen with sufficient velocity to maintain an exchange with formation water surrounding the screen. When water is removed from a well at a rate minimizing vertical flow and the associated induced stress to the groundwater system, as measured by drawdown in the well, then the pumped water is more representative of the aquifer adjacent to the well screen (CalEPA, 2008).

Conventional groundwater purging and sampling methods (e.g. bailers and high-speed pumps) not only cause hydrologic stress on the groundwater system, but also cause other adverse impacts including the collection of samples with high levels of turbidity (Puls and Barcelona, 1996). Suspended sediment at the bottom of the well casing can bias contaminant concentrations high and filtering samples can remove naturally mobile particles biasing contaminant concentrations low (Puls and Barcelona, 1996). Note, however, that analysis of dissolved metals in groundwater does require appropriate filtering.

Field staff can ensure that low-flow conditions have been achieved and samples can be drawn from the well by following the procedures described in this document. Indicator field parameters (pH, redox potential (ORP), conductivity, dissolved oxygen (DO), temperature, and turbidity) and water level drawdown are measured during purging to determine when formation water has been accessed. It is important to establish stabilization prior to sample collection and consistently implement the same methods for each well sampled (stabilization criteria are discussed in Section 2.5). Consistently reproducing this methodology will improve data quality and help eliminate field errors that may cause DEQ to request sampling events to be repeated.

Any deviations made in the field need to be documented in writing where the supporting and resulting data are discussed, for example in the site investigation (SI) report or monitoring report, and in the field log book or groundwater sampling log. The following materials provide a generalized how-to approach to low-flow sampling.

Some of the advantages and disadvantages of the low-flow sampling process follow (ASTM, 2005; Puls and Barcelona, 1996):

Advantages	Disadvantages
• Generates less purge water than traditional purge methods, which decreases disposal costs • Less operator variability • Better sample consistency • Reduces adverse effects at the groundwater-well interface during sample collection by minimizing formation disturbance (e.g. mixing of stagnant casing water and settled sediment) adjacent to the screened interval • Minimal groundwater column drawdown and minimal disturbance of fines in the bottom of the well • Provides for sampling from discrete intervals in the well • Yields results representative of site contaminant conditions	• Potentially greater set-up and/or sampling time in the field • Difficult to sample low-yield wells

3.1 LOW-FLOW SAMPLING PROCEDURE

Please refer to Sections 2.1 – 2.8 for standard sampling procedures (instrument calibration, sample collection, decontamination, etc.). Details regarding procedures specific to low-flow sampling are described in the following sections.

3.1.1 Installation of Low-Flow Pump

After attaching all necessary tubing and safety cables to the low-flow pump, lower the pump slowly into the monitoring well to the pre-determined depth. Pump tubing lengths outside of the monitoring well casing connected to flow-through cells and monitoring instruments should be kept as short as possible to minimize heating of the groundwater in the tubing by sunlight and ambient air temperatures. Heating of the groundwater in the tubing should be avoided as it may cause groundwater to degas, which can adversely affect data quality of samples for VOCs and dissolved gases.

3.1.2 Continued Water Level Measurement

Depth to groundwater measurements should be taken during the entire low-flow pumping and sampling procedure to ensure that stress is not being placed on the hydrologic system by a high pumping rate. The objective is to pump in a manner that minimizes water level drawdown in the system (Figure 1). At the beginning, drawdown may exceed the goal of <0.1 meters (m) [0.3 feet {ft.}] during purging and then "recover" as pump rates are adjusted. Aquifers with particularly high conductivity may be able to sustain higher flow rates with laminar flow into the well and without excessive drawdown. The flow rate used to achieve a stable pumping level should be recorded and remain constant while monitoring the indicator

parameters. Recording of water quality indicator parameters begins once the depth to groundwater level has stabilized and enough water has been purged to fill the flow-through-cell and submerge all water quality meter sensors (USEPA, 2017a).

3.1.3 Purging the Monitoring Well

Use previous sampling event data to assist in determining pump rate and pump settings. Flow rates of 0.1 – 0.5 L/min are necessary to conduct low-flow sampling; however, this is dependent on site specific hydrogeology (Puls and Barcelona, 1996; ASTM 2005, NJDEP, 2003). Some extremely coarse-textured formations have been successfully sampled at flow rates to 1 L/min.

Start the pumping at a low rate (0.1 L/min is suggested). Once low-flow pumping begins, all purged water is collected in a graduated container to determine the total volume of purge water, which is recorded in the field logbook or field sampling form. Slowly increase flow rate until water level begins to drop. Reduce flow rate slightly until water level stabilizes. Water levels should not drop below 0.3 ft of the initial water level. Record pump settings at this time and calculate flow rate. Continue to collect water level measurements every three to five minutes until water level stabilizes. If groundwater is highly turbid, continue to purge groundwater until the water visually clears. Do not allow the water level to drop below the pump intake.

3.1.4 Monitoring Stabilization Parameters

After the depth to groundwater has stabilized, ensure that the sample tubing and/or flow-through cell are free of gas bubbles. Begin collecting water quality field parameters (pH, ORP, conductivity, DO, and turbidity). Temperature data can also be collected, but is not a required indicator of stabilization (Puls and Barcelona, 1996). Collect water quality field parameters every three to five minutes until parameter stabilization is achieved. Note that a complete exchange of water through the flow-through cell is necessary between measurements; the flow cell volume should be recorded in the field book and flow should be monitored to confirm that complete exchange has occurred between parameter readings. If this is not achievable in five minutes, extend the sample time accordingly. See Section 2.5 of this Groundwater Sampling Guidance for more details on stabilization criteria.

4.0 MULTIPLE VOLUME PURGE SAMPLING

Multiple volume purge sampling is when groundwater samples are collected after a predetermined volume (generally three to five well volumes) of water has been removed from the well and field parameters have stabilized. Well volume is calculated by using the following equation:

$$V = \pi r^2 h(7.48)$$

where:

V = volume in gallons

r = radius of monitoring well in feet

h = height of the water column in feet (this may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point)

7.48 = conversion factor in gallons per cubic foot

Wells are typically purged by bailer or a pump in an effort to remove stagnant well water prior to sample collection. In low yield wells, the well is generally purged dry and sampled after sufficient recovery has occurred. Some of the advantages and disadvantages of multiple volume purge sampling follow:

Advantages	Disadvantages
• Easy to implement • Well yield does not limit the applicability of the sampling method except in low-yield wells that may be pumped dry.	• High volumes of purge water that require treatment or disposal • Less sample consistency • Inadequate purging may cause stagnant well water to mix with formation water • High purge volumes can underestimate concentrations due to dilution. High purge rates can under- or over-estimate concentrations by pulling water from other vertical zones. • High purge rates can increase sample turbidity and may result in higher contaminant concentrations • In the case a low-yield well is pumped dry, sampling recovered water will likely result in underestimated VOCs due to cascading/aeration.

5.0 NO PURGE SAMPLING

No purge samples are generally collected by bailer or pump without purging the well. These samples are most commonly collected from temporary sampling points. The difficulties of sampling from temporary sampling points are discussed in Section 7.2. Although no purge samples can be useful as a screening tool, they are not typically used for groundwater monitoring. Bailers, pumps, or other sample collection devices may be used for no purge sampling. Some of the advantages and disadvantages of the no purge sampling process follow:

Advantages	Disadvantages
• Easy to implement • Potentially no purge water generated • Minimal set-up and sample times	• Less sample consistency • Potential for sample to contain sediment and/or stagnant well water • Uncertainties about representativeness • Depending upon the sampling method, low sample volumes may limit lab analyses

6.0 PASSIVE SAMPLING

Passive samplers collect groundwater samples from within the screened interval of a well without purging. Because purging is not required, there is minimal disturbance of the sampling point. Passive samplers may include more rapid samplers such as the Hydrasleeve™ and Snap Sampler ®, or samplers that rely on sorption (Gore™ Module), or diffusion (passive diffusion bags). A thorough discussion of the use and considerations for passive samplers is provided in *Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater* (ITRC, Feb. 2007). Some of the advantages and disadvantages of the passive sampling process follow:

Advantages	Disadvantages
• Easy to implement • Generates no purge water • Provides for sampling from discrete intervals in the well • Less set-up and sample times	• Method may require calibration with other sampling techniques to assess applicability • Requires equilibration with groundwater • Sorption or diffusion based sampling requires multiple mobilizations per sampling event • Sorption or diffusion based samplers are only applicable for certain constituents • Limited sample volume

7.0 SPECIAL CONSIDERATIONS

Different types of wells and borings may be available for DEQ and consultants to collect representative groundwater samples. The following are specific situations with examples to assist in quality groundwater sample collection. This may include instances where data collection from conventional monitoring wells is not possible, it is desirable to supplement groundwater data from conventional monitoring wells, or it may be important to determine the presence and concentration of contaminants in drinking water sources.

7.1 DIRECT PUSH TECHNOLOGY (DPT) WELLS

If direct push technology (DPT) wells are installed with filter packs, they may allow for well development and lower sample turbidity. The speed and mobility of DPT sampling may allow for the installation of more sample points, which may provide a more complete assessment of groundwater quality than would be available with conventional wells. Commercially available screen lengths as short as one foot allow DPT wells to be installed in a vertically precise manner (i.e., avoiding excessive or inadequate screen lengths). Drill cuttings and purge water volumes are minimal due to the smaller well diameters. Several studies have been completed comparing DPT installed wells with conventionally installed wells (USEPA, 1998; Kram, Mark et. al., 2001). The studies found no significant difference in the quality of samples taken from properly installed and developed DPT wells as compared to conventionally installed wells.

The limitations of DPT installed wells are a consequence of the small diameter of such wells. Specific limitations could include limited volumes of groundwater to obtain sufficient sample qualities. Also, USEPA specifically does not recommend DPT where telescoping wells are required to limit migration below confining layers (Ohio EPA, 2005). The inside diameter probe rods or temporary drive casings used for DPT wells range from 1 ½ to 3 ½ inches. The smaller diameters limit the choices of purging and sampling equipment. Several types of appropriate equipment are currently available, including small-diameter bladder pumps and small-diameter electric submersible pumps. If the DPT well is less than 2 inches, it may be necessary to use a peristaltic pump, although this is not the preferred method. In addition, due to the smaller well diameter, a smaller radius of the formation is impacted during well development, potentially resulting in a less developed well than a larger diameter well. As with all DPT applications, installation of wells with DPT is limited to unconsolidated sediments, and may be limited by depth or the presence of gravels or cobbles. These limitations should be considered in site sampling and analysis plans (Ohio EPA, 2005).

7.2 DPT ONE-TIME SAMPLE COLLECTION

DPT one-time samplers do not allow for long-term groundwater monitoring; however, they can be very useful as screening tools. With respect to site screening investigations in which groundwater samples are not being collected for compliance purposes, DPT (closed screen, open screen, and groundwater profilers) may delineate contaminated groundwater plumes more quickly and efficiently than monitoring wells. Because they are easy to use and do not require well construction materials, DPT one-time samplers typically have a significant advantage over traditional monitoring wells as site screening tools. In addition, they often facilitate hydrogeological evaluation and plume mapping, and can be very helpful in optimizing the

location and construction of permanent monitoring wells. Conversely, with respect to obtaining representative groundwater samples that generate accurate and verifiable data, the use of DPT one-time samplers does present a few challenges. Correct placement of the screened interval is particularly important given the short screen and discrete sampling interval, so that contaminant layers are not missed. The short time frame of many DPT investigations is often insufficient for adequate well development and equilibration with the surrounding formation water. Because there is no filter pack installed around a DPT sampling tool fines may clog the well screen when sampling in fine-grained formations preventing groundwater from reaching the sampler. Also, the lack of a bentonite seal may allow volatile organic compounds (VOCs) to off-gas into the atmosphere from the groundwater zone if the vadose zone/surficial materials are relatively cohesive and the annular space has not collapsed. Clogging of the screen could cause samples to be biased lower than actual contaminant concentrations. Problems with turbidity may arise due to the inability to adequately develop the sampler. Finally, when sampling objectives include trend analysis and monitoring of remediation efforts, the one-time sampling inherent in samples taken with DPT tools is often not appropriate for these monitoring requirements (Ohio EPA, 2005).

7.3 IRRIGATION WELLS

Construction and/or completion details about irrigation wells may be unknown or unreliable; therefore, before proposing use of irrigation wells for groundwater monitoring, DEQ advises considering several factors such as: whether the pumps are running continuously or intermittently and whether any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing. If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance, DO, ORP, and turbidity are recorded at the time of sampling and compared to previous measurements to confirm that purging is complete. See Section 2.5 for parameter stabilization criteria.

If the pump runs intermittently or infrequently, the sampling team's best judgment, along with advice from DEQ, should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Generally, under these conditions, 15 to 30 minutes will be adequate. Measurements of pH, specific conductance, DO, ORP, and turbidity should be made and recorded at intervals during the purge to determine when purging is complete, and the final field parameters measured at the time of sampling (USEPA, 2017a). Sampling through hoses or tubing should be avoided. Collecting groundwater samples from irrigation wells has limitations. Irrigation wells are commonly screened over a broad range of geological materials. Preferential flow paths in more hydraulically conductive units could influence or dilute evidence of chemicals of concern (Gosselin et al. 1994).

7.4 DOMESTIC OR RESIDENTIAL WELLS

In some instances, samples will be acquired from residential wells. Several factors should be considered when collecting samples from a residential well. Obtain a copy of the well log from Montana's Groundwater Information Center (GWIC) to determine the well depth, diameter, and estimated static water level so that the amount of water per well volume can be calculated for

purging. It should be determined if the residence is equipped with a water softener or other filtration system. Samples should be collected before any type of treatment system, if possible. Samples should also be collected from as close to the well influent as possible. Sampling through hoses or tubing should be avoided. The sample should be collected directly from spigots or faucets. In residences, the size of the holding tank should be determined. If it is not possible to collect a sample before the holding tank, then the volume of the holding tank should be purged before sample acquisition, if feasible. Water quality parameters should be collected during the purge to determine when purging is complete, and the final field parameters measured at the time of sampling. Sample analysis requirements are case specific.

DEQ personnel or contractors *should not* open the wellhead. If depth-to-water is a critical parameter, it can be measured with a sonic depth-to-water meter. Using a tape or probe to measure depth-to-water in a drinking water well is not advisable because they can easily get entangled with the discharge piping or electrical wiring for the submersible pumps.

If samples are being collected for bacteria, sterilize the spigot with bleach or 95% ethanol, then rinse with DI water prior to sample collection.

Collecting groundwater samples from domestic wells has limitations. Domestic wells are commonly screened over a broad range of geological materials. Preferential flow paths in more hydraulically conductive units could influence or dilute evidence of chemicals of concern (Gosselin et al., 1994). However, the importance of sampling domestic or residential wells is usually to monitor a direct exposure route.

7.5 SAMPLING WELLS WITH FREE PRODUCT

Sampling groundwater at wells with free product, light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquid (DNAPL), is not a common occurrence and is not typically required. However, collecting groundwater samples beneath LNAPL may be necessary for determining the co-solvency effect upon dissolved-phase contaminant concentrations for product mixtures, evaluating coalescing contaminant plumes from multiple sources, designing groundwater treatment systems, and collecting natural attenuation parameters. If the collection of groundwater from a monitoring well where free product is observed is required at a facility, the following methods and procedures provide guidance for those activities. Alternative approaches will be considered if those methods can be shown to provide better or equivalent data quality.

7.5.1 Sampling Groundwater Below LNAPL

LNAPL can be a persistent source of groundwater contamination, frequently contributing to chemical groundwater exceedances above screening or cleanup levels. Standard groundwater sampling methods are inappropriate for sample collection beneath LNAPLs because sampling implements become coated as they pass through LNAPL, thereby potentially cross-contaminating groundwater samples. Entrained product increases contaminant loading of groundwater samples, and may damage field instrumentation. Typically, groundwater in monitoring wells containing LNAPL is not sampled due to complexity and the special handling needed to collect representative samples. However, if a circumstance exists to warrant collection of groundwater samples from beneath LNAPLs, DEQ recommends using

one of the following procedures. Please consult with the DEQ technical contact for approval of alternative methods that can achieve reliable results.

7.5.1.1 Sealed Casing Method

Water levels and LNAPL thickness is measured. A 1-inch diameter polyvinyl chloride (PVC) casing sealed at the bottom with plastic sheeting (i.e., cling film, saran wrap) is lowered through the LNAPL layer and placed approximately one to two feet below the bottom of the LNAPL. The plastic sheeting is attached using a band clamp. A ½ -inch diameter pipe is lowered inside the 1-inch diameter casing and pushed through the plastic sheeting at the bottom. The ½ -inch diameter pipe is placed approximately one to two feet below the bottom of the outer casing. Disposable plastic tubing is connected to a peristaltic pump configured to discharge air through the tubing instead of drawing air into the tubing. The tubing is lowered inside the ½ -inch piping until the intake end of the tubing reaches below the ½ -inch diameter piping and into the underlying groundwater column. The peristaltic pump is turned off, and the intake end of the tubing is lowered to the desired sample acquisition depth (e.g. typically near the bottom of the well screen in the lower portion of the water column, but not in the lower two feet of the well, if possible). Prior to sampling the well, the peristaltic pump configuration is reversed to draw water into the tubing, and a small quantity of groundwater (e.g., 100 ml) is discharged from the tubing (Revised Supplemental Work Plan for Investigation of Chlorinated Volatile Organic Compounds and Petroleum Hydrocarbons (3rd Revision), Burlington Northern Facility Havre dated May 2006 by Kennedy/Jenks Consultants, Inc. for BNSF Railway Company).

7.5.1.2 Ice-Coating Methods

In this procedure, ice is used as a barrier to inhibit sampling equipment from becoming coated with product during sample collection. Ice should be made from laboratory distilled or deionized water. A detailed description of this procedure is available online (http://www.bioremediationgroup.org/BioReferences/Tier2Papers/collection.htm), but is also directly cited below.

Ice is used as a temporary barrier to protect sampling implements from becoming product coated as they pass through LNAPLs within monitoring wells. Sampling implements are coated with approximately 0.1 to 0.3-inch-thick layer of ice (laboratory-grade distilled water) using simple molds fabricated from PVC pipe and end caps. Bench-scale testing of two different ice-coating procedures demonstrates that product initially coats the ice, but sloughs off within seconds as the ice begins to melt. The ice coating melts completely within a few minutes and the product-free implement is used to sample groundwater. Melting ice is expected to have a negligible effect on groundwater quality due to the minimal volume of ice relative to the storage capacity of most monitoring wells. If the impact of melting ice on groundwater quality is a concern, the standing water column could be purged or the well could be allowed to equilibrate prior to sampling. Note that this method does not prevent coating on the way back out of the well, so special care should still be taken to properly decontaminate the equipment. An example ice-coating

procedure is described below for sampling beneath LNAPLs.

Ice-Coating Method: Conduit Procedure
This procedure involves placing a silicon stopper in one end of a Schedule 40 PVC pipe and coating the end of the PVC pipe containing the stopper with ice. The ice-coated pipe is lowered through the LNAPL until the stoppered end of the PVC pipe extends at least three feet into groundwater. Following melting of the ice coating, a messenger rod is used to push the stopper from the end of the PVC pipe, creating a portal in the LNAPL through which sampling may be performed. A monofilament line attached to the stopper allows retrieval of the stopper from the well bore at the time the conduit is retrieved (Collection of Groundwater Samples from Beneath an LNAPL: An Ice-Coating Method, I. Richard Schafferner, JR., P.G., James M. Wieck, GZA GeoEnvironmental, Inc.).

7.5.2 Sampling Wells With DNAPL

DNAPLs are denser than water and have limited and varying solubilities in water (ITRC, 2015). The most common DNAPLs are chlorinated solvents such as trichloroethylene (TCE), tetrachloroethylene (PCE), and carbon tetrachloride.

Prior to sampling a groundwater well where DNAPL may be present, it is important to use an interface probe to monitor the total depth of the well and determine whether a DNAPL has accumulated at the bottom of the monitoring well. If the interface probe comes in contact with a DNAPL, immediate sampling should be delayed due to cross contamination on the interface probe moving through the water column as it is removed.

When sampling groundwater at a site with DNAPL present, it may be appropriate to locate the pump intake in the lower portion of the well or screen; however, if possible, the pump should not be placed in proximity (less than 2 feet) to the DNAPL to avoid disturbance of the DNAPL. The use of an appropriate low-flow sampling technique to ensure that the DNAPL is not disturbed during the sampling is important to ensure the data quality of the sample.

8.0 References

ASTM International. (2005). Standard practice for environmental site assessments: Phase I environmental site assessment process. ASTM International, West Conshohocken, PA.

California Environmental Protection Agency (CalEPA). (2008). Representative Sampling of Groundwater for Hazardous Substances, Guidance Manual for Groundwater Investigations. California Environmental Protection Agency Department of Toxic Substances Control.

Gosselin, D.C. et al. (1994). Modeling concentration variations in high-capacity wells: Implications for ground-water sampling. *Water Resources Bulletin*, 30(5), 613-622.

Groundwater Well Sampling Pumps (GWSP). 2016. http://rimip.com/groundwater-well-sampling-pumps/.

Interstate Technology & Regulatory Council (ITRC). April 2015. Types of DNAPLs and DNAPL Properties. http://www.itrcweb.org/DNAPL-ISC_tools-selection/Content/2%20Types%20of%20DNAPLS%20and%20DNAPL.htm

Kennedy/Jenks Consultants Inc. (2006). Sealed Casing Method for Sampling Groundwater Below LNAPL. In *Revised Supplemental Work Plan for Investigation of Chlorinated Volatile Organic Compounds and Petroleum Hydrocarbons (3rd Revision), Burlington Northern Facility Havre.*

Kram, Mark et. al. (2001). Performance Comparison: Direct Push Wells Versus Drilled Wells. Navel Facilities Engineering Service Center Technical Report. TR-2120-ENV, p.55.

New Jersey Department of Environmental Protection (NJDEP). (2003). Low-Flow Purging and Sampling Guidance.

Ohio Environmental Protection Agency (Ohio EPA). (2005). Technical Guidance for Groundwater Investigations. Division of Drinking and Ground Waters, Columbus Ohio.

Parker, L.V. (1994). The effects of ground water sampling devices on water quality: a literature review. *Groundwater Monitoring & Remediation,* 14(2), 130-141.

Parker, L.V., and T.A. Ranney. (1997). Sampling Trace-Level Organic Solutes with Polymeric Tubing Part I. Static Studies. In *Groundwater Monitoring and Remediation,* 17(4), 115-124.

Parker, L.V., and T.A. Ranney. (1998). Sampling Trace-Level Organic Solutes with Polymeric Tubing Part 2. Dynamic Studies. *Groundwater Monitoring and Remediation*, 18(1), 148-155

Powell & Associates Science Services. (2016). http://www.powellassociates.com/PAServices/GWsampling/GWsampling.html

Puls, R.W. and M.J. Barcelona. (1996). Low-Flow (minimal drawdown) Ground-Water Sampling Procedures. U.S. Environmental Protection Agency.

Puls, R.W. and C.J. Paul. (1995). Low-Flow Purging and Sampling of Ground-water Monitoring Wells with Dedicated Systems. *Groundwater Monitoring and Remediation,* 15(1), 116-123.

United States Environmental Protection Agency (USEPA). (1998). Innovations in Site Characterization Case Study: Hanscom Air Force Base Operable Unit 1 (Sites 1, 2, and 3). Office of Solid Waste and Emergency Response, Technology Innovation Office. EPA-542-R-98-006.

USEPA, Region I. (2017a). Low Stress (low-flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells. Quality Assurance Unit, North Chelmsford, MA. Revised September 19, 2017. https://www.epa.gov/sites/production/files/2017-10/documents/eqasop-gw4.pdf

USEPA, Region 4. (2017b). Standard Operating Procedures, Groundwater Sampling. Science and Ecosystem Support Division, Athens, GA. April 26, 2017. https://www.epa.gov/sites/production/files/2017-07/documents/groundwater_sampling301_af.r4.pdf

United States Geological Survey. (2016). http://pubs.usgs.gov/gip/gw_ruralhomeowner/

Yeskis, D. and B. Zavala. (2002). Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. In *Groundwater Forum Issue Paper EPA* (pp.1-53).

ATTACHMENT
EXAMPLE GROUNDWATER PURGING AND SAMPLING SHEET

RAMBOLL

Low Flow Groundwater Sampling Field Log

Monitoring Well - **MW-103B**

Client or Site Name
Princeton, NJ

Sampling Information

Date - **March 5, 2015**
Personnel - **W. Larrison & T. Correll**
Weather - **Mostly Sunny, 28°F**

Sampling Device - **2-Inch Bladder Pump**
Water Quality Meter - **Horiba U-52**
Monitoring Equipment - **MiniRAE PID 3000**

Well Information

Well Vault PID - **0.0** ppm
Well Casing PID - **0.4** ppm
Measured Depth to Bottom - **75.00** ft BTOC
Well Screened Zone - **65 - 75** ft BTOC

Well Diameter - **2.0** inch
Depth to Pump Intake - **70.0** ft BTOC
Static Depth to Water - **23.14** ft BTOC
Post-Pump Depth to Water - **23.10** ft BTOC
Well Volume - **8.46** gallons

Well Evacuation Data

Stabilization Criteria			± 0.1 SU	± 3 %	± 10 %	± 3 %	± 10 mV	± 10 %	0.3 ft	
Time	**Vol.** L	**Rate** mL/min	**pH** Std	**Cond.** ms/cm	**Turb.** NTU	**Temp.** C	**ORP** mV	**DO** mg/L	**DTW** ft	**Appearance or Comments**
9:54	--	550	9.86	0.24	78.9	10.18	16	11.89	23.8	Slightly silty
9:59	0.0	320	7.89	0.36	70.4	11.17	77	9.98	23.5	Slightly silty
10:04	1.6	250	7.71	0.364	58.2	11.14	93	9.84	23.3	Slightly silty
10:09	2.8	250	7.68	0.361	48.6	11.04	100	9.64	23.3	Clear
10:14	4.1	250	7.68	0.36	30.3	10.96	107	9.59	23.3	Clear
10:19	5.3	250	7.66	0.36	16	11.11	107	9.5	23.3	Clear
10:24	6.6	250	7.68	0.362	9.3	11.09	111	9.87	23.3	Clear
10:29	7.8	250	7.69	0.363	5.7	11.26	114	9.49	23.3	Clear
10:34	9.1	250	7.64	0.362	5.8	11.21	115	9.5	23.3	Clear
10:39	10.4	250	7.65	0.362	5.6	11.2	118	9.52	23.3	Clear
10:44	***SAMPLE***	100	7.66	0.363	5.5	11.32	118	8.82	23.30	Clear

Sample ID - **MW-103B-150305**
Sample Time - **10:44**

Notes / Sample Information

Appearance at Start - **Slightly silty**
Appearance After Purging - **Clear**

Total Volume Purged - **12.1** liters
Purge Rate - **100-550** mL/min

Additional Sample - **None**
Additional Sample ID - **N/A**

DTW After Purging - **23.30** ft bTOC
DTW at Time of Sampling - **23.30** ft bTOC

Analyses - TCL VOCs (8260B);
TCL SVOCs (8270C/8270C + SIM);
Dissolved Organic Carbon (SM5310);
Dissolved Mn, Mg, Ca, Na, K (200.8);

Notes _____

Title: **Field Activity Documentation for Environmental Investigations**	Procedure Number: **SOP 001**
	Revision Number: **0**
	Effective Date: **August 2018**

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides personnel in the documentation of field activities for environmental investigations.

Field activity documentation is one of the most important activities that occur during field work. There is abundant information available for documenting the details of field work at the time the field work is taking place. It is critical that sufficient detail be documented during field work as it happens to allow others not present during the field activities to fully comprehend the field procedures and conditions at the time of the field work.

The objective of documenting field activities is to ensure that a collection of facts is recorded, the activities can be reconstructed from the documentation, and that the field activities are adequately logged in a manner that will be acceptable if the record is required as evidence in legal proceedings. An additional objective of adequately documenting field activities is to provide complete information that is useful and understandable to someone other than the note taker. Because the field books and field data forms provide the basis for future reports and analysis, facts and observations must be accurately recorded. Some regulatory agencies require that a copy of the field notes be included as part of the report submittal.

This SOP was not intended for use if computer tablets will be used. Consult with the Remediation Practice Quality Coordinator for procedures when tablets will be used.

1.2 Equipment

The following list is an example of items that may be utilized for field activity documentation. Project-specific conditions or requirements may warrant the use of additional items or deletion of items from this list.

- Field book(s) – bound book with water-resistant pages
- Indelible marking pens
- Field data forms – generic or project-specific
- Digital camera
- Pocket ruler
- GPS device

2.0 PROCEDURES

All entries must be legible and must be made in blue or black permanent ink, signed or initialed, and dated. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error.

The original entry should still be legible even though crossed out. Pages should never be removed from a field book.

2.1 Setup of Field Book and Logs

When multiple field personnel are on site, the Field Team Leader should decide the appropriate distribution of field books, field logs or project-specific forms necessary to document field activities. It is not necessary for each participant to take field notes.

1. Each field book assigned to a project should have the following information on the title page (the inside cover of the field book):

    - Project name
    - Site address
    - Site contact, if available
    - Project number(s)
    - TRC's name, address and phone number
    - Start and end dates of field book entries

2. Each field book may have a designated number (i.e., Book #1, Book #2, etc.) listed on the outside front cover.

3. Each field book will be a bound field survey book or notebook, water-resistant, and have sequentially numbered pages.

4. Other field books may or may not be required, dependent on the project needs, at the discretion of the Project Manager.

2.2 Documentation Requirements for Field Books or Daily Field Report Logs

Data collection activities performed during the field effort will be recorded in field books or on Daily Field Report Logs. Entries will be of adequate detail so that others will be able to comprehend a particular situation and it will be possible to reconstruct each activity without reliance on memory.

Entries into the field book or Daily Field Report Log may contain a variety of information. The terminology used in recording all field data should be objective, factual, and free of personal interpretation that may prove inappropriate. At the beginning of each daily entry, the date, start time, weather, and names of all field team members present will be entered. It is good practice to record the date on every page. The start and end of each day's entries in the field book or Daily Field Report Log will be signed or initialed and dated by the person(s) making the entry.

In general, it is expected that field notes will be collected every 15 minutes, as appropriate. Information included in the field book or Daily Field Report Log may include, but need not be limited to, the following:

- Chronology of activities, including entry and exit times;
- Names of all people involved in field activities and organizational affiliations;
- Level of personal protection used (if different from site-specific protocol/plan);

- Any changes made to site-specific protocol/plan
- Names of visitors to the site during field work and reason for their visit (unless in Daily Personnel Log)
- Sample location and identification
- Weather conditions, including temperature and any precipitation
- Day's objectives/scope of work
- Vehicle used (personal, rental) with travel time to site and mileage
- Measurement equipment identification (model/manufacturer) and calibration information
- Summary of equipment brought by subcontractor
- Communications while on site impacting site-specific protocol/plan
- Field screening results
- Site observations
- Sample collection methods and equipment
- Sample collection date (month/day/year) and time (military)
- Sample depths
- Whether grab or composite sample collected
- How sample composited, if applicable
- Sample description (color, odor, texture, etc.)
- Tests or analyses to be performed
- Sample preservation and storage conditions
- Equipment decontamination procedures
- QC sample collection
- Sample shipping methods, including tracking numbers, if applicable
- Unusual events or observations
- Record of photographs (unless in Photograph Log)
- Volume and type of investigation derived waste generated
- Sketches or diagrams
- Signature or initials of person recording the information

Upon receipt of the field book or Daily Field Report Log for a particular activity, the designated person recording the notes will begin recording notes on a new page. The person(s) recording the notes will sign/initial the new page and indicate the date, time, and weather conditions, prior to recording information about the field activity. The field book or Daily Field Report Log should indicate whether any Field Data Forms are being used. When the designated person recording the notes either relinquishes the field book or Daily Field Report Log to another team member or turns the book or log in at the end of the day, the person relinquishing the field book or Daily Field Report Log will affix a signature and date to the bottom of the last page used. If the page is not full, a diagonal line should be struck across the blank portion of the page. A

Field data forms may be used to document sampling information for routine activities that have an associated form. A stockpile of blank forms will be kept in the field trailer/office or with the Field Team Leader. The field book or Daily Field Report Log should reference the form used during that event. Examples of field data forms include:

- Sample log sheets (e.g., groundwater, sediment, soil gas, indoor air)
- Groundwater static water level data sheet
- Slug test data sheet

- Monitoring well construction summary/well development
- Monitoring well decommissioning
- Photograph log
- Soil boring/Rock core log
- Equipment log
- Calibration log

2.3 Documentation Requirements for Daily Personnel Logs

If applicable, the Daily Personnel Log will be maintained in the field trailer/office or by the Field Team Leader for the duration of the project to record the identities of all personnel who are on site. The following information will be recorded on Daily Personnel Logs:

- Names of field personnel
- Names of subcontractor personnel
- Names of visitors
- Affiliation of each person on site
- Date/time of entry and exit

2.4 Documentation Requirements for Photograph Logs

A field book/Daily Field Report Log entry or Photograph Log will be used to record the date and time of photographs taken at the project site. Digital cameras that imprint the date and time of the photograph may also be used to document conditions; however, prior to taking any site photographs with a digital camera, the photographer must verify the correct clock and calendar settings in the camera. An appropriate site figure may be used to note the location and direction of photographic documentation and should be referenced and attached to the log, if used. Examples of items that warrant photographic documentation include:

- General site topography
- Sampling and/or drilling locations
- Existing monitoring well locations
- Pre-existing property conditions and conditions following restoration
- Physical appearance of environmental samples
- Evidence of possible contamination
- Well casing or pad damage
- Rock cores

2.5 Documentation Requirements for Equipment Calibration Logs

A field book/Daily Field Report Log entry or Equipment Calibration Log will be completed to record appropriate information for the instruments calibrated each day. This information may include:

- Equipment manufacturer, model number and serial number
- Dates and times of calibration
- Supplies used (e.g., calibration gas)
- Individual who performed the calibration
- Adjustments made to the instrument during calibration

- Notes regarding the maintenance of the instrument

2.6 Documentation Requirements for Health and Safety Logs

A field book/Daily Field Report Log entry or Health and Safety Log will be completed to record Health and Safety issues during field activities. Entries may include:

- Daily health and safety meeting prior to performing work
- Any injuries, illnesses, near-misses, or the use of first aid supplies
- Activity under Level D conditions or the use of specific personal protective equipment (for Levels A, B or C only, if needed)
- Occurrence of possible work-related symptoms
- The date, name(s) of affected individuals and a description of the issue or incident and response
- A record of air monitoring results, any action level exceedances, and actions taken as the result of any action level exceedances

2.7 Documentation Requirements for Air Monitoring Logs

A field book/Daily Field Report Log entry or Air Monitoring Log will be completed to record monitoring results from real-time air monitoring instruments during field activities. The air monitoring devices will be located and operated in accordance with the Air Monitoring Plan. For hand-held instruments without data logging capabilities, readings will be recorded in the field book/Daily Field Report Log or on the Air Monitoring Log. For instruments with data logging capabilities, the instruments will be periodically checked, with results recorded in the field book/Daily Field Report Log or on the Air Monitoring Log. Data will be downloaded at the end of each workday and maintained in the project files.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

The Field Team Leader has the responsibility to maintain the various logs, forms, and books that document daily field activities. Individual responsibilities may be delegated to other field staff, as appropriate.

Quality control procedures will place emphasis on the completeness and accuracy of all information recorded in the field and will be used to confirm that field notes contain statements that are legible, accurate, and comprehensive documentation of project activities. Field books/Daily Field Report Logs should be reviewed on a frequent basis by the Field Team Leader to confirm that:

- Field books/Daily Field Report Logs and standardized forms have been filled out completely and that the information recorded accurately reflects the activities that were performed.

- Records are legible and in accordance with good record-keeping procedures, i.e., entries are signed or initialed and dated, data are not obliterated, and changes are initialed, dated, and explained.

- Sample collection, handling, preservation, and storage procedures were conducted in accordance with the protocols described in the project plans, and that any deviations were documented and approved by the appropriate personnel.

- Instruments were calibrated and operated in accordance with the procedures specified in the project plans.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation requirements for investigation-derived waste disposal with the Project Manager.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all field books/Daily Field Report Logs used during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

Completed standardized forms will be maintained by the Project Manager or Field Team Leader during the duration of the program and will be archived in the project files following completion of the field effort.

It is good practice to scan field notes and logs at the conclusion of field activities and store the resulting pdf files in the project directory.

6.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	August 2018	NOT APPLICABLE

Title: **Chain-of-Custody Procedures**	Procedure Number: **SOP 002**
	Revision Number: **0**
	Effective Date: **August 2018**

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FIGURES

Figure 1: Example Sample Label and Custody Seal
Figure 2: Example Chain-of-Custody Form
Figure 3: Example Federal Express Air Bill

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides personnel in proper Chain-of-Custody practices.

This SOP was prepared to direct personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. Sample custody procedures are an important part of the field investigation program in order to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law or other evidentiary venue. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration (i.e., representative of the identified sample media).

1.2 Summary of Method

Evidence of the sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be properly documented.

A sample or evidence file is considered to be in a person's custody if the item is:

- In a person's possession
- In the view of the person after being in a person's possession
- Secured and preserved so that no one can tamper with it after having been in a person's possession
- In a secured area, restricted to authorized personnel

The Field Team Leader or designee is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field. The Field Team Leader or designee is also responsible for ensuring sample custody until the samples have been transferred to a courier or directly to the laboratory. Once received by the laboratory, the samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

1.3 Equipment

The following list is an example of items that may be utilized when implementing sample custody procedures in the field. Project-specific conditions or requirements may warrant the use of

additional items or deletion of items from this list. Many of these items may be provided by the selected analytical laboratory for a given project.

- Chain-of-Custody forms
- Sample labels
- Sample tags
- Custody seals
- Computer
- Indelible/waterproof ink
- Printer

2.0 PROCEDURES

Sample custody and transfer procedures are summarized below. These procedures are intended to ensure that the samples will arrive at the laboratory with the Chain-of-Custody intact. The Chain-of-Custody procedures are initiated in the field immediately following sample collection. The procedures consist of four main components: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the Chain-of-Custody (COC) form, (3) reviewing the COC form for accuracy and (4) preparing the samples for shipment and transfer of custody.

2.1 Specific Chain-of-Custody Procedures

2.1.1 Sample Labels

Field personnel are responsible for uniquely identifying and labeling all samples collected during a field investigation program. All labeling must be completed in indelible/waterproof ink and securely affixed to the sample container. Individual sample containers may be pre-labeled or labeled in the field at the time of collection. Sufficient sample information should be cross-referenced in the field documentation for tracking purposes.

Sample labels typically contain the following information:

- Unique sample identification
- Sample location and/or depth/description number, if different from above
- Sample matrix
- Type of analysis to be performed
- Type of chemical preservation used
- Grab or composite designation
- Filtered or unfiltered
- Sampling date and time
- Sampler's affiliation and initials
- Site and/or client name

An example of a sample label is provided in Figure 1.

2.1.2 Custody Seals

Custody seals may be secured across the shipping container to ensure content integrity. The seals contain both the date and the signature of the person affixing them and must be completed in indelible/waterproof ink. Custody seals are attached to the cover seal of the cooler and can be covered with clear plastic tape after being signed and dated by field personnel. An example of a custody seal is shown in Figure 1. The use of custody seals will be determined on a project-specific basis by the Project Manager.

2.1.3 Chain-of-Custody Form

For all analyses, COC forms must be completed for each sample set submitted. COC forms are initiated by the samplers in the field and maintained until samples are analyzed by the laboratory. If multiple laboratories are being used, a separate set of COC forms must be completed for each laboratory receiving samples to ensure proper transfer of custody from the time of sample collection to analysis. These forms serve as a record of sample collection, transfer, shipment, and receipt by the laboratory. These forms typically contain the following pertinent information:

- Project/site name and/or project number
- Carrier name, if applicable
- Air bill numbers(s), if known and applicable
- Laboratory name and address
- Sample identifications
- Sample matrix (e.g., soil, water)
- Type of sample (i.e., grab or composite)
- Date/time sample collected
- Size, type, and number of containers
- Preservative used
- Required analysis or method
- Turnaround time
- Names of individuals responsible for custody of samples
- Date shipped or otherwise transferred

Figure 2 provides an example COC form. It should be noted that this is an example format only. Laboratories typically provide their own laboratory-specific COC form. Other COC formats may be used as long as all of the applicable information is included. COC forms will be initiated in the field.

All entries on the COC form must be legible and must be made in blue or black permanent ink. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error. The original entry should still be legible even though crossed out.

2.1.4 Transfer of Custody

Samples will be accompanied by a properly completed COC form during each step of custody transfer and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving them will sign, date, and record the time of transfer on the COC form.

All samples will be delivered directly to the laboratories by a member of the sampling team, an overnight commercial carrier, or a laboratory-supplied courier service.

In the case of sample shipment by an overnight commercial carrier, a properly prepared air bill, including the project number (Figure 3), will serve as an extension of the COC form while the samples are in transit. The COC forms will be sealed inside the sample cooler within a clear plastic bag and the custody seals, if used, will be completed on the outside of the cooler prior to shipment. Commercial carriers are not required to sign off on the custody forms since the forms are sealed inside the cooler prior to shipment so any custody seal remains intact. The original COC form will accompany the samples at all times. A copy of all COC forms submitted to the laboratory will be retained by the sampler along with field records/logbooks documenting sample collection and will be placed in the project files.

If at the completion of sampling the samples are not shipped directly from the field or point of collection to the analytical laboratory, the samples will be temporarily stored in an iced cooler at a secure location (e.g., locked vehicle, residence, office) or in a locked refrigerator at the office. Access to the secure location and transfer of the sample containers for laboratory delivery shall only be provided by a member of the sampling team and such sample transfer shall be recorded on the COC form.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Following sample collection, all samples will be brought to a location for batching and paperwork checks. At this location, labels and logbook information are cross-checked to ensure there is no error in sample identification or sample collection time and that all samples are accounted for. The sample information is transferred to the COC form. The samples are packaged to prevent breakage and/or leakage, and the shipping containers are labeled for transport.

The Field Team Leader has the responsibility of maintaining the COC and air bill documentation. Individual responsibilities may be delegated to other field staff, as appropriate. Quality control procedures will place emphasis on ensuring that appropriate samples were collected and submitted to the laboratory for the correct analyses. The COC forms will also be reviewed by the Field Team Leader or designee to ensure that all required information is clearly presented.

Many laboratories will provide a sample receipt confirmation via electronic mail upon request. COC forms should be cross-checked with laboratory sample receipt confirmations, if applicable, to ensure that all samples were received and logged-in correctly by the laboratory.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Not applicable.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all COC forms completed during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

It is good practice to scan all completed COC forms at the conclusion of field activities and store the resulting electronic PDF files in the project directory.

6.0 REFERENCES

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001. December 1987.

U.S. Environmental Protection Agency (EPA) Office of Enforcement and Compliance Monitoring – National Enforcement Investigations Center (NEIC) requirements (NEIC, 1986)

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	MARCH 2013	NOT APPLICABLE

Figure 1

Example Sample Label and Custody Seal

Example Custody Seal

Sample Label

CLIENT/SOURCE	☐ GRAB ☐ COMPOSITE OTHER
SITE NAME	DATE
SAMPLE #	TIME
ANALYSIS	PRESERVATIVE
	COLL. BY

Custody Seal

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CUSTODY SEAL

Date

Signature

Figure 2 Example Chain-of-Custody Form

Boott Mills South, Foot of John Street • Lowell, Massachusetts 01852
Telephone 978-970-5600 • Fax 978-453-1995

Chain-of-Custody Record

Page ____ of ____

Project Name _____
Project No.: _____
Sampling Date(s): _____
Laboratory Name: _____
Laboratory Location: _____
Sampler Name(s): _____

Shipping Carrier ❑ FED EX ❑ COURIER
Date Shipped _____
Airbill No. _____

MCP Work Only: Have the appropriate number of field samples been collected for this program?
❑ YES ❑ NO

Turnaround Time (Circle One)
15 Day 10 Day 5 Day 3 Day Other: _____

ANALYSIS AND PRESERVATIVE

SAMPLE ID	DATE/TIME SAMPLED	COMPOSITE OR GRAB	MATRIX	VOLUME / CONTAINER TYPES	NUMBER OF CONTAINERS
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	

COMMENTS

Send results to: _____

Cooler temperature: _____

Relinquished By:(Signature)	Date/Time	Received By:(Signature)	Date/Time
	/		/
Relinquished By:(Signature)	Date/Time	Received By:(Signature)	Date/Time
	/		/

№ 0020

WHITE – LABORATORY YELLOW – LABORATORY COPY PINK – OFFICE COPY GOLD – FIELD COPY

Figure 3 Example Federal Express Air Bill

Title: **Water Level and Product Measurements**	Procedure Number: **SOP 004**
	Revision Number: **0**
	Effective Date: **August 2018**

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct personnel in the methods for conducting water level, separate-phase product, and/or total well depth measurements in monitoring wells, piezometers, and boreholes during field investigations.

1.2 Summary of Method

Depth-to-water (DTW) measurements are used to evaluate pressure and/or elevation changes within the aquifer. The procedure involves using a water level indicator capable of an accuracy of ±0.01 feet, or a similar piece of equipment, to measure the DTW in a monitoring well, piezometer, or borehole from a set reference point. When used in conjunction with an accurate site elevation survey, DTW data can be converted to potentiometric surface elevations to support groundwater flow direction analysis, as well as other aquifer characteristics. In addition, pressure changes recorded in a well during a slug, pumping, or packer test can be used to determine aquifer characteristics, such as hydraulic conductivity and storage parameters.

It is also a good practice to gauge the total depth of a monitoring well while taking water levels. This practice can help confirm: 1) the correct well in a cluster of wells screened at different depths; 2) that the well is clear of obstructions; 3) whether the well may be silting up and need further development; and 4) the correct purge volume for a well when sampling. Total depth measurements in a well may be necessary when site wells have not been accessed for a significant amount of time.

The objective of separate-phase product measurements is to obtain measurements of the thickness of separate-phase product in the water column. The thickness of both dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) can be determined using an oil/water interface probe. It should be noted that the thickness of LNAPL or DNAPL in a well ("apparent thickness") most likely differs from the thickness in the formation ("actual thickness").

- For LNAPL, the procedure involves measuring the depth to the separate-phase product and the depth to the underlying groundwater from a set reference point. The difference between these two measurements is the thickness of the LNAPL in the well.

- For DNAPL, the procedure involves measuring the depth to the separate-phase product and the depth to the bottom of the well, borehole, etc. The difference between these two measurements is the thickness of the DNAPL in the well.

1.3 Equipment

The following list of equipment may be utilized when conducting water level and separate-phase product measurements. Site-specific conditions may warrant the use of additional items or deletion of items from this list.

- Appropriate level of personal protection
- Electronic water level indicator
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Field book and monitoring form
- Well keys
- Socket-wrench
- Containers to hold water and isopropanol for calibration
- Tap water
- Isopropanol
- Previous measurement data (if available)
- Precision ruler or measuring tape
- Permanent marker (e.g., Sharpie®)
- Decontamination supplies

1.4 Definitions

Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and, therefore, floats on the surface of the water.
Monitoring Well	A well made from a polyvinyl chloride (PVC) pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
Non-aqueous Phase Liquid (NAPL)	Petroleum or other fluid that is immiscible in water and tends to remain as a separate liquid in the subsurface.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.

Separate-phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Low-permeability Formation	A geologic formation that has very slow recharge and discharge rates due to small pore spaces in the formation material. A clay formation is considered to have low permeability and has a very slow recharge rate compared to a more permeable formation, such as sand or gravel.
Total Depth of Well	Distance from the measuring point to the bottom of the well.

1.5 Health & Safety Considerations

Personnel shall follow the site-specific health and safety plan (HASP) and will use the appropriate level of personal protective equipment (PPE) as defined in the HASP and by site policies.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

1.6 Cautions and Potential Problems

- DTW measurements of all wells in a water level survey should be collected within the shortest amount of time possible but, at a minimum, within a 24-hour period to ensure near contemporaneous data collection during a groundwater elevation recording event. However, note that certain conditions may produce relatively rapid changes in groundwater elevations, which might necessitate collecting readings over a shorter time period. Such conditions should be noted in the field book. Rapid groundwater elevation changes may occur due to:
  - Rapid changes in atmospheric pressure
  - Variable pumping of nearby wells
  - Precipitation events
  - Tidal influences
  - Rapid changes in nearby surface water levels (e.g., dam release, upstream thunderstorm)
- Allow water levels in newly installed wells to stabilize for approximately 24 hours before taking measurements for the purpose of a water level survey. Recovery might take longer in wells installed in low permeability formations.
- Because the tops of monitoring wells and piezometers are often cut unevenly, be sure to take DTW measurements from a pre-marked or notched spot on the well to ensure consistent data collection over time. Since land survey vertical elevation measurements are generally taken from the highest point on the well casing (i.e., where survey rod rests), this point should also be marked and used for water level measurements. If the tops of the monitoring wells and piezometers are not marked, the DTW measurement should be taken from the north side of the riser and the location marked on the casing top edge.

- To limit the possibility of cross contamination, DTW measurements should be collected in order from the least to the most contaminated wells and piezometers when contamination is known or suspected. Be sure to decontaminate the entire length of the submerged tape between well measurements to reduce the potential for cross contamination. Some wells with NAPL or excessive condensation may have residues on the side of the riser that may also contaminate the tape.
- If the presence of NAPL is suspected at a site, an oil/water interface probe should be used to conduct water level measurements. When DNAPL is a suspected contaminant characteristic at a site, the interface probe should be lowered to the bottom of the well until DNAPL is encountered, if present.
- NAPL may foul the probe and could cause a delayed response when going from NAPL to water. Resolution may require taking repeated measurements by raising and/or lowering the probe through the interface.
- Most water level meters have a "sensitivity" setting, which is often located on the on/off dial. The sensitivity setting may need adjustment depending on the site water chemistry.
- Excessive condensation on the inside well materials may cause the tape to stick on the well casing and/or cause a false reading above the water level. This is especially true of deeper wells. Previous elevation data should be consulted to determine if a reading is consistent and plausible for that well. The above mentioned sensitivity adjustment can be used to compensate. In some cases, the line may have to be weighted to remedy the line sticking to the casing.
- Tight well caps and low permeability formations may not have allowed the potentiometric surface to equilibrate in the well after seasonal, tidal or other area groundwater level fluctuations. If this is the case, allow the wells to equilibrate before collecting measurements by taking readings several minutes after removing the well plug; in addition, re-measure the first well after the last well to verify that the water level is not fluctuating. Another round of water levels may need to be collected if a significant discrepancy from the first set of measurements is observed; this should be discussed with the Project Manager. If this is a concern, vented well caps or plugs may need to be used.
- In some instances, artesian well conditions may exist, where the potentiometric surface is higher in elevation than the top of the well casing (TOC). In these situations, it is pertinent to note the water level elevation as above the TOC or add a known length of riser pipe in order to measure an actual elevation. Once the water level has equilibrated in the riser pipe, the same procedures can be followed for measuring water level when separate-phase product is not suspected. Note that when converting the DTW measurement to an elevation, the riser pipe length needs to be added to the surveyed TOC.
- Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps, and the same water level indicator should be used for all measurements if possible. All wells should be measured within the minimum possible time. This is particularly important in areas with potential tidal influences.

- If more than one measuring device must be used for multiple wells across an area with a shallow groundwater gradient, the "zero calibration check" (see Section 2.1.1) becomes especially important.

- If the monitoring well or piezometer is secured with an air- and water-tight lockable cap, caution should be taken when removing the cap due to the possible buildup of pressure in the well casing. Try to ease the cap off and relieve the pressure slowly in order to prevent injury. Do not stand or lean over top of well when releasing cap.

- Flush-mounted wells may be subject to water collection in the well can around the top of the riser pipe. In such instances, sufficient water should be evacuated from the well can prior to removing the well cap to ensure that ambient water does not enter the riser. The condition should be documented and the potential need for repair discussed with the Project Manager.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Workers (HAZWOPER)
- 8-hour annual refresher training

2.0 PROCEDURES

To be useful for establishing groundwater gradient, the reference point should be tied with a known vertical datum, such as the National Geodetic Vertical Datum (NGVD), or a local datum (e.g., site-specific arbitrary datum).

Water levels should be allowed to equilibrate prior to measurement after removing sealing well caps. There are no set guidelines, and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology, and project objectives.

If available, prior site water and product level measurement data should be reviewed and available to field personnel during the collection of new data for direct comparison to aid in identifying and resolving potential measurement errors while in the field.

When measuring well depths with an electronic water level indicator, measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth.

The following procedures must be followed during the collection of water level and product measurements. Procedures may vary depending on the equipment used and contaminants present at the site.

2.1 Calibration and Operational Checks

Refer to the project's Quality Assurance Project Plan (QAPP) for calibration frequency and any site-specific calibration procedures for water and separate-phase product level meters. Calibration of the meters is optional; the need for calibration and the frequency of calibration will be dependent upon the meter used and project-specific data quality objectives. Operational checks of meters will be performed prior to use in the field at the start of each day and several times throughout the day, as appropriate.

2.1.1 Operational Check of Water Level Meters

1. Push the Start or Test button (typically provided) on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate (if equipped).

2. Release the start/test button and lower the water level probe into a container filled with tap water until the meter audible indicator sounds or visual indicator light turns on. During this check, set sensitivity adjustment (if provided) to highest setting, then decrease if necessary (e.g., saline water).

Inspect the measuring tape and water level probe connection for any signs of visible damage (e.g., cuts, kinks, separating splices). If the tape appears damaged at the connection to the probe, while the meter is sounding, perform the procedure in Section 2.1.2.

2.1.2 Calibration of Water Level Meters

1. While the meter is sounding from the procedure used in Section 2.1.1, use a ruler or measuring tape to measure the distance between the water surface and the 1-foot increment mark on the water level tape.

2. Check that the 1-foot increment is actually 1 foot from the water surface. Note any discrepancy in the field book and discuss with the Project Manager. If necessary, repair and/or replace the water level meter.

2.1.3 Calibration and Operational Check of Oil/Water Interface Meters

1. Oil/water interface meters will have one distinguishing sound and/or colored light to represent detection of water and a separate distinguishing sound to represent detection of separate-phase product. Read the instrument manufacturer's operations manual to determine the instrument's audible sound or light differentiation for water and separate-phase product (e.g., continuous beep for product and intermittent beep for water).

2. Push the Start or Test button (typically provided) on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate (if equipped).

3. Water Level Sensor Operational and Calibration Checks

    a. Lower the water level probe into a container filled with tap water until the appropriate sound for water is heard as determined in Step 1.

b. While the meter is sounding, use a ruler or measuring tape to measure the distance between the water surface and the 1-foot increment mark on the water level tape.

c. Check that the 1-foot increment is actually 1 foot from the water surface. Note any discrepancy in the field book and discuss with the Project Manager.

4. Oil Level Sensor Operational and Calibration Checks

   a. If the operation or calibration of the oil level probe is suspected to be faulty, consult with the meter manufacturer for additional troubleshooting.

2.2 Procedures for Measuring Depth to Water When Separate-phase Product is Not Suspected

If possible, and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated. Additionally, allow sufficient time for each monitoring well or piezometer to equilibrate after removing the protective cap prior to taking readings.

1. Record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.), equipment being used, and the current weather conditions in the field book or on the water level monitoring form or well inspection report.

2. Use HASP-specified gloves. Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure build up that may have occurred in the well casing. Follow HASP requirements for well head and breathing zone air monitoring.

3. Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book or on the water level monitoring form (e.g., top of riser or top of casing).

4. Using a previously decontaminated water level meter, turn on the meter, check the audible/visual indicator (push the "Test" button), reel the electronic probe into the well riser (with the increments visible) slowly until the meter sounds.

5. Grasp the tape with hand, withdraw the tape, and lower it again slowly until the sound is again audible. Check the DTW on the tape and make a mental note of the depth to within 0.01 feet.

6. Lower the probe again slowly and repeat the measurement for precision. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step #3 to the nearest 0.01 feet. If measuring the total depth of the well, proceed to Section 2.4).

7. Decontaminate the probe and the entire length of the submerged tape in accordance with the manufacturer specifications.

2.3 Procedure for Measuring Depth to Water and Product Levels When Separate-phase Product is Suspected

If possible, and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated. Additionally, allow sufficient time for each monitoring well or piezometer to equilibrate after removing the protective cap prior to taking readings.

1. Record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.), equipment being used, and the current weather conditions in the field book, water level monitoring form, or well inspection report.

2. Use HASP-specified gloves. Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure build up that may have occurred in the well casing. Follow HASP requirements for well head and breathing zone air monitoring.

3. Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book or on the water level monitoring form (e.g., top of riser or top of casing).

4. Using a previously decontaminated oil/water interface probe, turn on the meter, check the audible indicator, and slowly reel the electronic probe into the well riser (with the increments visible) until the appropriate sound for water or separate-phase product is heard as determined in Section 2.1.3.

5. If water is encountered first (as determined by the audible sound on the meter, which represents water), follow steps 5 and 6 from Section 2.2. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step 3 to the nearest 0.01 feet.

6. If water is encountered first and DNAPL is suspected, continue lowering the probe until product is encountered (as determined by the audible sound on the meter, which represents product). In the field book or on the water level monitoring form, record the depth to product from the measuring point noted in Step #3.

7. Calculate the thickness of the DNAPL in the well using the following equation:

   (Total depth of well) - (Depth to product) = DNAPL thickness

8. If LNAPL is encountered before water, record the depth to product from the measuring point noted in Step #3 in the field book and continue lowering the probe until water is encountered.

   NOTE: For LNAPL, it is necessary to take both the air/product interface measurement on the way down into the product and the water/product interface measurement on the way back up. This is required when passing through product into water, since some product may adhere to the probe sensors due to surface tension and, as a result, a greater product thickness measurement may be erroneously obtained. Therefore, when LNAPL is detected, the probe should be lightly shaken or raised and lowered rapidly in a short vertical motion

while the probe is within the water column to remove any product that may have been carried down with the probe. After passing through the product, the water/product interface should then be measured as the probe is raised very slowly back up from the underlying water into the product. Once the interface is detected, the probe can be raised and lowered in small increments to precisely determine the interface and obtain accurate measurements. Repeat these measurements as needed to confirm water/product interfaces and product thickness on multiple measurements.

9. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step #3. If measuring the total depth of the well, proceed to Section 2.4.

10. Calculate the thickness of the LNAPL in the well using the following equation:

    (DTW) - (Depth to product) = LNAPL thickness

11. Decontaminate the probe and the entire length of the submerged tape in accordance with the manufacturer specifications.

2.4 Procedure for Measuring Total Well Depth

When measuring the total depth of a well, the water level and separate-phase product level, if present, should be determined first (see Section 2.2 or 2.3). It is recommended that the tone function of the instrument remain engaged during the total depth measurement.

1. After the water level and product level, if present, have been determined, continue reeling the electronic probe into the well riser (with the increments visible) until the probe encounters resistance. Resistance may be inferred when the probe appears to stop descending and the tape slackens against the side of the riser.

2. Determine whether the observed resistance likely represents the total depth of the well by raising and then lowering the probe to the level of the previously encountered resistance several times at different positions in the well. Then compare the observed level of resistance to available information about the total depth of the well, such as well log data or previous total depth measurements.

3. Measure the total depth of the well by: 1) noting the depth (to the nearest 0.01 feet) at which the probe first touches bottom before the tape begins to slacken; 2) adding the measured length from the bottom of the probe to the fluid level sensor in the probe; and 3) recording the combined lengths as the total depth.

4. In the field book or on the water level monitoring form, record the total depth of the well from the measuring point.

5. Also, note any observations about the conditions encountered in the well during the total depth measurement. A clear and distinct bottom reading would indicate little or no sediment in the bottom of the well. A soft and indistinct probe landing would indicate the presence of silt or sediment in the bottom of the well. A total depth measurement

inconsistent with the well log or previous total depth measurements may indicate an obstruction in the well or significant sedimentation at the bottom of the well.

6. Decontaminate the probe and the portion of the tape inserted in the riser in accordance with the manufacturer specifications.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following Quality Assurance/Quality Control procedures apply:

- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency.
- Check the DTW at least two times in order to compare results. If results do not agree to within 0.02 feet, take a third measurement. If results still do not agree, check for possible equipment failure or review the cautions and potential problems listed in Section 1.6. Repeat the measurement when the cause of the precision nonconformance has been discovered and corrected.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

- Record water and separate-phase product level measurements on field forms or in a field book. The following additional information may be recorded in the field book:
  - Well/piezometer or monitoring point identification number
  - Well/piezometer or monitoring point location (sketch of the sample point or reference to a location figure)
  - Visual or sensory description (e.g., odors, product, etc.)
  - Time and date measurements were taken
  - Personnel performing the task
  - Weather conditions during task

- Other pertinent observations
- Measurement equipment used
- Calibration procedures used
- Decontamination procedures used
- Fixed measuring point used for DTW measurements

6.0 REFERENCES

Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

U.S. EPA Environmental Response Team, Standard Operating Procedures, *Manual Water Level Measurements*, SOP 2043. February 11, 2000.

U.S. EPA Region 4. Science and Ecosystem Support Division (SESD) Operating Procedure, *Groundwater Level and Well Depth Measurement*, SESDPROC-105-R2. January 29, 2013.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	August 2018	NOT APPLICABLE

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ATTACHMENTS

Attachment A Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions
Attachment B Example Groundwater Field Data Records

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide personnel with general guidance in performing groundwater sampling activities. This SOP details equipment and sampling procedures for low-flow sampling, multi-volume purge sampling and passive diffusion bag sampling from monitoring wells. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., equipment/instrument, flow rate, etc.) that may be applicable and take precedence, depending on the program.

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

1.2 Summary of Method

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling.

For low-flow and multiple well volume removal, there are various types of equipment available to perform groundwater sampling. The most common of these are the submersible pump, peristaltic pump, and bailer. However, the equipment selected and the purge method used, if any, will depend on project goals, data quality objectives (DQOs), hydrogeologic conditions, and regulatory requirements. Care should be taken when choosing the sampling procedures and device(s), as some procedures have the potential to affect the representativeness of the sample more than others. For repeated monitoring events, the sampling methodology and operating equipment employed should be consistent to minimize potential variability due to sampling procedures. The type of sampling method utilized is dependent upon site-specific conditions and it is not within the scope of this document to recommend a specific methodology. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following equipment is commonly used to collect groundwater samples from a monitoring well. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator capable of measuring to 0.01 foot accuracy
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Submersible pump with low-flow capabilities (less than 1 liter/min) constructed of inert materials (e.g., stainless steel and Teflon®), such as a bladder pump (with sufficient quantity of bladders, o-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on type of pump used)
- Bottom-filling bailer constructed of inert materials (i.e., polyethylene, polyvinyl chloride [PVC], stainless steel or Teflon®)
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon®, Teflon®–lined polyethylene, or high density polyethylene [HDPE], type dependent upon project objectives)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Flow-through cell
- T-connector
- Turbidity meter
- Passive sampling device (and any device-specific accessories)
  - Passive diffusion bags (PDBs)
  - Tether (stainless steel cable or marine-grade polyethylene rope), well cap, and weights, unless already installed
  - Funnel (Fill kit)
  - PVC cable ties
  - Tool to cut cable ties
  - PVC discharge tubes
  - Tether reel
- Well lock keys
- Bolt cutters

- Appropriate tools for equipment and to open well box (e.g., socket wrench, pry bar, etc.)
- Containers with lids for purge water (i.e., 5-gallon buckets, drums, etc.)
- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (can request from lab – for equipment blanks)
- Chain-of-custody (COC) forms
- Sample cooler(s)
- Photoionization detector (PID) or flame ionization detector (FID) for well head monitoring
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Groundwater Field Data Record (multiple copies)
- Filtration equipment
- In-line filter (0.45 micron [µm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Ice
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open
- Umbrella, tent, or equivalent for shading equipment (particularly the flow-through cell) from sunlight or blocking rain
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- Map of well locations and well construction data
- Copy of field notes from previous sampling event for reference
- Project-specific work plan

1.4 Definitions

Bailer — A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface. A bailer may be made in varying diameters; however a bailer that fits in a two-inch well is the most common. In some instances a < 1-inch diameter bailer (a.k.a. pencil bailer) is used for small diameter wells.

Borehole — A hole drilled into the soil or bedrock using a drill rig or similar equipment.

Dense Non-aqueous Phase Liquid (DNAPL) — Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.

Depth To Water (DTW) — The distance to the groundwater surface from an established measuring point.

Drawdown — The response to purging/pumping a well resulting in the lowering of groundwater within the water column in the well or in a water-bearing zone.

FID — An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured.

Flow-Through Cell — The container used to immerse the multi-parameter probes in well purge water during pre-sampling well purging. The flow-through cell is usually made of transparent acrylic and is connected to the end of the discharge tubing creating an in-line, sealed container in which purge water circulates around the measurement probes. The discharge from the pump prior to the flow-through cell may be fitted with a check valve or T-connector for collection of water for turbidity measurement.

Flush Mount — The type of well completion where the riser terminates at or below grade. Flush-mounted wells are typically completed with a “curb box” which is an “at-grade” enclosure designed to protect the well riser.

Light Non-aqueous Phase Liquid (LNAPL) — Separate-phase product that is less dense than water and therefore floats on the surface of the water.

Monitoring Well	A well made from a PVC pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.
Protective Casing	The pipe installed around the well riser that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) in order to protect the well integrity. Protective casings are typically constructed of steel or aluminum and usually closeable with a locking cover/hasp to maintain well integrity between sampling events.
Recharge Rate	The rate at which groundwater returns to the water column in the well.
Separate-Phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressure.
Well Cover	The cap or lid constructed at the end of the protective casing (above-grade completions) or flush-mounted curb box (ground surface completions) to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes or vaults are opened and closed using a threaded bolt.
Well Filter Pack	A material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.
Well Plug/Expansion Plug	The plug fashioned into a cap placed into the top of the well riser (e.g., J-Plug). Well plugs are usually designed with an expandable gasket that is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.

Well Riser Sections of blank (non-slotted) pipe that extend from the well screen to or above the ground surface.

Well Screen Pipe (typically PVC or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The openings/slots can vary based on formation and filter pack material specifications.

1.5 Health & Safety Considerations

Sampling personnel shall follow the site-specific HASP and use the appropriate level of PPE as defined in the HASP and by site policies.

The well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field.

1.6.1 Pre-Sampling Issues

(a) Selection of equipment for groundwater sampling should consider multiple factors, including: DTW, well specifications (e.g., depth and length of well screen intervals), desired flow rate, possible weather conditions, type and concentration of contaminant(s), and remoteness/accessibility to the site. The benefits and limits of each type of groundwater sampling equipment should be fully reviewed during project planning or prior to mobilization if the project-specific work plan does not identify the required equipment. For example, peristaltic pumps are incapable of withdrawing water in wells in which the depth to water is greater than approximately 20-25 feet below ground surface (bgs).

(b) If the screen or open borehole is greater than 10 feet in length, consult the project-specific work plans for the target sampling interval. Generally, pumps are either placed in the middle of the saturated zone if the water level is below the top of the screen or in the middle of the screen interval if the water level is above the top of the screen.

(c) The need for redevelopment of the monitoring wells should be evaluated periodically in accordance with the project-specific requirements. This is assessed by comparing the measured total depth of the well with the constructed depth. If the measured depth is less than the constructed depth, this may indicate siltation of the well and/or the presence of an obstruction in the well. If it is determined that redevelopment is necessary, it should be performed in accordance with SOP 006, *Well Development*. The time necessary for a well to restabilize after redevelopment will be determined on a project-specific basis and may depend on regulatory requirements.

(d) During the total well depth measurement, there is the potential for sediment, if present at the bottom of the well, to be disturbed, thereby increasing the turbidity of the groundwater. Therefore, the total well depth measurement should be collected the day prior to collecting groundwater samples, if possible.

(e) Use caution if using compressed gas cylinders (e.g., nitrogen, carbon dioxide) for purging/sampling of groundwater. Check for leaks around regulator connections by spraying soapy water on the connections. If a leak is discovered, the connection to the regulator should be disassembled, wrapped with Teflon® tape, and reconnected to the cylinder. If the leak continues, the regulator should be replaced. It should be noted that Department of Transportation (DOT) regulations apply to the transportation and handling of compressed gas cylinders (see 49 Code of Federal Regulations [CFR] 171). Never transport cylinders with the regulator attached. Replace the cylinder valve cover on the compressed gas cylinder before transport.

(f) All field personnel must be made aware of the water level measurement reference point being used for each well at a site (i.e., must be clearly marked) in order to ensure collection of comparable data between events.

(g) Bolt cutters may be necessary to remove rusted locks. Dipping rusted locks in a soapy solution may help with opening difficult locks. Oils and other products containing VOCs (e.g., WD-40) should not be used on locks as these compounds may cause contamination of water samples collected at the well. Replace cut locks and note in the field book.

(h) Prior to accessing the well, physical conditions around the well head should be assessed for situations that might result in cross-contamination or the introduction of foreign material/debris into the well. For example, flush-mounted wells may have water or road sand/salt/debris inside the curb box. Rodents and insects (e.g., bees, wasps) have been known to construct nests within the protective casing of a well. If bees, wasps, or other insects are encountered, insecticides should be used with caution as the chemicals may cause contamination of water samples collected at the well. If water or foreign material is introduced into the well, the Project Manager should be immediately notified.

1.6.2 General Purging and Sampling Issues

(a) Prior to installation of a submersible pump into a well, ensure that the tubing is properly sealed to the pump to avoid losing the pump down the well and to prevent escape of air or water from the pump, which could result in poor pump performance and the aeration of the well water. Do not do this by tugging on tubing. Never lower pumps into the well using only tubing; instead a security line attached to the pump is required to prevent potentially losing the pump down the well.

(b) A submersible pump should not be lowered to the bottom of the well to avoid stirring up any sediment at the bottom of the well and prevent getting the pump stuck (fine sediment accumulation in the bottom of the well can create a strong suction with a flat bottom pump such as a bladder pump, which may require jetting to retrieve the pump).

(c) Start with the lowest pumping rate possible and increase until a sustainable rate is reached. Avoid high pumping rates (> 1 liter/min), as this could lead to damage of the well filter pack, if present. Where practical and/or possible, refer to previous sampling events to establish consistent flow rates.

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the "soda straw" method to collect the VOC sample which does not allow the water to go through the pump head:

   (1) After purging the well with the peristaltic pump, collect all fractions <u>except VOCs</u> from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
   (2) Turn the pump off.
   (3) Change into clean gloves.
   (4) Disconnect the tubing coming out of the well from the inlet side of the pump and <u>immediately</u> put a finger over the end of this tubing to prevent water from draining out of the tubing.
   (5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
   (6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

(e) In the event that a well cannot be purged and sampled with a pump, the alternative to pumping may be the use of a bottom-filling bailer. The applicable regulatory agency requirements and the Project Manager should be consulted if in doubt about the appropriateness of using a bailer at a site or during a particular sampling event.

(f) During purging and sampling, the tubing should remain filled with water to minimize possible changes in water chemistry due to contact with the atmosphere. All flow-through cells should be shaded from direct sunlight to minimize the potential for off-gassing and temperature fluctuations.

(g) Ensure monitoring instruments (i.e., multi-parameter water quality instrument, turbidity meter, water level measuring device) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(h) Adverse weather conditions may present challenges that need to be dealt with on a case-by-case basis. For example, air temperatures below 32°F may cause ice formation in the tubing, flow-through cell, and on the sampling equipment, or heavy rain could cause standing water issues with flush-mounted wells. Heavy rain can also impact electronic sampling equipment; preventative measures should be taken to keep electronic equipment dry.

(i) Observe and avoid any uncontrolled ambient/surrounding air conditions that could affect analytical results (e.g., truck/vehicle exhaust nearby, industrial building vents). Always ensure that vehicles are turned off during sampling to avoid introducing vehicle exhaust into the sample. If uncontrolled ambient/surrounding air conditions cannot be avoided, contact the Project Manager for further instruction; collection of a field blank sample may be warranted in this situation.

(j) Procedures should be established to minimize potential cross-contamination. For example:

- Wrap monitoring and sampling equipment with protective material (e.g., aluminum foil, polyethylene sheeting, Ziploc® bags) after decontamination and between sampling locations to minimize the potential for cross-contamination between well purging events at different locations.
- Use dedicated or disposable sampling equipment or new tubing at each sampling point when appropriate to minimize the need for decontamination.
- Protect sampling equipment and/or the open well head from blowing soil and dust by covering with plastic sheeting as needed.
- If a bailer and rope are used to purge and/or sample the well, then there is the possibility of contamination from the rope used to lower the bailer. New or dedicated rope should be used when appropriate. Alternatively, a decontaminated, Teflon®-coated stainless steel leader can be attached between the rope and the bailer. The leader acts as an extension to the rope and allows for the top of the bailer to enter the water column without immediately placing the rope into the water. It is important to keep the rope clean and not allow contact with the ground surface during bailing.

(k) Disposal of the groundwater collected during purging must be performed in accordance with all applicable regulations and the project-specific work plan.

(l) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

(m) In cases where it is difficult to obtain sufficient sample volume for multiple analytical fractions as well as required quality control (QC) analyses (*e.g.*, field duplicates, matrix spike/matrix spike duplicate [MS/MSD] analyses), discuss this situation with the Project Manager and laboratory prior to sample collection. Laboratories can often "make do" with less volume, especially for inorganic parameters, or increase the reporting limit proportional to the sample volume obtained.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Procedures for collecting groundwater samples from monitoring wells are described below. The project-specific work plan should also be consulted for specific details regarding sampling.

Sampling should always begin at the monitoring well with the least contaminated groundwater and systematically proceed to the well with the most contaminated groundwater, if possible.

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on all wells at the site prior to sampling, regardless if the well is being sampled.

(b) Prior to field activities, review historical groundwater sampling logs (if available) to maintain consistency for the current sampling event (e.g., equipment type, pump intake depth setting, flow rate, etc.)

(c) Organize monitoring, purging, and sampling equipment taking care not to allow cross-contamination. This can be accomplished by laying new polyethylene sheeting near the well or using new buckets, etc.

(d) Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to relevant SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

(e) Unlock the well cover on the well.

(f) Record the sample location, time, and date in the field book and/or on the Groundwater Field Data Record.

(g) On the Groundwater Field Data Record, note the physical condition of the well, including damage, deterioration, and signs of tampering, if any. Collect photographic documentation of serious damage to present to the Project Manager.

(h) Open the well cap and expansion plug, and stay upwind of and not directly over the well. Note any unusual odors, sounds, or difficulties in opening the well and, if required, measure the organic vapor reading at the rim of the well with a suitable organic vapor screening device (e.g., PID or FID), and record the reading in the field book and/or on the Groundwater Field Data Record. If pressure or vacuum is noted or suspected in the well, allow sufficient time for the water level elevation in the well to equilibrate.

(i) Gently lower a clean, decontaminated water level measuring device into the well to determine the static water level. If appropriate for site conditions, check for the presence of LNAPL or DNAPL using an oil/water interface probe (refer to SOP 004, *Water Level and Product Measurements*). If LNAPL or DNAPL is detected, contact the Project Manager before proceeding with purging and sampling activities. Record the information on depth to groundwater to the nearest 0.01 feet, depth to LNAPL or DNAPL, and/or thickness of NAPL in the field book and/or the Groundwater Field Data Record. Refer to SOP 004, *Water Level and Product Measurements*, for proper procedures in performing these measurements.

(j) If required in the project-specific work plan, measure the depth to the bottom of the well to assist in calculating the well volume of the well. If possible, avoid making total well depth measurements on the same day as sampling due to the tendency to disturb sediment during this measurement. If NAPL is suspected, use a decontaminated oil/water interface probe. If the measured depth is less than the constructed depth, this may indicate that the well needs to be redeveloped (see SOP 006, *Well Development*). Consult the project-specific work plan or Project Manager for further instructions.

2.2 Groundwater Purging Activities

Purging is conducted to ensure that representative groundwater is obtained from the water-bearing unit for analysis. The multiple-volume or low-flow purging approach may be used to remove water from the well and monitor the water in order to determine when a well has been adequately purged (i.e., stabilized); at a minimum, the pH, specific conductance and temperature of the groundwater removed during purging should be monitored and recorded in the field notes. Other parameters may be required in some regulatory jurisdictions (e.g., turbidity). Additionally, the purge volume should be monitored and recorded. In some instances, such as when monitoring at solid waste disposal facilities, simply removing an adequate volume of water (e.g., three well volumes) may be suitable for adequate purging, and sampling can commence. Check with the project-specific work plan and appropriate regulatory guidance to determine any specific purging requirements.

If the well has been previously sampled consistent with this SOP, then the prior purging strategy (e.g., method, pump intake depth and the flow rates) should be followed during subsequent sampling events to maintain consistency and minimize potential variability due to the sampling procedure.

2.2.1 Multiple-Volume Purging Approach

The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization. The field parameters should be recorded at regular volumetric

intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough (e.g., every 3 to 5 minutes) to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

Purge Volume

Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. The specific methodology for obtaining these measurements is included in SOP 004 *Water Level and Product Measurements*.

Once this information is known, the well volume can be calculated using Equation 1:

Well Volume (V) = πr^2 h (cf) **Equation 1**

where:

π = pi (3.14)

r = radius of well in feet (ft)

h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]

cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) and liters/linear foot (L/ft) for common-size wells are as follows:

Well Inside Diameter (inches)	Volume (gal/ft)	Volume (L/ft)
1	0.0408	0.1529
2	0.1631	0.6174
3	0.3670	1.3892
4	0.6524	2.4696
6	1.4680	5.5570

If the volumes for the common-size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f) **Equation 2**

where:

h = height of water column (feet)

f = the volume in gal/ft or L/ft

For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed. The field notes should reflect the single-well volume calculations or determinations according to one of the above methods and a reference to the appropriate multiplication of that volume, (i.e., a minimum of 3 well volumes) clearly identified as a purge volume goal.

For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.

If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. If, after 3 well volumes have been removed, the field parameters have not stabilized (see discussion in Section 2.2.3), additional well volumes (up to a total of 5 well volumes), should be removed. If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging. If, after 5 well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible with respect to turbidity. The conditions of sampling should be noted in the field book.

2.2.2 Low-flow Purging Approach

The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample. The term low-flow refers to the low velocity with which water enters the pump intake during purging and sampling. The objective is to draw representative saturated zone water through the well screen to the pump intake while avoiding disturbance of the stagnant water above the well screen through minimizing drawdown of the water column in the well. To achieve this, the flow rate should be adjusted to less than 1 L/min (usually, this will be a rate less than 500 ml/min and may be as low as 100 ml/min). Once drawdown stabilizes, the sampled water is isolated from the stagnant water in the well casing, thus eliminating the need for its removal. This sampling method is based on the principle that water within the screened zone passes through continuously and does not mix with water above the screen. Water entering the pump can be considered representative of water in the formation after drawdown and indicator parameters have stabilized.

When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval (or center of the water column within the well screen if the water level is below the top of the well screen) to help prevent disturbance of any sediment at the bottom of the well. If known, the pump can be placed adjacent to the areas with the highest hydraulic conductivity or highest level of contaminants. Dedicated pumps can be utilized to minimize disturbance of the water column. Subsequent sampling events should duplicate as closely as possible the pump intake depth and the stabilized flow rate from the previous events.

To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.

The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings. Note any flow rate

adjustments on the Groundwater Field Data Record. Once an appropriate purge rate has been achieved, record this information, continue purging until water quality indicator parameters have stabilized (see Section 2.2.3), and then sample the well.

Attempts should be made to avoid pumping a well dry. If drawdown cannot be maintained at less than 0.3 feet and the falling water level is approaching the top of the screened interval (or the top of the pump for sampling that began with the water level below the top of the screen), perform the following steps:

1. Reduce the flow rate, or turn the pump off and allow for recovery. (The pump must have a check valve to prevent backflow if it is shut off).
2. Begin pumping again at a lower flow rate.
3. If water draws down to the top of the screened interval again (or the top of the pump for sampling that began with the water level below the top of the screen), turn the pump off and allow for recovery.
4. If two tubing volumes (including volume of water in the pump and flow-through cell) have been removed during purging, sampling can proceed the next time the pump is turned on without waiting for indicator field parameters to stabilize. The project-specific work plan or Project Manager should be consulted for guidance.
5. If this procedure is used, this should be recorded in the field book and/or on the Groundwater Field Data Record.

2.2.3 Field Parameter Stabilization During Purging

Stabilization criteria may depend on project objectives or regulatory-specific requirements. Refer to Appendix A for some of the regulatory-specific requirements for field parameter stabilization. Generally, an adequate purge with respect to the ground water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered as stabilized

Other parameters, such as DO, may also be used as a stabilization parameter. Typical stabilization goals for DO are within 0.2 mg/L or 10% saturation, whichever is greater. DO measurements should be conducted using either a flow-through cell or an over-topping cell to minimize or reduce potential oxygenation of the sample.

Because groundwater temperature is generally not very sensitive in distinguishing between stagnant casing water and formation water and is subject to rapid changes during purging, its usefulness is subject to question for the purpose of determining parameter stability. Even if temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters, during well purging, as it may be needed to interpret other parameter results.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

For wells with slow groundwater recovery, attempts should be made to avoid purging the well dry. This may be accomplished by slowing the purge rate. As water enters a well that has been purged dry, the water may cascade down the sand pack and/or the well screen, potentially stripping VOCs that may be present and/or potentially mobilizing soil fines into the re-accumulating water column.

However, even with slower purge rates, in some situations, a well may be pumped or bailed dry (evacuated) during the purging process. In these situations, evacuation generally constitutes an adequate purge and the well may be sampled following sufficient recovery (enough volume to allow filling of all sample containers). **It is not necessary that the well be evacuated three times before it is sampled.** Purging parameters should be measured and recorded during sample collection to serve as the measurements of record for the sampling event.

It is particularly important that wells be sampled as soon as possible after purging to maintain sample representativeness. If adequate volume is available upon completion of purging, the well should be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells that have a slow recovery should be scheduled so that they can be purged and sampled in the same day after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

Temporary Monitoring Wells

Procedures used to purge temporary groundwater monitoring wells may differ from permanent wells, because temporary wells are installed with different DQOs for immediate sample acquisition. Wells of this type may include standard well screens and risers placed in boreholes created by hand augering, power augering, or by drilling. Alternatively, they may consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler, or a Hydropunch® sampler.

Purging to address stagnant water may not necessarily apply to temporary wells, because stagnant water is not typically present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column may become, and the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing saturated conditions, resulting primarily in increased turbidity. Therefore, the goal of purging, if conducted, may be to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and

routinely achieved by the use of low-flow/low-stress purging techniques using variable-speed peristaltic pumps.

2.2.5 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The pump of choice is usually a function of the purging approach (e.g., multiple-volume vs. low-flow), well diameter, the DTW, the total depth of the well, the amount of water that is to be removed during purging, the specific analytical testing program for the well, and the equipment previously used during purging and sampling of the well. A peristaltic pump is appropriate for purging whenever the head difference between the sampling location and the water level is less than the limit of suction (approximately 25' to 30') and the volume to be removed is reasonably small. For wells where the water level is below the limit of suction, and/or where there is a large volume of water to be purged, the variable-speed electric submersible pump or adjustable-rate bladder pumps would be appropriate. Bailers may also be used for purging in appropriate situations (e.g., shallow wells with small purge volumes); bailers are not suitable for low-flow purging.

The following subsections describe well evacuation devices that are most commonly used. Other devices are available but are not discussed in this SOP due to their limited use. Site-specific operating procedures should be developed in the case that an uncommon purge device is used.

2.2.5.1 Purging with a Suction Pump

There are many different types of suction pumps. They commonly include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that incorporates a roller to squeeze flexible tubing, thereby creating suction. This tubing can be dedicated to a well for re-use or discarded. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2 (applicable to peristaltic pumps only).
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.
(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications.
(d) Ensure that the pump tubing is set at the pre-determined pump intake depth.
(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, adjust the rate accordingly or, if consistent with the purging and sampling objectives, lower the tubing further into the well and continue pumping.

(g) Using the water quality meter, take an initial reading of the required indicator parameters. All measurements, except turbidity, must be obtained using a transparent flow-through cell unless an unforeseen situation makes this impractical or inadvisable. Initially, turbidity may be elevated. Once turbidity has decreased to a measurable range, begin monitoring indicator parameters at approximately every 3-5 minutes, or as appropriate. Please note that flow-through cell size should be taken into account in conjunction with the flow rate to determine the length of time between water quality parameter readings. At least one flow-through cell volume should be turned over between readings. For example, if the flow through cell size is 500 mL and the flow rate is 100 mL/min, then it would be appropriate to measure water quality parameters every 5 minutes.

(h) Record the readings on the Groundwater Field Data Record. The monitoring probes must be submerged in water at all times. Record the indicator parameters, along with the water level, as described in Step (g) above. If removing a specified volume of water (e.g., 3-5 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. Stabilization criteria are discussed in Section 2.2.3.

Particulate build-up in the flow-through cell may impact indicator parameters. If the cell must be cleaned during pumping operations, continue pumping and disconnect the cell for cleaning, then reconnect and continue monitoring. Record the start and stop times, and describe the cleaning steps in the field book.

If indicator parameter stabilization is required and parameters have not stabilized after 2-hours of purging (or other pre-determined length of time), one of three options may be taken after consultation with the Project Manager:

1) continue purging until stabilization is achieved;
2) discontinue purging, do not collect any samples, and record in the field book and/or on the Groundwater Field Data Record the stabilization conditions and steps taken to attempt to achieve stabilization; or,
3) discontinue purging, collect samples and document attempts to achieve stabilization.

NOTE: If parameters do not stabilize, or turbidity remains greater than 5 NTU within the project-determined time range (EPA recommends up to 2 hours), contact the Project Manager to develop a modified sampling approach.

(i) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(j) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.2.5.2 Purging with a Submersible Pump

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110-

or 220-volt AC power supply. Those units powered by compressed gas (e.g., bladder pump) normally use a small electric controller that also needs a 12-volt DC battery or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells and the height of the potentiometric surface/water table (e.g., pressure head). It is recommended that 1/4-inch or 3/8-inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.

(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications. If the pump itself is being lowered into the well, ensure a safety line is attached.

(d) Non-dedicated purge/sampling vs. dedicated purge/sampling systems.

Dedicated systems: Pump has already been installed. Refer to historical monitoring well information, and record the depth of the pump intake in the field book and/or on the Groundwater Field Data Record.

Non-dedicated systems: Determine the target depth of the pump intake. Note that this may be a historical intake depth; see well construction data or the project-specific work plan. If there is not an established intake depth, the center of the screened interval should be targeted. If the measured water level is lower than the top of the well screen, position the pump intake at the midpoint of the water column. The intake should be generally 1 to 2 feet above the bottom of the well to minimize potential mobilization of any settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the pump tubing and resulting sample. Slowly lower the pump, safety line, and tubing into the well to the pre-determined pump intake depth. The tubing should be cut to the desired length to assist in installing the pump. Measure the depth of the pump intake while lowering the tubing/pump into location. Record the pump intake depth in the field book and/or on the Groundwater Field Data Record. For deeper wells and large diameter wells, two staff members may be necessary to accomplish this task.

(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Measure the flow rate of the pump with a graduated container and stop watch. The pump pressure may need to be increased for discharge to occur. Record the volume of water collected for a period of 1 minute and calculate the flow rate as follows.

$$Flowrate\,(mL/min) = \frac{volume\,collected\ \ (mL)}{1\,minute}$$

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.

(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.

(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.

(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.

(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).

(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.

(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.

(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).

(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

(a) New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.

(b) If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell or sample from the T-connector, if used. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.

(c) If using bottom-filling bailers,

- Slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling).
- Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.

2.3.1 Sample Collection Order

Fractions of the groundwater sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals); and
6. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

2.3.2 VOC Sample Collection

Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH): Samples for VOCs will be collected first unless they are being collected by the "straw" method described in Section 1.6.2 (d), and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

Note: When using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial, if possible.

When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

2.3.3 Non-VOC Sample Collection

Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.4 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of groundwater from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note “filtered” or “dissolved” on sample label and COC document.

2.4 Groundwater Sample Collection Without Purging (Passive Sampling)

Passive sampling can be defined as the free flow of contaminants from the media being sampled to a receiving phase in a sampling device. Depending upon the sampler, the receiving phase can be a solvent (e.g., water), chemical reagent, or porous adsorbent (e.g., activated carbon). While there are many different types of passive samplers, most have a barrier between the medium being sampled and the receiving phase. The barrier determines the sampling rate that contaminants are collected at a given concentration and can be used to selectively permit or restrict various classes of chemicals from entering the receiving phase.

There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers.

Passive samplers are deployed down a well to the desired depth within the screened interval or open borehole to obtain a discrete sample without using pumping or a purging technique. Most samplers are able to be stacked to obtain samples at multiple depths. Some samplers can also be used to measure contaminants in groundwater as it enters a surface water body.

Diffusion, or equilibrium, samplers are devices that rely on diffusion of the analytes to reach equilibrium between the sampler fluid and the well water. Samples are time-weighted toward

conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Typically, conditions during only the last few days of sampler deployment are represented. Depending upon the contaminant of concern, equilibration times range from a few days to several weeks. Diffusion samplers are less versatile than grab samplers as they are not generally effective for all chemical classes.

Both the diffusion and integrating samplers depend upon permeation or diffusion through barriers that hold the receiving phase. This diffusion process is chemical and barrier specific. Diffusion samplers are commonly known as PDBs or rigid porous polyethylene (RPP) samplers. PDBs may be used to sample for VOCs, and RPPs may be used to sample for various organic and inorganic constituents. PDBs must be allowed to remain in the well for a sufficient period of time to allow the deionized water in the sampler to come into equilibrium with the constituents in the ambient groundwater.

Some regulatory agencies allow groundwater samples to be collected without purging the well. This may be accomplished by suspending a passive sampler in the well for a period of time appropriate for the type of passive sampler being used. It is important to confirm that the chosen sampler is compatible with the contaminants of concern including all VOCs of interest at the site.

Diffusion passive samplers are used most commonly and the procedure for their use is as follows:

(a) Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.

(b) New passive samplers are attached via PVC cable ties to a tether (a pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well. There should be sufficient well screen saturation within the well to completely cover the passive sampler. For VOCs, it is recommended that there should be several feet of groundwater above the top of the PDB.

(c) The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers). Longer equilibration times may be necessary in lower permeability formations. Once sufficient time for equilibration has passed, the PDB samplers can be retrieved when convenient.

(d) Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.

(e) Detach the passive sampler from the tether.

(f) Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

(g) Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. Tilting the passive

sampler will control the flow rate. The VOA vials must be filled within the first several minutes of passive sampler retrieval. (Note that sample vials should be prepared and opened on a stable surface or holding device such as a foam pack. Decanting sample from passive samplers into containers requires techniques that may require some practice and patience.) Refer to Section 2.3.2 for special circumstances regarding the filling of VOA vials.

(h) A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.

(i) Dispose of the passive sampler after use.

2.5 Post-sampling Activities

(a) Cease pumping and, if system is non-dedicated, disassemble and decontaminate the purging and sampling equipment. Verify the end of the tubing is not submerged in the purge bucket prior to turning off the pump.

(b) Dispose of the bailer (if disposable) and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the bailer in a plastic bag for transport to the site decontamination area.

(c) Dispose of the empty passive sampler and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the empty passive sampler in a plastic bag for transport to the site decontamination area

(d) Replace the well cap and well cover on the well and lock the outer casing (if present).

(e) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.

(f) Place all samples in a cooler with ice.

(g) Ensure samples are delivered to the laboratory well before the required holding time expires.

(h) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of QC samples is dependent upon the DQOs. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of groundwater samples:

(a) For QC purposes, each duplicate sample will be typically submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for groundwater sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Groundwater Field Data Record.

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, and filtered inorganic constituents), the duplicate sample containers will be alternately filled with groundwater for each parameter.

(c) All collection and preservation procedures outlined for groundwater sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is run through the bailer (if not disposable), rope, leader line, decontaminated pump, a representative section of the pump's tubing, or any other piece of sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. If dedicated or disposable systems are used, equipment blanks are not required, although an initial blank could be performed to demonstrate that the dedicated equipment is clean prior to use. If only dedicated tubing is used, the equipment blank will include only the pump in subsequent sampling events. A passive sampler is considered a dedicated device and no equipment blank is required.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 MS/MSDs and MS/Duplicates

MSs are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. MSDs are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the Comments column of the COC document.

4.5 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book and/or the Groundwater Field Data Record. The Groundwater Field Data Record (Attachment B) should be used to record the following information:

- Volume of each sample
- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling
- Field parameters such as water level, pH, temperature, conductivity, turbidity, ORP, and DO
- Sample collection equipment and method used
- Decontamination procedures
- Analytical parameters
- Preservation method and amount of preservative

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

Interstate Technology Regulatory Council (ITRC). March 2006. *Technology Overview of Passive Sampler Technologies.*

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. April 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA Ground Water Issue. EPA/540-S-95-504. USEPA Office of Solid Waste and Emergency Response.

USEPA. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. EPA/542-S-02-001. USEPA Office of Solid Waste and Emergency Response.

USEPA. September 2004. Field Sampling Guidance Document #1220: Groundwater Well Sampling. USEPA Region 9 Laboratory Richmond, California.

USEPA, January 19, 2010. *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. USEPA Region 1, Rev. 3.

USEPA. March 6, 2013. *Groundwater Sampling.* SESDPROC-301-R3. USEPA Region 4, Science and Ecosystem Support Division. Athens, Georgia.

USEPA. April 22, 2014. Passive (No Purge) Samples. http://www.clu-in.org/characterization/technologies/default.focus/sec/Passive_%28no%20purge%29_Samplers/cat/Overview/

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2018	NOT APPLICABLE

Attachment A:

Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions

Jurisdiction	Information Source	Applicable Stabilization Criteria
USEPA Region 1	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells; U.S. Environmental Protection Agency Region 1, January 19, 2010. http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf (for low flow PDF) http://www.epa.gov/region1/lab/qa/qualsys.html (for EPA's Quality System Documents)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% if >5 NTUs; if three Turbidity values are <5 NTU, consider the values as stabilized Dissolved Oxygen: ±10% if >0.5 mg/L, if three Dissolved Oxygen values are <0.5 mg/L, consider the values as stabilized Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 2	Groundwater Sampling Procedure: Low Stress (Low Flow) Purging and Sampling, SOP # SST-7, Revision No. 1, November 2010.	Same as above
USEPA Region 4	USEPA Region 4 SOPs: http://www.epa.gov/region4/sesd/fbqstp/index.html See Chemical Parameter Stabilization Criteria (section 3.2.1.1.2 of Groundwater Sampling SOP, revision 3/6/2013: http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Sampling.pdf	pH: ±0.1 unit Specific Conductance: ±5% Temperature: Not used Turbidity: "Stabilized" (no criteria specified) if >10 NTUs ; if three Turbidity values are <10 NTUs, consider the values as stabilized Dissolved Oxygen (optional parameter): ±0.2 mg/L or ±10% of saturation, whichever is greater Oxidation/Reduction Potential: Not used
USEPA Region 5	Ground Water Forum Issue Paper (May 2002, Yeskis and Zavala) http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf A minimum set of parameters would include pH, conductivity, and turbidity or DO. Puls and Barcelona, 1996 (pH, specific conductance, ORP, turbidity) Wilde et al., 1998 (pH, turbidity, DO)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: Not used Turbidity: ±10% if >10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 9	See USEPA Region 1 (above)	
USEPA Region 10	See USEPA Region 5 (above)	
Alabama	Alabama Environmental Investigation and Remediation Guidance (section C.3.1) http://www.adem.state.al.us/MoreInfo/pubs/AEIRGInvestigation.pdf	pH: ±0.1 unit Specific Conductance: ±10% Temperature: "Constant" (no criteria specified) Turbidity: Stabilized (no criteria specified), or <10 NTUs Dissolved Oxygen: No criteria specified Oxidation/Reduction Potential: No criteria specified

Jurisdiction	Information Source	Applicable Stabilization Criteria
Indiana	Indiana Department of Environmental Management The Micro-Purge Sampling Option http://www.in.gov/idem/files/remediation_tech_guidance_micro-purge.pdf The parameters normally measured for stability (listed in increasing order of sensitivity) are pH, temperature, specific conductivity, oxidation-reduction potential, DO and turbidity. At least one of the last three listed must be used.	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% Dissolved Oxygen: ±10% Oxidation/Reduction Potential: ±10 millivolts (document says microvolts, but that may be an error)
Michigan	MDEQ Part 201 Op Memo 2, Attachment 5 http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_2_Attachment5_249853_7.pdf	No specific values to determine stabilization are listed, but the Op Memo lists several other groundwater sampling guidance documents. If a valid reference exists, then it can be used to justify a sampling approach and stabilization parameters.
New Jersey	New Jersey Department of Environmental Protection http://www.state.nj.us/dep/srp/guidance/fspm/	pH: ± 0.1 unit Specific Conductance: ± 3% Temperature: ± 3% Dissolved Oxygen: ± 10% Turbidity: ± 10% for values greater than 1 NTU ORP/Eh: ± 10 millivolts
Ohio	Ohio EPA SOPs: http://www.epa.state.oh.us/portals/30/rules/FSOPs.pdf See Purging Stabilization Criteria (SOP 2.2.4, dated January 2, 2007, review in progress)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: No criteria specified Turbidity: Below 10 NTUs ideal; ±10% if greater than 10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
This table was last updated in July 2014.		

Attachment B:

Example Groundwater Field Data Records

Groundwater Field Data Record	Project:	Project No.:	Date/Time:	Sheet ___ of ___
	TRC Personnel:		Well ID:	

WELL INTEGRITY

	YES	NO
Protect. Casing Secure		
Concrete Collar Intact		
PVC Stick-up Intact		
Well Cap Present		
Security Lock Present		

Sampling Equipment: _____

Flow-thru Cell Volume: _____

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up _____ ft. (from ground)

Riser Stick-up (from ground) _____ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch

Other: _____

WELL MATERIAL

☐ PVC ☐ SS

Other: _____

Well Depth _____ ft. ☐ top of riser ☐ top of casing ☐ _____ ☐ measured ☐ historical

Water Depth _____ ft.

Well Volume _____

LNAPL/DNAPL Depth = _____

NAPL Thickness = _____

Depth of pump intake: _____

Static water level after pump put into well: _____

Initial purge Rate/ Water Level (100-400 ml/min): _____

Adjusted purge Rates/time/WL(record changes)

Flow rate at time of sampling: _____

Total volume of water purged: _____

FIELD WATER QUALITY MEASUREMENTS (record at appropriate intervals)

Time									
Temp. (°C)									
Conduct. (µmhos/cm)									
DO (mg/L)									
pH (su)									
ORP (millivolts)									
Turbidity (NTU)									
Flow (ml/min)									
Depth To Water (ft)									
Cumulative Purge Vol. (gal or L)									

Time						
Temp. (°C)						
Conduct. (µmhos/cm)						
DO (mg/L)						
pH (Std. Units)						
Eh/ORP (millivolts)						
Turbidity (NTU)						
Flow (ml/min)						
Depth To Water (ft)						
Cumulative Purge Vol. (gal or L)						

Stabilization Criteria*
(3 consecutive readings)

- Temperature: ± 3 %
- Conduct. (µmhos/cm): ± 3 %
- DO (mg/L): ± 10 % (for values >0.5 mg/L)
- pH (Std. Units): ± 0.1 SU
- ORP (millivolts): ± 10 mV
- Turbidity (NTU): +/- 10 % (for values >5.0 NTUs)
- Drawdown: < 0.3 ft (can be greater as long as water level stabilizes above well screen)

	Purge	Sample
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bladder Pump	☐	☐
Bailer	☐	☐
Other: _____	☐	☐

Comments: _____

Analytical Parameter	Filtered (Y/N)	Preservation	# Bottles	Size/Type Bottles	Time Collected	QC	Sample #

* Consult the applicable regulatory guidance for the specific criteria.

Signed: _____

Rev: April 2014

WATER SAMPLE LOG

PROJECT NAME:		PREPARED		CHECKED	
PROJECT NUMBER:		BY:	DATE:	BY:	DATE:

SAMPLE ID:	WELL DIAMETER: ☐ 2" ☐ 4" ☐ 6" ☐ OTHER _____
WELL MATERIAL:	☐ PVC ☐ SS ☐ IRON ☐ GALVANIZED STEEL ☐ OTHER _____
SAMPLE TYPE:	☑ GW ☐ WW ☐ SW ☐ DI ☐ LEACHATE ☐ OTHER _____

PURGING	TIME:	DATE:	SAMPLE	TIME:	DATE:

PURGE METHOD:	☐ PUMP _____	PH: _____ SU	CONDUCTIVITY: _____ umhos/cm
	☐ BAILER _____	ORP: _____ mV	DO: _____ mg/L
DEPTH TO WATER:	_____ T/ PVC	FLOW-THRU CELL VOLUME	TURBIDITY: _____ NTU
DEPTH TO BOTTOM:	_____ T/ PVC		☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY
PUMP INTAKE DEPTH:	_____ T/ PVC	_____ LITERS	TEMPERATURE: _____ °C OTHER: _____
WELL VOLUME:	_____ ☐ LITERS ☐ GALLONS		COLOR: _____ ODOR: _____
VOLUME REMOVED:	_____ ☐ LITERS ☐ GALLONS		FILTRATE (0.45 um) ☐ YES ☐ NO
COLOR:	_____ ODOR: _____		FILTRATE COLOR: _____ FILTRATE ODOR: _____
TURBIDITY			QC SAMPLE: ☐ MS/MSD ☐ DUP- _____
☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY			COMMENTS:
DISPOSAL METHOD:	☐ GROUND ☐ DRUM ☐ OTHER		

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

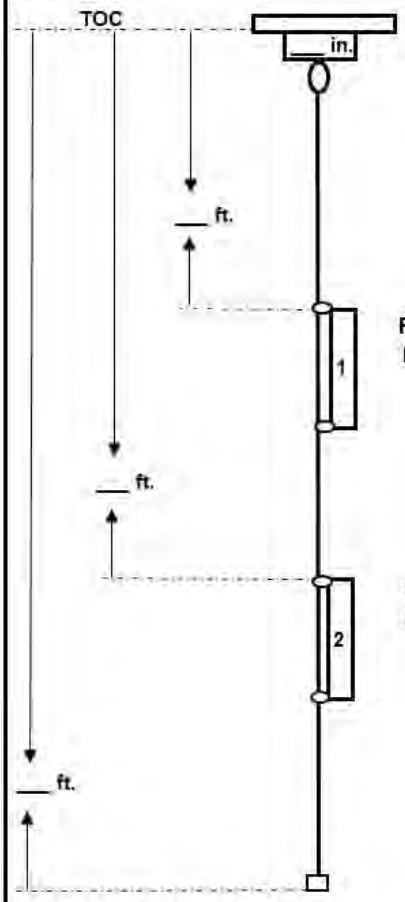
BOTTLES FILLED	PRESERVATIVE CODES	A - NONE	B - HNO3	C - H2SO4	D - NaOH	E - HCL	F - _____

NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD:	_____	DATE SHIPPED:	_____	AIRBILL NUMBER:	_____
COC NUMBER:	_____	SIGNATURE:	_____	DATE SIGNED:	_____

Groundwater Sampling Record for Organics (For Wells with Passive Diffusion Bags)	Project Name/No:	Well ID:

Installation of PDBs:	Sampling of PDBs:
TRC Personnel: _____	TRC Personnel: _____
Date: _____	Date: _____
Time: _____	DTW (ft): _____
DTW (ft): _____	



PDB #1
Length: ___ in.

Sample ID: _____
Sample Time: _____
Evidence of algae, iron or other coatings?: _____

PDB #2
Length: ___ in.

Sample ID: _____
Sample Time: _____
Evidence of algae, iron or other coatings?: _____

Measured well depth during tether installation: ___ ft.

Field Notes:

Rev: April 2014

Title: **Equipment Decontamination**	Procedure Number: **SOP 010**
	Revision Number: **0**
	Effective Date: **August 2018**

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct personnel in the procedures needed for decontamination of equipment used in the field during environmental investigations (e.g., sediment, soil, groundwater investigations). Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination.

The use of dedicated, disposable, new sampling equipment (e.g., disposable liners, plastic spoons, plastic or aluminum bowls) should be considered as an alternative to equipment decontamination and the subsequent generation of decontamination fluids.

1.2 Summary of Method

Equipment decontamination is used to remove potential contaminants from a sampling device or piece of field equipment prior to and between the collection of samples and is also used to limit personnel exposure to residual contamination that may be present on used field equipment.

Contaminants can be physically removed from equipment or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and nonabrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water, followed by a wash/rinse process using appropriate cleaning solutions. A solvent rinse may be required when organic contamination is present, and an acid rinse may be required when metals are parameters of interest. Equipment decontamination procedures can vary depending on the media being sampled and the type of sampling equipment being used. Disposal of decontamination fluids will be handled on a project-specific basis and will be in accordance with all applicable regulations.

1.3 Equipment

The following equipment may be utilized when decontaminating equipment. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap

- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate (may be supplied by the laboratory or purchased from commercial vendors depending on project requirements)
- Pump sprayer
- Pressure sprayer
- Squeeze bottle filled with pesticide-grade hexane (option for organic analyses)
- Squeeze bottle filled with pesticide-grade methanol (option for organic analyses)
- Squeeze bottle filled with pesticide-grade isopropanol (option for organic analyses)
- Squeeze bottle filled with 10 percent nitric acid (option for metals analyses and stainless-steel equipment)
- Squeeze bottle filled with 1 percent nitric acid (option for metals analyses)
- Container (squeeze bottle to 5-gallon bucket) filled with potable water and a nonphosphate, laboratory-grade soap (approximately 1 tablespoon of soap to 5 gallons of water)
- Extra quantities of above listed liquids
- Potable water
- Containers, such as buckets or wash basins (the type and number of containers is dependent on the procedure)
- Scrub brushes
- Small wire brush
- Aluminum foil
- Polyethylene sheeting
- A container for decontamination of pumps and associated tubing.

1.4 *Health & Safety Considerations*

Personnel shall follow the site-specific HASP and use the appropriate level of PPE as defined in the HASP and by site policies. Samples containing chemical contaminants may be handled during implementation of this SOP. Certain decontamination fluids, including solvents and/or acids, are considered hazardous materials, and personnel will appropriately handle and store them at all times. Appropriately manage chemicals that pose specific toxicity or safety concerns, and follow any other relevant requirements as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Some hazardous substances may be incompatible with clothing or equipment and can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through inhalation or skin contact or if exposed to heat/flame and they combust. Safety data sheets for chemicals handled by personnel should be maintained in a designated location at the project site.

1.5 Cautions and Potential Problems

- The use of deionized, distilled or organic-free water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been certified by the vendor as analyte-free and/or meets the project-specific requirements.

- Alconox®, Liquinox®, or other nonphosphate, concentrated, laboratory-grade soap may contain trace quantities of perchlorate.

- Avoid using an excessive amount of soap during decontamination procedures, as this could result in difficulty rinsing the soap residue off of the equipment. Typically the soap solution is prepared using 1 tablespoon of soap to 5 gallons of water.

- Use sufficient amount of decontamination fluid (e.g., acid or solvent rinses) so that the fluid flows over the equipment and runs off. Spraying the equipment with a minimal amount of decontamination fluid that does not run off is ineffective.

- Spent decontamination solutions are considered investigation-derived waste (IDW) and must be managed as directed by the site-specific field program. Project and regulatory requirements, chemical compatibility, ambient conditions and professional judgment should be used to determine the appropriate decontamination process with respect to combining and/or segregating decontamination fluids. Section 3 of this SOP provides more guidance on the disposal procedures.

- Several procedures can be established to minimize the potential for cross-contamination or analytical interference by decontamination fluids. For example:

  - The use of methanol in the decontamination procedure may not be appropriate if methanol is a contaminant of concern.

  - Isopropanol may be used as a substitute for methanol but may not be appropriate when collecting samples for volatile organic compound (VOC) analyses. Residual isopropanol on the equipment may cause substantial interferences in subsequent VOC analyses and may result in unnecessary dilutions and/or false positive results if isopropanol is not removed in subsequent decontamination steps. It should also be noted that the application of isopropanol to hot metal surfaces (e.g., a steam-cleaned split spoon) may cause oxidation of the isopropanol to acetone.

  - If hexane is used in the decontamination procedure, caution should be used to ensure that the hexane is completely volatilized and the equipment is subsequently rinsed when samples are to be analyzed for VOCs and volatile petroleum hydrocarbons (VPH). Residual hexane on equipment could interfere with the VOC and VPH analyses and may result in unnecessary dilutions and/or false positive results.

  - Cover monitoring and sampling equipment with protective material (i.e., aluminum foil, polyethylene sheeting, or Ziploc® bags) to minimize potential re-contamination after decontamination.

- Use disposable sampling equipment when appropriate to minimize the need for decontamination. Although disposable sampling tools are encouraged in order to minimize the generation of decontamination fluids, it should be noted that plastic tools may not be appropriate for collection of samples to be analyzed for semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Potential phthalate contamination may cause significant interferences in the subsequent analyses and may result in unnecessary dilutions and/or false positive results.

- After decontamination, equipment should be handled only by personnel wearing clean disposable powder-free nitrile gloves to prevent recontamination.
- If equipment decontamination is performed in the field, the equipment should be moved away (preferably upwind) from the decontamination area to prevent recontamination.
- Equipment that is not decontaminated properly may result in potentially high biased results in field samples. **Note:** Equipment blank collection may be appropriate after decontamination of equipment used to collect highly contaminated samples.

1.6 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Refer to the site-specific sampling plan and/or Quality Assurance Project Plan (QAPP), if applicable, for site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field notes.

2.1 General

All personnel, sample containers, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants by abrasive and/or washing actions, inactivate contaminants by disinfection or sterilization, or both. Decontamination procedures should be documented in the field book.

2.2 Physical Decontamination Procedures

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and nonabrasive methods. In general, heavy equipment decontamination is conducted by drilling and construction subcontractors and not by sampling personnel. However, sampling personnel will typically need to document such decontamination efforts as part of project work.

ABRASIVE CLEANING METHODS APPROPRIATE FOR DRILLING EQUIPMENT (DRILLING RIGS, ETC.)

Abrasive cleaning methods involve rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available but are not commonly used:

- *Mechanical:* Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- *Air Blasting:* Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs, or auger bits. The equipment used in air blasting employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive material strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages, including it is unable to control the amount of materials removed, it can aerate contaminants, and it generates large amounts of waste.

- *Wet Blasting:* Wet blasting, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. One disadvantage of this method is the generation of a large amount of waste.

NONABRASIVE CLEANING METHODS APPROPRIATE FOR FIELD EQUIPMENT (DRILLING AUGERS AND RIGS, ETC.)

Nonabrasive cleaning methods involve forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using nonabrasive methods. The following non-abrasive methods are available:

- *High-pressure Potable Water:* This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high-pressure hose. Flow rates typically range from 20 to 140 liters per minute.

  This procedure is used the majority of the time and is more appropriate for equipment with painted surfaces.

- *Ultrahigh-Pressure Potable Water:* This system produces a pressurized water jet. The ultrahigh-pressure spray removes tightly adhered surface film. The water velocity ranges from 500 meters per second (m/sec) to 900 m/sec. Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

  This procedure is not commonly used but would be appropriate for carbon steel drilling rods and augers.

2.3 Procedure for Sampling Equipment

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure**.** **Note:** The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. The number of decontamination steps and designated containers should be determined prior to field sampling based on the site-specific sampling plan. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. If more than one, the nonwater rinsate fluids may need to be separated. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. Place the containers on the polyethylene sheeting. The decontamination line should progress from “dirty” to “clean”.

   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.

2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container. Do not use an excessive amount of the soap (approximately 1 tablespoon of soap to 5 gallons of water), or rinsing the soap residue off of the equipment will be difficult.

3. Brush any visible dirt off of the sampling equipment into a designated area before getting equipment wet.

4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container, removing all dirt or visible hydrocarbons. Allow excess soap to drain off the equipment into the container when finished. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

5. Rinse the equipment with potable water over an appropriate container, using a coarse scrub brush or pressure sprayer to aid in the rinse if necessary. If an additional acid or solvent rinse is not required, proceed to Step 8.

6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to

minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.

Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Cautions and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.

   Allow the equipment to completely air dry prior to proceeding to the next step.

   **** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.**

8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container) (See*NOTE).

   ***NOTE** that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field book or on the appropriate form.

10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.

11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

12. Record the decontamination procedure in the field book or on the appropriate form.

2.4 Procedure for Measuring Equipment

Measuring equipment, such as pressure transducers, water level indicators, oil/water interface probes, and soil moisture/pH meters will be cleaned using the following procedure, unless it conflicts with the manufacturer's recommendations.

1. Fill two clean containers (e.g., plastic wash basins or buckets) with potable water.

2. Add sufficient nonphosphate concentrated laboratory-grade soap to one container to form a thin layer of soap suds. If oily residues are apparent, the use of Simple Green® may be required.

3. Brush any visible dirt off of the measuring equipment before getting the equipment wet.

4. Either spray rinse the device with the soap solution over the first container, or for heavily soiled equipment, immerse the device in the container containing soap and gently agitate. Scrub device if it is soiled. Do not submerse any electrical controls or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

5. Immerse the device in the container containing the potable water and gently agitate. Do not submerse any electrical connectors or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

6. Spray rinse equipment with deionized, distilled, or organic-free water over the last container used.

7. Allow the equipment to air dry if time allows.

8. Record the decontamination procedure in the field book or on the appropriate form.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for IDW disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the equipment blank. The equipment blank provides information about the effectiveness of the decontamination process employed in the field. An equipment blank can detect contamination that may arise from potentially contaminated equipment or equipment that has not been decontaminated effectively.

Equipment blanks consist of a sample of analyte-free (i.e., deionized, distilled, organic-free) water that is poured over and through a decontaminated sampling device and placed in a clean sample container. Ideally, the reagent water should come from the laboratory and be certified as clean. If the blank water is not certified as clean and/or not supplied by the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should also be sent to the laboratory for analysis.

Equipment blanks are typically collected for all parameters of interest at a minimum rate of 1 per 20 samples for each parameter. The frequency of equipment blank collection will vary from project to project, depending upon the data quality objectives, and will be specified in either the site-specific sampling plan or QAPP. Equipment blanks are typically not required if dedicated sampling equipment is used.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or on the appropriate form. Any deviations from the decontamination procedures specified in the sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field book. Refer to SOP 001 for field documentation procedures.

6.0 REFERENCES

USEPA. December 1987. *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001.

USEPA. January 1991. *Compendium of ERT Groundwater Sampling Procedures*. OSWER Directive 9360.4-06. PB91-9211275.

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. January 1999. *Compendium of ERT Groundwater Sampling Procedures*. EPA/540/P-91/007. OSWER Directive 9360.4-06. PB91-921275.

USEPA. December 20, 2011. *Field Equipment Cleaning and Decontamination*. SESDPROC-205-R2. Region 4. Science and Ecosystems Support Division. Athens, Georgia.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	APRIL 2014	NOT APPLICABLE

Title: **Calibration of Field Instruments for Water Quality Parameters**	Procedure Number: **SOP 011**
	Revision Number: **0**
	Effective Date: **August 2018**

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LIST OF ATTACHMENTS

Attachment A Oxygen Solubility at Indicated Pressure
Attachment B Example Field Instrument Calibration Logs

1.0 INTRODUCTION

1.1 Scope and Applicability

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for ground water and surface water. Water quality instruments addressed in this SOP include those that measure temperature, pH, dissolved oxygen (DO), conductivity/specific conductance, oxidation-reduction potential (ORP), and turbidity.

1.2 Summary of Method

All monitoring instruments must be calibrated before they are used to measure environmental samples. This SOP outlines the general methods for field instrument calibration, calibration documentation requirements, and corrective action procedures that will be implemented during field activities. Calibration procedures are different for each field instrument used and these procedures should be provided by the instrument manufacturer. The manufacturer's instruction manual (including the instrument specifications) should accompany the instrument into the field.

At a minimum, calibration and/or a calibration check must be performed at the beginning of each day prior to use. Site-specific work plans should be consulted for required calibration frequency. Note: The initial calibration may be performed in the office prior to the field event or by the equipment supplier; however, calibration checks should be performed on site prior to use on the day of the fieldwork.

1.3 Equipment

The following equipment may be utilized when calibrating water quality parameter measuring equipment. Project-specific conditions or laboratory requirements may warrant the addition or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP).
- Water quality meter capable of measuring one or more of the following based on project scope: pH, temperature, DO, specific conductivity, and ORP (e.g., YSI 600XL, Horiba U-50, Hydrolab Quanta/QED MP-20, or equivalent)
- Turbidity meter (e.g., LaMotte Model 2020e, Hach 2100P, or equivalent)
- Deionized water
- Flow-through cell
- Ring stand with clamp
- Paper towels
- Soft tissue (e.g., Kimwipes®)
- Cuvettes

- Buffer solutions at pH 4, 7 and 10 standard units (SU)*. Commercially available solutions that have been validated by comparison to National Institute of Standards and Technology (NIST) standards are recommended for routine use.
- Conductivity solution (potassium chloride, typically 1,413 micromhos/centimeter [µmhos/cm])*
- ORP calibration solution (e.g., Zobell)*
- Turbidity standards (0, 1, 10 nephelometric turbidity units [NTUs] or StablCal Kit)*
- Zero DO solution (0.0 milligrams per liter [mg/L])*
- DO membrane kit (electrolyte solution, membranes)
- NIST thermometer (0.2ºC accuracy)*
- Small glass or polyethylene jars to hold the calibration standards (4-8 oz.)
- Field book
- Field instrument calibration logs
- Cup or spray bottle for the deionized water

*Dependent on the project-specific requirements and the instrument manufacturer

1.4 Definitions

Not applicable

1.5 Health & Safety Considerations

Personnel shall follow the site-specific HASP and use the appropriate level of PPE as defined in the HASP and by site policies.

Implementing this SOP will require the use of calibration solutions. The following health and safety precautions must be taken with the pH, conductivity, turbidity, zero DO and ORP solutions: Avoid inhalation, skin and eye contact, and ingestion.

Maintenance of the instruments will require the use of liquid cleaners. Although these substances are not hazardous materials, sampling personnel will appropriately handle and store them at all times in accordance with manufacturer's instructions.

1.6 Cautions and Potential Problems

General cautions and potential problems are discussed below. Specific issues for individual parameters are discussed in Section 2.

- Prior to calibration, all instrument probes must be cleaned according to the manufacturer's instructions. Failure to perform this step (proper maintenance) can lead to erroneous measurements. Rental instruments are routinely maintained by the vendor but should be checked for residues upon receipt.

- Prior to using calibration standards, check and record all expiration dates and lot numbers for the solutions on the field instrument calibration log. Discard any calibration standards that are past their expiration date.
- Avoid storing calibration solutions in extremely hot or cold temperatures to maintain solution integrity and prevent calibration errors.
- The volume of the calibration solutions must be sufficient to cover both the probe being calibrated and the temperature sensor (see manufacturer's instructions for additional information).
- Pre-rinse the sensor and calibration cup with a small amount of calibration solution to minimize dilution or cross-contamination.
- If desired, use a ring stand and clamp to secure the sonde in an upright position. This will prevent the sonde from falling over and damaging the probes.
- While calibrating or performing sample measurements, make sure there are no air bubbles lodged between the probe and the probe guard.
- Do not immerse the sensors in sea water or other highly saline water, alcohol or organic solvents.
- Problems during calibration may indicate the need to clean or replace sensors, electrodes or membranes or replace the calibration solutions.
- Have several clean absorbent paper towels or cotton cloths available to dry the probe between rinses and calibration solutions. Shake excess water off of the probes and dry off the outside of the probe sensors.
- All meters may have different relative accuracy, which will be specified in the instrument manual. Confirm that the meter being used meets the project's accuracy requirements.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Prior to use, instruments that will be used during field activities will be inspected to ensure they are clean, checked for possible malfunctions, and calibrated in accordance with manufacturer's

procedures. Often, equipment provided by a rental company is calibrated prior to shipment, and a calibration certificate is provided with the equipment. Review the calibration certificate provided by the equipment supplier.

Calibration checks (or verifying that instrument readings fall within an acceptable range of a standard without running through the full instrument calibration steps) will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of faulty readings or instrument malfunction occurs. Some instruments or certain project scopes may require more frequent calibration checks depending on project quality objectives. In general, instrument selection and calibration will include the following steps:

- Determine which instruments are needed for the specific field tasks. Record the make, model number, and serial number of the instrument on the field instrument calibration log or in the field book.
- Obtain the necessary instruments and standard solutions for calibration. Check expiration dates on standard solutions and replace if out of date. Record the manufacturer, true value, lot number and expiration date of the standard solutions on the field instrument calibration log or in the field book.
- Assemble the instrument and turn it on allowing the instrument to warm up.
- Check battery charge, and charge or replace if necessary.
- Clean instrument (if necessary).
- If applicable, program the multi-probe instrument so that the applicable parameters to be measured will be displayed.
- Calibrate the instrument prior to field use in accordance with manufacturer's procedures. (Note: If applicable, calibrate DO and conductivity first, because these parameters may affect the other calibrations).
- Document all calibration activities and results on the field instrument calibration log or in the field book.
- If the instrument malfunctions and cannot be corrected, obtain a replacement.
- Clean and decontaminate the instrument after use and before storage.
- Conduct calibration checks at least once per day or as needed.

The subsections that follow provide additional details and guidance regarding calibration for specific parameters; however, since every field instrument is different, refer to the specific instrument's manual for appropriate operating and calibration procedures.

2.1 Temperature

Most instrument manuals state that calibration of the temperature sensor is not required, but this SOP recommends that the temperature sensor be checked to verify its accuracy. This accuracy check should be performed at least once per year and the accuracy check date/information should be kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was performed over a year prior to the date of use, it is recommended that the temperature sensor accuracy be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor should be checked. Accuracy checks may be performed by the manufacturer/equipment supplier or in the field. Review the calibration certificate provided by the equipment supplier.

In the event of suspect temperature readings, the following verification procedure can be performed.

FIELD VERIFICATION PROCEDURE

1. Record the manufacturer, model number, and the certification number of the NIST thermometer being used to check the instrument's temperature sensor on the field instrument calibration log or in the field book. Allow a container filled with water to equilibrate to ambient temperature.

2. Place an NIST thermometer and the instrument's temperature sensor into the water, and wait approximately 2 to 3 minutes for both temperature readings to stabilize.

3. Record the temperature displayed by the thermometer and the temperature sensor on the field instrument calibration log or in the field book.

4. Compare the two measurements. The instrument's temperature sensor must agree with the NIST thermometer measurement within the accuracy of the sensor (typically $\pm$0.15ºC). If the measurements do not agree, determine the correction factor to be applied to any subsequent temperature measurements made with this instrument. This correction factor must be applied to all readings made with the temperature sensor of this instrument.

   Correction Factor = NIST thermometer value – temperature sensor value

5. Record the date the temperature sensor check was performed and the correction factor that was determined, if applicable, on the field instrument calibration log or in the field book.

2.2 Dissolved Oxygen

DO is the volume of oxygen that is dissolved in water and is typically measured using an electrochemical membrane sensor.

CAUTIONS AND POTENTIAL PROBLEMS WITH DO MEASUREMENTS

- The DO probe's membrane and electrolyte solution should be checked prior to the sampling period and replaced if needed. If wrinkles or air bubbles are present under the membrane, if the membrane is torn or dirty, or if the electrolyte solution looks contaminated, replace both the membrane and electrolyte solution prior to calibration. Failure to perform this step may lead to erratic or erroneous measurements.
- Rental instruments are routinely maintained by the vendor, but the membrane should be checked for signs of wear upon receipt.
- If the probe reading shows the error message, "value out of range", the instrument probe must be recalibrated at a minimum. If the error persists, replace the sensor membrane and recalibrate.
- Most meters will allow you to calibrate the meter in air or against a wet sponge, which gives a "saturated air" calibration. Like pH, conductivity, and ORP, DO is heavily dependent on temperature. DO is also dependent upon barometric pressure. Typically DO is calibrated by entering the barometric pressure (usually in mm of mercury).

Barometric pressure is dependent upon elevation, so be aware of substantial differences in elevation between your sampling location and the location from which you are obtaining the barometric pressure reading. Use the Oxygen Solubility at Indicated Pressure chart in Attachment A for comparison to your calibrated reading.

- Barometric pressure should be corrected to local altitude for DO calibration:

  True BP (mm Hg) = [Corrected BP (mm Hg)] – [2.5 * Local Altitude (ft. above sea level)/100]

- If the calibration cup is used for DO, ensure the cup is loose to allow for pressure equilibration.
- Wait 3 to 5 minutes for the air in the cup to saturate with water during DO calibration.
- If calibrating in air, remove water droplets from the membrane by shaking the probe prior to inserting it into the calibration environment.
- Allow the temperature to stabilize completely in the calibration environment.
- Always keep the sensor clean of biofouling, such as bacteria or algae growth which may generate or consume oxygen resulting in erroneous readings.
- Keep the sensor free of oil, which could clog the membrane and prevent oxygen from diffusing to the sensor.
- Store the probe in a moist environment to keep the membrane from drying out, but do not store it in water which could encourage algae growth on the probe.

CALIBRATION PROCEDURE

1. Gently dry the temperature sensor according to manufacturer's instructions.

2. Place a wet sponge, a wet paper towel, or 1/8 inch of water on the bottom of the DO calibration container that comes with the instrument. (The protective cover of the probe assembly also serves as the container used for the DO calibration.)

3. Place the DO probe in the container without the probe coming in contact with the wet sponge or paper towel. The probe must fit loosely in the container to ensure it is vented to the atmosphere.

4. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 3 to 5 minutes as temperature becomes stable). During this time, turn on the instrument to allow the DO probe to warm up (may require at least 10-20 minutes warm-up time).

5. Record the barometric pressure (usually in mm of mercury) from the instrument's onboard sensor, if available. If the instrument does not have an onboard barometer, this measurement can also be determined from an on-site barometer if a weather station is on site and manually entered into the meter. It is recommended that the barometric pressure not be obtained from the local weather service unless the pressure is corrected for the elevation of the sampling location and this is the only source of barometric data. [**Note:** inches of mercury times 25.4 mm/inch mercury equals mm of mercury].

6. Record the DO reading in mg/L and percent and compare this reading to the Oxygen Solubility at Indicated Pressure chart in Attachment A. For example, if the barometric pressure is 750 mm Hg and the temperature inside the calibration cup is 25ºC, the DO in mg/L reading should be 8.13 mg/L. Record this value on the field instrument calibration log.

7. If the values recorded on the field instrument calibration log for DO in mg/L do not agree with the published values from Attachment A and are not within the accuracy of the instrument (such as ± 0.2 mg/L and ± 2%, depending on the reading), repeat calibration. If this does not work, change the membrane and electrolyte solution and repeat calibration.

8. Remove the probe from the container, rinse it with deionized water, pat it dry with a towel, and place it into a zero (0.0 mg/L) DO standard if being used as part of the calibration. Fill the protective cup with the fresh zero DO standard. Pour the zero DO standard into the protective cup; the standard should be close enough to the top, so that the DO probe fits tightly into the container (no headspace). Check and record the unit's temperature reading.

9. Wait until the "mg/L DO" readings have stabilized. The instrument should read between -0.5 and +0.5 mg/L or to the accuracy of the instrument (usually ± 0.2 mg/L) within 3 minutes. Record this value on the field instrument calibration log. If the instrument does not reach this value, it may be necessary to clean the probe and change the membrane and electrolyte solution. Repeat the zero DO step if the value obtained is not acceptable. If this does not work, prepare a new 0.0 mg/L standard. If these procedures do not work, consult the equipment vendor for troubleshooting or equipment replacement.

   NOTE: For Zero DO checks: The solution used for this check contains sodium meta-bisulfite or sodium sulfite, which are harmful to the sensor and membrane. It is common practice to recalibrate the meter to 100% saturation after conducting a zero DO check to confirm that the sensor is still operating correctly. A zero DO check is not performed every day the instrument is in use for this reason, but a check should be performed at a minimum of once per sampling event. If conducting this check, be sure to record the manufacturer, true value, lot number, and expiration date of the solution on the field instrument calibration log.

2.3 pH

The pH is the measure of the degree of the acidity or alkalinity of a solution as measured on a scale of 0 to 14 SU. The pH of a sample is determined electrometrically using a glass electrode. All pH measurements are in SU.

CAUTIONS AND POTENTIAL PROBLEMS WITH PH MEASUREMENTS

- Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. For ground water, the pH will usually be close to 7 SU. A minimum of two standards are typically needed for the calibration: one close to 7 SU, one at least two pH units below 7 SU or at least two pH units above 7 SU. The instrument will need to be re-calibrated if the water sample's pH is outside the range defined by the two standards used in the initial calibration, either by adding a third calibration point (if the meter will allow) or by selecting two new pH standards that bracket the water sample's pH.

- Regardless if performing a two- or three-point calibration, always calibrate with pH 7 buffer first.

CALIBRATION PROCEDURE

1. Allow the buffered standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the buffered standards to ensure the pH probe and temperature sensor are completely submerged.

3. Remove the cover of the probe, rinse the probe in a cup filled with deionized water or use a spray bottle, and blot the probe dry with a soft tissue.

4. Enter the value of the first pH buffer solution (e.g., pH 7), immerse the probe in the standard, and allow at least 1 minute for temperature equilibration before proceeding. Record the temperature on the field instrument calibration log.

5. Enter the buffered solution value (7) into the pH calibration menu of the instrument. Allow the pH reading to stabilize for approximately 30 seconds, and if the reading does not change, finish the calibration and record the calibrated value on the field instrument calibration log. The calibration values after adjustment shall be within the accuracy of the instrument, or as required by the project. For example, if the accuracy of the meter is $\pm$0.1 SU, then the calibration values after adjustment shall be between 6.9 and 7.1 SU. If the calibration values after adjustment are outside of this range, recalibrate. If readings continue to fluctuate or readings do not stabilize after recalibration, consult the equipment vendor for troubleshooting or equipment replacement (e.g., may need a new pH electrode).

6. Remove probe from the initial buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

7. Immerse probe into the second buffer solution (e.g., pH 4). Repeat step #5, substituting “4” into the pH calibration menu instead of “7”.

8. Remove probe from the second buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

9. Immerse probe in third buffer solution (e.g., pH 10) or continue to step #11 if only a two-point calibration is being performed. Repeat step #5, substituting “10” into the pH calibration menu instead of “7”.

10. Remove probe from the third buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

11. To perform the instrument pH check, select monitoring/run mode, (ensure that the initial buffer solution temperature [pH 7] has not changed), and immerse the probe into the buffer solution. Wait for the reading to stabilize. The instrument should read the initial standard value (7 SU) within the accuracy of the instrument, or as required by the project. Record the pH 7 check reading on the field instrument calibration log. If the reading is not within the acceptance criteria, then re-calibrate the instrument. If re-calibration does not correct the

instrument reading, then the calibration range may be too wide. Reducing the calibration range by using standards that are closer together may improve the instrument's accuracy.

2.4 Specific Conductance

Conductivity is used to measure the ability of an aqueous solution to conduct an electrical current. Specific conductance is the conductivity value corrected to 25ºC. Calibrating an instrument for specific conductance automatically calibrates the instrument for conductivity and vice-versa.

CAUTIONS AND POTENTIAL PROBLEMS WITH SPECIFIC CONDUCTANCE MEASUREMENTS

- Most instruments are calibrated against a single standard that is near the specific conductance of the environmental samples. A second standard that is above the environmental sample specific conductance can be used to check the linearity of the instrument in the range of measurements. However, a single-point calibration standard is adequate to assess the accuracy and operation of the sensor.
- Calibrate the conductivity with a standard near the anticipated conductivity of the water. For fresh water, a 1 mS/cm standard is appropriate.
- For some meters, it is important that the top vent hole of the conductivity sensor be immersed during the calibration. Review the instrument manual to determine if this is required.
- Specific conductance/conductivity can have different units (e.g., mmho/cm, mS/cm, µmho/cm, µS/cm), especially on auto-ranging instruments. Note: mhos/cm = Siemens/cm. Check with the Project Manager or database manager to determine if field measurements should be restricted to a consistent unit (e.g., µmhos/cm or µS/cm, not mmhos/cm or mS/cm) so that conversion is not necessary when importing data into a database.
- Be aware of meters which autocorrect for temperature and how to enter the calibration value per the procedures in the instrument's manual. To calibrate instruments that autocorrect for temperature, enter the calibration value of the solution (µmhos/cm <u>at 25°C</u>). For instruments without automatic temperature compensation, the solution's conductivity value must be corrected for the temperature that the sensor is reading before entering the value into the meter. In some cases, you may be able to adjust the temperature of the calibration solution to near 25°C, such that the standard calibration value is applicable; otherwise an adjustment for temperature needs to be accounted for. Additionally, if calibrating for conductivity instead of specific conductance, the solution's conductivity value must be corrected for the temperature that the sensor is reading.

CALIBRATION PROCEDURE

1. Allow the calibration standard to equilibrate to the ambient temperature.

2. Remove probe from its storage container, rinse the probe with a small amount of deionized water, and pat dry the sensor with a soft tissue.

3. Lower the sensor into the conductivity standard. Gently move the probe up and down in the solution to remove any air bubbles from the sensor if present. Allow the probe to sit in the solution for at least 30 seconds to allow values to equilibrate before proceeding.

4. Enter the calibration value of the solution (e.g., 1,413 µmhos/cm at 25°C). Record the temperature of the solution on the field instrument calibration log, and allow the specific conductance reading to stabilize for approximately 30 seconds. Record the calibrated value after stabilization on the field instrument calibration log. The reading should be within ±5% of the true value. If the reading is not within this range, recalibrate. If readings continue to fluctuate significantly after a recalibration, consult the equipment vendor for troubleshooting or equipment replacement.

5. Remove probe from the standard, rinse the probe with deionized water, and replace the protective cover over the sensors.

2.5 Oxidation-Reduction Potential (ORP)

The oxidation-reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

CAUTIONS AND POTENTIAL PROBLEMS WITH ORP MEASUREMENTS

- Note that ORP is not usually the same as Eh. Eh is ORP measured relative to a standard hydrogen electrode (SHE). Typical ORP reference electrodes used in the field are Ag/AgCl electrodes, not SHEs. The difference is that Eh would be approximately 200mV higher than ORP measured against a Ag/AgCl reference electrode. See Standard Methods 2580B and YSI Tech Note (2005) for more details.
- Some meters allow you to calibrate ORP, but many do not allow calibration. Testing solutions are available to verify your ORP reading but they are not accurate enough to be used as calibration standards.
- ORP is temperature dependent. Look up the millivolt (mV) calibration value at the measured temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. It may be necessary to interpolate millivolt values between temperatures.

CALIBRATION OR VERIFICATION PROCEDURE

1. Allow the calibration standard (e.g., a Zobell solution) to equilibrate to ambient temperature.

2. Remove the cover of the probe, and place it into the standard.

3. While stirring the standard, wait for the probe temperature to stabilize, and then read the temperature.

4. Look up the millivolt (mV) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. It may be necessary to interpolate millivolt values between temperatures. Enter the

temperature-corrected ORP value, and calibrate the instrument. Record the values on the field instrument calibration log.

5. The reading should remain unchanged within manufacturer's specifications. If it changes, re-calibrate. If readings continue to change after calibration, consult the manufacturer.

6. If the instrument instruction manual states the instrument is factory calibrated, then verify the factory calibration against the standard. If the reading does not agree with the standard within the accuracy of the instrument, the instrument will need to be re-calibrated by the manufacturer.

2.6 Turbidity

Turbidity refers to how clear the water is and is a measure of relative sample clarity. The greater the amount of total suspended solids in the water, the higher the measured turbidity. The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidity meter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed 90 degrees to the path of the light source. Turbidity values are recorded in NTUs.

CAUTIONS AND POTENTIAL PROBLEMS WITH TURBIDITY MEASUREMENTS

- Some instruments will only accept one standard. For these instruments, the standards will serve as check points.
- Some regulatory agencies will not allow turbidity measurements through a flow-through cell, and require a stand alone turbidity meter. Verify that the selected meter will meet project objectives prior to use.
- For the greatest accuracy during the calibration procedure, ensure that after the meter is blanked and the blank is scanned as a sample, the reading is 0.00 NTU. If not, re-zero the meter and scan the blank again until it reads 0.00 NTU. When scanning the calibration standards as the sample, scan the calibration standard three times removing the tube from the chamber after each scan. The readings should be consistent. Use the last consistent reading to calibrate the meter. If the readings are not consistent, avoid using an aberrant reading to calibrate the meter.
- The meter should be placed on a surface that is free from vibrations. Vibrations can cause high readings.
- Gently mix the sample by inverting before taking a reading, but avoid introducing air bubbles.
- Scratches, fingerprints, and water droplets on the outside of the cuvettes can cause additional light scatter, leading to inaccurate readings. If necessary, wipe the outside of the cuvette with a soft tissue. If the cuvette is scratched or dirty, discard.
- Ensure that the cuvette is always placed in the chamber in the same orientation, as differences in orientation can cause differences in results. Proper cuvette orientation may be indicated by a mark or arrow on both the cuvette and the instrument.

CALIBRATION PROCEDURES – STAND ALONE TURBIDITY METER

NOTE: Sometimes standards are provided in the cuvette with the meter.

1. Rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe the inside of the cuvette, because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

2. Place the 0.0 NTU standard into the instrument and scan the sample (measure the standard). Record the reading on the field instrument calibration log. The 10.0 NTU standard can be measured after the 0.0 NTU standard is scanned.

3. Select the 10.0 NTU standard and scan the sample (measure the standard). The reading should be within ±10% of the true value. Record the reading on the field instrument calibration log. If the reading is within the acceptance criteria, then move on to step # 5. If not, calibrate the instrument to 10.0 NTU. Record the reading and any significant changes on the field instrument calibration log.

4. After adjusting the calibration, re-read the 10.0 NTU standard to ensure it is now meeting accuracy requirements. If not, repeat step #3. Otherwise, continue to step #5.

5. Repeat step #3, if needed, for the 1.0 NTU standard.

6. After adjusting the calibration, re-read the 1.0 NTU standard to ensure it is now meeting accuracy requirements (±10% of the true value). If not, repeat step #3. Otherwise, continue to step #7.

7. As a final check of the instrument, scan the blank (0.0 NTU standard). The unit display should read very close to zero. Record the reading on the field instrument calibration log.

   NOTE: If during the calibration procedure, you find the value of the standard is >50% from the expected value (e.g., 0.49 NTU for the 1.0 NTU standard), scrolling to the true value (e.g., 1.0 NTU) and attempting to calibrate will result in an error code, because the value to which you have changed it is >50% of the expected value of the standard. In this case, it is necessary to re-calibrate the unit from the beginning starting with a blank. If this fails to produce adjustable and reproducible values for the 1.0 and 10.0 NTU standards, re-calibrate using new standards and discard the current standards. If the meter still fails to calibrate following repeated attempts at calibration, consult the equipment vendor for troubleshooting or equipment replacement.

   NOTE: If only performing a two-point calibration (depending on project requirements), the 0.0 NTU and 10 NTU (or comparable NTU level) standards should be used.

CALIBRATION PROCEDURES – MULTI-PARAMETER METER WITH FLOW-THROUGH CELL

This is a two point calibration with a standard and turbidity free water. The standard can be formazin, polymer beads, or a meter-specific quick calibration solution. Turbidity free water

can be obtained by filtering distilled or deionized water through a 0.1, 0.3, or 0.45 micron filter.

1. Rinse the calibration cup and sensors with the turbidity free water. Fill the cup with enough water so that the turbidity sensor is covered (sensors pointed down).

2. Scan the sample (measure the standard). After the reading has stabilized, enter the zero turbidity value into the meter in accordance with manufacturer directions and record the reading on the field instrument calibration log.

3. Rinse the calibration cup and sensors with the standard solution. Fill the cup with enough standard solution so that the turbidity sensor is covered (sensors pointed down).

4. Scan the sample (measure the standard). After the reading has stabilized, enter the standard solution turbidity value into the meter in accordance with manufacturer directions and record the reading on the field instrument calibration log. If the reading is within the acceptance criteria, calibration is complete. If not, recalibrate the instrument. Record the reading and any significant changes on the field instrument calibration log.

   NOTE: If during the calibration procedure, you find the value of the standard is outside of the range acceptable by the meter and attempting to calibrate results in an error code, it is necessary to re-calibrate the unit from the beginning starting with a blank/turbidity free water. If this fails to produce acceptable and reproducible values for the standards, re-calibrate using new standards and discard the current standards. If the meter still fails to calibrate following repeated attempts at calibration, consult the equipment vendor for troubleshooting or equipment replacement.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum or roll-off bin, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

In addition to checking the calibration of instruments prior to measurements, calibration checks may also be required at other times of the day. If there are significant temperature fluctuations or erroneous readings, a calibration check may be required. Some programs require a post-calibration check at the conclusion of the day to ensure that instrument drift has not occurred. Refer to the site-specific work plan for calibration frequency.

Comparing current values with historical values at the same measuring location can be helpful in assessing instrument and calibration reliability.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All work must be dated and signed by the analyst. Any changes should be crossed out with a single line, initialed, and dated.

Prior to calibrating, the field equipment and calibration standard information should be recorded on a field instrument calibration log and/or in the field book. For field equipment, the information recorded should include the make, model number, and the serial number of the instrument. Each instrument can be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log.

For calibration standards, the information recorded should include the manufacturer, expiration date, true value, and any other description, such as lot number. Each calibration standard can also be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log. If standards are not supplied with an expiration date, the standards should be initialed and dated when received and when opened (not applicable for standards supplied with the rental equipment).

The calibration records provided by the equipment vendor and the certificates of analysis for each standard will be maintained in the project files.

All calibration measurements must be documented in the field book or on a separate field instrument calibration log. Example field instrument calibration logs are presented in Attachment B. At a minimum, the field instrument calibration log must include the instrument information described above, calibration standard information described above, calibration date, and the instrument calibration results.

6.0 REFERENCES

USEPA. January 19, 2010. *Standard Operating Procedure, Calibration of Field Instruments,* Revision No. 2. USEPA Region I.

American Public Health Association, American Water Works Association, and Water Environment Federation. January 2012. *Standard Methods for the Examination of Water and Wastewater,* 22nd Edition.

YSI Environmental. 2005. *Measuring ORP on YSI 6-Series Sondes: Tips, Cautions and Limitations*. YSI Environmental Tech Note. http://www.ysi.com/media/pdfs/T608-Measuring-ORP-on-YSI-6-Series-Sondes-Tips-Cautions-and-Limitations.pdf.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	August 2018	NOT APPLICABLE

Attachment A

Oxygen Solubility at Indicated Pressure

Attachment A (page 1 of 2)

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12-98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Table taken from EPA Region I SOP, Calibration of Field Instruments, January 10, 2010.

Attachment A (Page 2 of 2)

Oxygen Solubility at Indicated Pressure (continued)

Temp.	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.07	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Table taken from EPA Region I SOP, Calibration of Field Instruments, January 10, 2010.

Attachment B

Example Field Instrument Calibration Logs

Field Instrument Calibration Log

Date:_____ Site Name:_____

Water Quality Instrument Type / ID:_____

Turbidity Instrument Type / ID:_____

Date of Last Temperature Probe Check:_____

Dissolved Oxygen (DO)

Time	Barometric Pressure (mm Hg)	Temperature (°Celsius)	Oxygen Solubility at Indicated Pressure (mg/L) (On Instrument)	Actual Oxygen Solubility at Indicated Pressure (mg/L) (Refer to Attachment A)	Zero DO Check (mg/L)	Comments	Initials

pH

Time	Solution Temperature (°Celsius)	pH 7	pH 4	pH 10	pH 7 Check	Comments	Initials

Specific Conductance

Time	Specific Conductance Reading (umhos/cm3)	Comments	Initials

Oxidation Reduction Potential (ORP)

Time	Solution Temperature (°Celsius)	ORP Reading (mV) (Refer to std instruction sheet)	Actual ORP Reading (mV) (On Instrument)	Comments	Initials

Turbidity

Time	Zero Standard	Standard #1 (___NTUs)	Standard #2 (___NTUs)	Comments	Initials

Calibration Fluid ID / Expiration Date:

Zero DO:_____ Specific Conductance_____

pH 4_____ pH 7:_____ pH 10_____

ORP:_____

Zero Turbidity:_____ Turbidity Std. # 1_____ Turbidity Std. # 2_____

Signed_____

PAGE _____ OF _____

WATER QUALITY METER CALIBRATION LOG

PROJECT NAME: 0	MODEL:	SAMPLER: SN	
PROJECT NO.: 0.00	SERIAL #:	DATE:	

PH CALIBRATION CHECK

pH 7 (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	pH 4 / 10 (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	CAL. RANGE	TIME
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	

SPECIFIC CONDUCTIVITY CALIBRATION CHECK

CAL. READING (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

ORP CALIBRATION CHECK

CAL. READING (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

D.O. CALIBRATION CHECK

CAL. READING POST-CAL. READING /SATURATED AIR	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

TURBIDITY CALIBRATION CHECK

CALIBRATION READING (NTU) (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	(LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	CAL. RANGE	TIME
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	

COMMENTS

☐ AUTOCAL SOLUTION (LOT #): (EXP. DATE):	☐ STANDARD SOLUTION (S) LIST LOT NUMBERS AND EXPIRATION DATES UNDER CALIBRATION CHECK
CALIBRATED PARAMETERS	CALIBRATION RANGES [1]
☐ pH	pH: +/- 0.2 S.U.
☐ COND	COND: +/- 1% OF CAL. STANDARD
☐ ORP	ORP: +/- 25 mV
☐ D.O.	D.O.: VARIES
☐ TURB	TURB: +/- 5% OF CAL. STANDARD
☐ _____	[1] CALIBRATION RANGES ARE SPECIFIC TO THE MODEL OF THE WATER QUALITY METER
☐ _____	

NOTES

PROBLEMS ENCOUNTERED	CORRECTIVE ACTIONS

SIGNED _____ DATE _____

CHECKED BY _____ DATE _____

REVISED 06/2011

Title:	Procedure Number**:**
Vapor Sampling	**SOP013**
	Revision Number
	0
	Effective Date:
	September 2020

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1. INTRODUCTION

1.1 Purpose and Scope

Air sampling of the influent and effluent of the dual-phase extraction (DPE) system will be conducted as follows:

- Individual influent DPE lines (SP-1 through SP-8) will be sampled to measure relative vapor concentrations from each DPE well.
- The combined influent DPE header (SP-301) will be sampled to calculate cumulative mass removal rate over time
- The effluent of the self-recuperative thermal oxidizer (SRCO) (SP-601) will be sampled in order to evaluate the efficiency of the vapor treatment system.

This standard operating procedure (SOP) provides information developed to guide the collection of analytical samples to obtain the potential concentration of volatile organic compounds (VOCs) present throughout the DPE system.

Although this SOP provides guidance for grab or instantaneous air sampling, it should be understood that for certain projects, alternative methods may be required. Specific requirements for these types of projects and activities will be defined in the project-specific work plan. To ensure that air monitoring is conducted correctly, personnel involved should ensure that they understand the scope of work and the level of detail necessary prior to the mobilizing to perform the work.

This SOP does not supersede Site-Specific Health and Safety Plan (HASP) requirements. All employees shall follow the guidelines, rules, and procedures contained in the site-specific HASPs prior to adhering to any procedure recommended in this SOP.

1.2 Equipment

The following equipment may be utilized when collecting vapor samples. Project-specific conditions or laboratory requirements may warrant the addition or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE), as specified in the site-specific HASP
- Photoionization detectors (PID) equipped with a 10.6 electron-volt (eV) lamp and capable of detecting parts per million (ppm) and parts per billion (ppb) levels of VOCs
- 1-Liter Tedlar® gas sampling bags
- Evacuated laboratory-cleaned 1-Liter stainless steel Summa® canisters
- Vacuum air sampling box capable of 28 inches of mercury vacuum (e.g, CEL Scientific Corp Vacuum Air Sampling Box)
- Wrench
- Tygon tubing
- ¼" and ½" Teflon tubing
- Field notebook
- Quick connect fitting with barb for hose attachment
- Chain-of-custody (COC) forms

2. PROCEDURES

2.1 Pre-Sampling Activities

Prior to the collection of measurements, the PID used for measuring total VOC concentrations must be calibrated with isobutylene span calibration gas and zero air/fresh air calibration gas. To measure VOC concentrations in parts per million, a PID MiniRAE (or equivalent) meter will be used. This meter uses 100 ppm isobutylene span gas and zero air/fresh air calibration gases. Before a sample is collected, each Tedlar® bag must be flushed out with zero air gas and checked with a calibrated PID to make sure that the contents of the bag read 0.0 ppm.

2.2 Collecting Grab Air Sample Under Vacuum with Tedlar® Bags

1. Place the Tedlar® bag into a vacuum box and insert the inlet stem of the sample bag into the chamber's sample inlet. Open the valve of the bag by turning the entire upper portion (septum body and cap) of the fitting counterclockwise one revolution.
2. Purge the sample bag by:
    a. Outside the vacuum box, connect a source of purified air to the sample inlet port (¼-inch OD fitting).
    b. Press the "PURGE" button to purge the sample bag.
    c. Open the valve on the regulator and press the "SAMPLE" button. Purified air will flow into the bag. Fill a 1-liter bag. The vacuum box will automatically stop when sample bag is full.
    d. Close the valve on the regulator.
    e. Evacuate the sample bag by pressing the "PURGE" until the bag is completely deflated.
3. Collect a grab sample by:
    a. Attach the vacuum box sample inlet to the hose barb on the ball valve at the sampling port.
    b. Close the vacuum box and secure both latches.
    c. Record the location, sampling time, and the position of the ball valve on the manifold.
    d. Open the valve on the sampling port and press the "SAMPLE" button. The vacuum box sample pump will turn on and the sample will fill the sample bag. The vacuum box sample pump will automatically stop when the bag is full. Close the valve on the sampling port.
    e. After sample is collected wait for 10 seconds. After 10 seconds open the lid.
    f. Close the valve on the sample bag by turning the entire upper portion (septum body and cap) of the fitting clockwise one revolution.
    g. Close the valve on the sampling port.
    h. Pull the bag fitting from the chamber's sample inlet.
4. To measure the VOC concentration within the Tedlar® bag, bring to a location outside of the DPE enclosure. Utilizing the PID, hook up the Tedlar® bag hose end to the PID and record the peak concentration of VOCs observed on the meter in the field logbook.

2.3 Collecting Grab Air Sample Under Vacuum with Summa® Canister

On the vacuum side of the system, samples will initially need to be collected in Tedlar® bags using a vacuum air sampling box to overcome the vacuum of the system. Follow steps 1 through 3 above. Multiple Tedlar® bags may be needed to fill each Summa® Canister.

1. Use a wrench to remove the dust cap from the top of the Summa® canister. Using a piece of silicone tubing, attach the canister inlet to the Tedlar® bag hose end.
2. Record the location, Summa® canister number, sampling time, and the sample ID in the field logbook and on the chain of custody COC.
3. Open the valve on the sample bag by turning the entire upper portion (septum body and cap) of the fitting counterclockwise one revolution. Turn the valve on the Summa® canister to the open position. The canister will begin to make an audible hissing sound. As soon as the sound stops, close the valve on the canister, and then close the valve on the sampling port.
4. Repeat steps 1 through 4 until sufficient sample volume is achieved.
5. Place the dust cap back on the canister and tighten it with the wrench.

2.4 Collecting Grab Air Sample Under Pressure with Summa® Canister

On the discharge side of the SRCO, samples can be collected directly in the Summa Canister as follows.

1. Use a wrench to remove the dust cap from the top of the Summa® canister.
2. Using a piece of silicone tubing, attach the canister inlet to the hose barb on the sample port.
3. Record the location, Summa® canister number, sampling time, and the sample ID in the field logbook and on the chain of custody COC.
4. Open the valve on the valve on the sampling port and turn the valve on the Summa® canister to the open position. The canister will begin to make an audible hissing sound. As soon as the sound stops, close the valve on the canister, and then close the valve on the sampling port.
5. Place the dust cap back on the canister and tighten it with the wrench.

3. PRECAUTIONS

- The integrity of the Tedlar® bags can become compromised. Inspect each bag prior to use. If any damage is observed replace the bag and dispose of the compromised bag.
- Summa® canisters are temperature sensitive and should be stored in a climate-controlled area at all times. This will allow the canister to maintain the proper amount of negative pressure, providing a more accurate sample.
- Summa® canisters must be used within 14 days of receipt.
- Tubing should create an air tight seal between the barbed sampling port and the canister. No VOC containing materials (i.e. glue, adhesives, or duct tape) can be used to seal integrity issues.

APPENDIX E2 – AOC-16 INTERIM MEASURE DRAFT SELF-RECUPERATIVE CATALYTIC OXIDIZER OPERATION, MAINTENANCE AND MONITORING PLAN

AOC-16 INTERIM MEASURE DRAFT SELF-RECUPERATIVE CATALYTIC OXIDIZER OPERATION, MAINTENANCE AND MONITORING PLAN

CALUMET MONTANA REFINING, LLC
GREAT FALLS, MONTANA

October 2020

Log of Revisions to OM&M Plan			
Revision No.	**Revision Date**	**Section or Pages Revised**	**Description of Revision**

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Table 1: Key Project Contacts

Table 2: Alarm Conditions

Table 3: Weekly Inspection Activities

Table 4: Monthly Inspection Activities

Table 5: Monthly Automated Data Recordkeeping

Table 6: Semi-Annual Inspection and Maintenance Activities

Table 7: Annual Maintenance Activities

ATTACHMENTS

Attachment A: SRCO Record Drawings

Attachment B: OM&M Field Log Sheets

Attachment C: SRCO Spare Parts List

ACRONYMNS AND ABBREVIATIONS

AOC-16	Area of Concern-16
CMR	Calumet Montana Refining, LLC
DPE	dual-phase extraction
F	Fahrenheit
HMI	human-machine interface
IM	interim measures
LEL	lower explosive limit
LNAPL	light non-aqueous phase liquid
MDEQ	Montana Department of Environmental Quality
OM&M	Operations, Maintenance and Monitoring
PIC	Principal-In-Charge
PLC	programmable logic controller
PM	project manager
PTT	passive treatment trench
QAPP	Quality Assurance Project Plan
Ramboll	Ramboll US Corporation
SAP	Sampling and Analysis Plan
SCFM	standard cubic feet per minute
SRCO	Self-Recuperative Catalytic Oxidizer
TBD	to be determined
VOC	volatile organic compound

1. INTRODUCTION

1.1 Overview and Purpose

Ramboll US Corporation (Ramboll), on behalf of Calumet Montana Refining, LLC (CMR), has prepared this Area of Concern-16 (AOC-16) Interim Measure (IM) Self-Recuperative Catlaytic Oxidizer (SRCO) Operation, Maintenance, and Monitoring (OM&M) Plan for the Calumet Great Falls Montana Refining facility located at 1900 10th Street NE, Great Falls, Montana.

The purpose of this OM&M Plan is to provide a brief description of the SRCO; identify and describe the operation of the SRCO components; include as-built (record) drawings of the constructed system, equipment schematics/operation and maintenance manuals, and parts listings; present system startup and operation procedures; and detail system monitoring, maintenance, and record-keeping requirements and schedules.

The SRCO is used to treat vapors recovered as part of a dual-phase extraction (DPE) system. The DPE System has been designed as IM corrective actions to address historic petroleum releases resulting in light non-aqueous phase liquid (LNAPL) and dissolved phase groundwater impacts in the AOC-16 area of the CMR facility. A separate OM&M Manual has been prepared for the DPE System. The DPE System OM&M Manual also incorporates long-term monitoring and sampling associated with the SRCO which are not included herein. This document focuses on the operation and maintenance requirements of the SRCO.

1.2 Key Project Contacts

Key project personnel for the AOC IM OM&M activities are presented in Table 1.

Table 1: Key Project Contacts

Company/Organization	Project Title	Name	Contact Info
Montana Department of Environmental Quality (MDEQ)	Project Manager (PM)	Denise Kirkpatrick	dkirkpatrick@mt.gov (406) 444-3983
CMR	Environmental Manager	Joe Dauner	joseph.dauner@ calumetspecialty.com (406) 454-9887
Ramboll	Principal-in-Charge (PIC)	David Heidlauf	dheidlauf@ramboll.com (312) 282-1377
Ramboll	PM	Scott Tarmann	starmann@ramboll.com (262) 901-0093
Ramboll	Field Team Leader	Paul Lindquist Abby Small	plindquist@ramboll.com (612) 209-8676 asmall@ramboll.com (608) 438-8658

Project Title	Company/Organization	Name	Contact Info
Montana Department of Environmental Quality (MDEQ) Project Manager	MDEQ	Denise Kirkpatrick	dkirkpatrick@mt.gov (406) 444-3983

Project Title	Company / Organization	Name	Contact Info
CMR Project Manager	Calumet Montana Refining, LLC	Joe Dauner	joseph.dauner@ calumetspecialty.com (406) 454-9887
Principal in Charge	Ramboll Environment and Health	David Heidlauf	dheidlauf@ramboll.com (312) 288-1377
Project Manager	Ramboll Environment and Health	Scott Tarmann	starmann@ramboll.com (262) 901-0093
Field Team Lead	Ramboll Environment and Health	To be determined (TBD)	TBD

For overall project purposes a designated on-site Field Team Lead will be present during OM&M activities and will provide on-site supervision required during the project. The on-site Field Team Lead will be in contact with the PM, who will then review compliance with project objectives and sampling protocols outlined in this OM&M Manual. Positions and their responsibilities are outlined briefly below:

MDEQ PM	-	The MDEQ PM provides regulatory oversight to the project. They provide approval of plans, reports and any deviations from previously approved plans. The MDEQ PM ensures that all project work is compliant with required regulations and Orders.
CMR Environmental Manager	-	The CMR Environmental Manager is the senior CMR employee managing and directing Ramboll's work.
Ramboll PIC		The Ramboll PIC will provide project direction and provide the primary contact among MDEQ, Ramboll, and CMR.
Ramboll PM	-	The Ramboll PM will supervise all Ramboll personnel and subcontractors and is responsible for the day-to-day management of the project. They will also serve as the liaison between MDEQ, subcontractors, and CMR.
Ramboll Field Team Lead	-	The Designated Field Team Lead is the senior Ramboll employee in the field. They are responsible for ensuring that all field personnel adhere to Quality Assurance Project Plan (QAPP) and Sampling and Analysis Plan (SAP) requirements. They will perform routine sampling of the DPE System, routine gauging and groundwater sampling of the passive treatment trench (PTT) and LNAPL Recovery trench. They will aid in scheduling and routine monitoring and maintenance. They will collect field forms and records and will be responsible for ensuring all samples are sent to the laboratory as required.
CMR Operations Manager	-	The CMR Operations Manager is the CMR employee in the field. They will perform routine sampling of the DPE System, routine gauging and groundwater sampling of the PTT and LNAPL Recovery Trench. They will perform routine monitoring and collect and compile field forms and records.

1.3 OM&M Plan Organization

This OM&M Plan is divided into the following sections:

- Section 2 – SRCO Operation and Maintenance
- Section 3 – Performance Monitoring and Reporting

2. SRCO OPERATION AND MAINTENANCE

2.1 SRCO Process Equipment

Process air from the DPE System is drawn into the SRCO by the system blower. The process air passes through the tube side of a primary heat exchanger where it is pre-heated prior to the electric heater. The electric heater raises the volatile organic compound (VOC) mixture temperature prior to entering the oxidation catalyst. As this vapor-laden air mixture passes through the catalyst, an exothermic reaction occurs which is in proportion to the VOC energy concentration. The hot purified gases then pass through the shell side of the heat exchanger where they pre-heat the incoming gases. The cooler clean air is then vented to atmosphere through the exhaust stack. Record drawings in Attachment A show the process and instrumentation diagram for the SRCO.

2.1.1 SRCO Blower and Dilution Control

A centrifugal blower draws process air from the DPE system and dilution air into the SRCO unit. Dilution air control is achieved by opening the remote dilution valve. As the exotherm (exit) temperature increases, the dilution valve opens allowing cool air to be pulled into the SRCO. Controlling the exit temperature prevents a system temperature overshoot and possible system high temperature shutdown.

2.1.2 Heat Exchanger

The oxidizer includes an integral shell and tube heat exchanger. The heat exchanger is constructed of 304 stainless steel. The heat exchanger preheats the incoming process air using the oxidizer exhaust stream. This minimizes electrical power required to bring the catalyst inlet temperatures to the set point required for adequate destruction efficiency.

2.1.3 Oxidizer Reactor Chamber and Catalyst Module

The catalyst module is mounted in the oxidizer reactor chamber. The module is bolted and gasketed. It is accessible for inspection or replacement from the reactor chamber access door. The catalyst is a precious metal on a metal ribbon substrate. It is designed to maximize destruction efficiency of VOC hydrocarbons with minimal pressure drop. Catalyst inlet and outlet temperatures are monitored by thermocouples mounted in ports on the side of the oxidizer reactor chamber.

2.1.4 Oxidizer Electric Heater

The heater system includes electric resistance sheathed heater elements for long life and corrosion resistance performance. The electric heaters are modular duct style pre-mounted on the reactor chamber. The heater is used to preheat the process airstream to the required catalyst inlet temperature.

2.1.5 Instrumentation

The catalyst inlet and outlet temperature are monitored by thermocouples. Pressure switches are located across the catalyst and on the oxidizer inlet piping.

2.1.6 Control Panel

The main control panel, located in the control room, houses the programmable logic controller (PLC) and the human-machine interface (HMI). The PLC provides central control and operating logic (i.e., interlocks and alarms) for the system, which is programmed into the PLC. The system computer records selected system operating data. The system computer is remotely accessible through a cellular internet connection, allowing personnel to remotely access the operator interface terminal and observe the same operating information available to the field staff. If monitoring data exceeds pre-established normal operating ranges, the system operator is notified via visual display elements on the control screen. If the system is shut down due to an alarm condition, the system operator and project personnel will receive notifications via text message to a cellular device or via electronic message.

2.2 DPE System Operation

2.2.1 Primary System Operation Parameters/Constraints

The SRCO system is typically operated within the following primary parameter ranges:

- Maximum flow rate of 1000 standard cubic feet per minute (SCFM)
- Inlet proess temperature of 220 – 270 degrees Fahrenheit (F)
- Catalyst inlet operating temperature of 650 degrees F
- Catalyst outlet operating temperature of 1160 degrees F
- Inlet VOC concentrations of less than 2900 parts per million by volume
- Potential explosive VOC concentrations less than 25% of the lower explosive limit (LEL)

2.2.2 Start-up

Start-up procedure to be provided by SRCO vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.3 Routine Operating Procedures

Routine operating procedures to be provided by SRCO vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.4 Troubleshooting

Troubleshooting details to be provided by SRCO vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.5 Restart, Shutdown, and Emergency Procedures

Restart, shutdown, and emergency procedures to be provided by packaged SRCO vendor upon delivery of equipment. Section to be included in the final version of the OM&M Plan prior to startup.

2.2.6 Alarm Responses

Table 2 provides the alarm conditions to provide the operator with a general understanding of SRCO system function and operation.

Table 2: Alarm Conditions

Attachment A Drawing No.	Interlock ID	Interlock and Control Logic Description
PID-07	I-12	Oxidizer system inlet blower B 401 discharge pressure is low. Shut down system. Send oxidizer system inlet pressure low alarm notification to operator.
PID-07	I-13	Oxidizer high temperature alarm. Shut down system. Send oxidizer alarm notification to operator.
PID-07	I-14	Oxidizer catalyst high pressure alarm. Shut down System. Send oxidizer alarm notification to operator.
PID-07	I-15	Oxidizer high temperature alarm. Shut down system. Send oxidizer alarm notification to operator.

2.3 SRCO Maintenance

2.3.1 General

This section covers general maintenance procedures to be followed during operation of the SRCO system. The procedures described herein are general in nature. OM&M field log sheets for the routine maintenance activities are provided in Attachment B. Recordkeeping of the maintenance activities performed on the DPE System are to be documented on the OM&M log sheets and in a project log book kept inside the control room of the DPE building. All entries into the logbook shall be copied/scanned and sent electronically to the Project Manager and Ramboll Field Team Lead.

2.3.2 Weekly/Monthly/Semi-Annual Inspections

The SRCO system is designed to function without the need of an on-site operator. However, routine maintenance and inspection of the equipment will be necessary to ensure optimal performance of the equipment and to maximize runtime of the system. During operation, the following inspections and maintenance tasks are to be conducted weekly.

Table 3: Weekly Inspection Activities

Description of Activity	Action Performed	
	Yes	No
Check system fan for unusual noises or vibrations		
Inspect screen/filter on dilution air intake for debris		
Visually inspect the oxidizer external components for hot spots, wear or damage		

During operation, the following inspections and maintenance tasks are to be conducted monthly.

Table 4: Monthly Inspection Activities

Description of Activity	Action Performed	
	Yes	No
Check all indicators for proper operation.		

Description of Activity	Action Performed	
	Yes	No
Check all sensor tubing and connectors for cracks or wear, and verify proper connection		
Drain any water condensate that may have collected out of tubing		
Span check and zero LEL monitor		

System operating data that are recorded automatically by the PLC and can be downloaded electronically on a monthly basis are summarized in Table 5.

Table 5: Monthly Automated Data Recordkeeping

Instrument/Parameter	Reading
Vapor Pressure (PT040) Entering Blower B-401	psig
Vapor Temperature Entering catalyst (TE0601A, TE0601B, TE0601C)	°F
Differential Pressure Across Catalyst	psig
Vapor Temperature Leaving Catalyst (TE0602A, TE0602B, TE0602C)	°F

During operation, the following inspections are to be conducted semi-annually.

Table 6: Semi-Annual Inspection and Maintenance Activities

Description of Activity	Action Performed	
	Yes	No
Perform steps in weekly and monthly inspection sections		
Verify integrity of electrical panel door seals. Check for signs of moisture in panel		
Lubricate process fan motor		
Check all piping and conduit fasteners for tightness		
Remove and clean flame arrestor element		
Inspect catalyst element for signs of contaminate buildup		
Inspect internal chambers of oxidizer for signs of cracks or contamination		
Re-calibrate LEL monitor		

2.3.3 Annual Inspections and Maintenance

The maintenance activities to be performed and documented on an annual basis are summarized in Table 7. Due to the technical nature of these procedures, only factory-trained personnel should perform them.

Table 7: Annual Maintenance Activities

Description of Activity	Action Performed	
	Yes	No
Perform inspection and maintenance on the process blower and drive		
Check operation of all system indicators		
Verify all controller parameters		
Test control panel disconnect and handle mechanism for proper operation		
Test system E-Stop button for proper orientation		
Remove and inspect heater element		
Clean heat sinks and cooling fans on heater controllers and verify operation of fans		
Inspect all electrical components, wiring, and connections		
Check tightness of all conduit fittings		
Inspect panel fuse holders for corrosion or thermal damage		
Exercise all panel circuit breakers by turning them off and on		
Verify all wire raceways are in good condition and covers are in place		
Verify all motor voltage and current draws		
Verify control power current		
Verify 24-volt DC power supply voltage		
Test the customer interlock(s) for safety shutdown		
Test the air flow switch(es) for safety shutdown		
Verify the set point on the airflow switch for minimum airflow proving		
Verify blower motor overload device set-point		
Test the blower motor starter interlock contact safety shutdown		
Verify PLC logic for appropriate responses to system operational modes.		
Test the system exit high temperature limit for safety shutdown		
Verify the set point of the system exit high temperature limit for maximum temperature		
Test the system inlet temperature controller (low temperature) alarm.		
Verify system inlet controller set-point calibration and PID loop control		
Test the system exit temperature controller set-point calibration and PID control		
Verify calibration of inlet and exit thermocouples		
Test process valve proof of closure switch for safety shutdown		
Test dilution valve open proving position switch for safety shutdown		

2.3.4 Inventory of Spare Parts

Effective maintenance depends on the availability of spare parts for all essential equipment. Inventories of spare parts will be kept in the CMR maintenance facility and revised as necessary to

ensure the availability of spare parts at all times. A spare parts list is provided in Attachment C. The spare parts will be restocked when the inventory becomes diminished. All spare parts will be stored properly in the CMR maintenance facility to ensure quick access and safekeeping of the equipment.

3. SRCO PERFORMANCE MONITORING AND REPORTING

Influent and effluent air samples will be collected and submitted for laboratory analysis to monitor air treatment efficiency of the SRCO. Details regarding monitoring and reporting are provided separately in the September 2020 *AOC-16 Interim Measures Draft Operation, Maintenance and Monitoring Plan* (Appendix E1 of the Final 100% IM Design Report).

ATTACHMENT A

SRCO RECORD DRAWINGS

(To be provided by SRCO vendor upon delivery of equipment and included in the final version of the OM&M Plan prior to startup)

ATTACHMENT B

OM&M FIELD LOG SHEETS

ALARM CONDITION LOG SHEET

Operator: _____

Date: _____

Alarm Condition	Date	Time	Responding Operator	Corrective Action or Repairs

RAMBOLL

EQUIPMENT PREVENTATIVE MAINTENANCE RECORD

Equipment Description: _____

Preventative Maintenance done by: _____

Item	Work Performed	Reference	Frequency

RAMBOLL

EQUIPMENT INSPECTION AND SERVICE COMPLETION RECORD

Operator: _________________________

Date: _____________________________

Service Record		
Date	**Work Done**	**Signed**

RAMBOLL

MAINTENANCE REPORT

Report Data: _____

Maintenance Type: _____

Work Order No.: _____

Work Order Date: _____

_____

Date Repair Started	Date Repair Completed	Component Repaired	Parts and Materials	Labor Hours	Labor Category

Remarks/Resolutions: _____

_____

_____

Name: _____

Signature: _____

Weekly Inspection Log

Operator: _____
Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Check system fan for unusual noises or vibrations.			
Inspect screen/filter on dilution air intake for debris.			
Visually inspect the oxidizer external components for hot spots, wear or damage.			

Monthly Inspection Log

Operator: _____
Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Check all indicators for proper operation.			
Check all sensor tubing and connectors for cracks or wear, and verify proper connection			
Drain any water condensate that may have collected out of tubing			
Span check and zero LEL monitor			

Semi-Annual Inspection and Maintenance Log

Operator: _____
Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Perform steps in weekly and monthly inspection sections			
Verify integrity of electrical panel door seals. Check for signs of moisture in panel			
Lubricate process fan motor			
Check all piping and conduit fasteners for tightness			

ANNUAL MAINTENANCE LOG

Operator: _____

Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Perform inspection and maintenance on the process blower and drive			
Check operation of all system indicators			
Verify all controller parameters			
Test control panel disconnect and handle mechanism for proper operation			
Test system E-Stop button for proper orientation			
Remove and inspect heater element			
Clean heat sinks and cooling fans on heater controllers and verify operation of fans			
Inspect all electrical components, wiring, and connections			
Check tightness of all conduit fittings			
Inspect panel fuse holders for corrosion or thermal damage			
Exercise all panel circuit breakers by turning them off and on			
Verify all wire raceways are in good condition and covers are in place			
Verify all motor voltage and current draws			
Verify control power current			
Verify 24 volt DC power supply voltage			
Test the customer interlock(s) for safety shutdown			

RAMBOLL

ANNUAL MAINTENANCE LOG

Operator: _____

Date: _____

Description of Activity	Action Performed		Comments
	Yes	No	
Test the air flow switch(es) for safety shutdown			
Verify the set point on the airflow switch for minimum airflow proving			
Verify blower motor overload device set-point			
Test the blower motor starter interlock contact safety shutdown			
Verify PLC logic for appropriate responses to system operational modes.			
Test the system exit high temperature limit for safety shutdown			
Verify the set point of the system exit high temperature limit for maximum temperature			
Test the system inlet temperature controller (low temperature) alarm.			
Verify system inlet controller set-point calibration and PID loop control			
Test the system exit temperature controller set-point calibration and PID control			
Verify calibration of inlet and exit thermocouples			
Test process valve proof of closure switch for safety shutdown			
Test dilution valve open proving position switch for safety shutdown			

ATTACHMENT C

SRCO SPARE PARTS LIST

1000E SRCO Spare Parts List

P&ID Identifier	QTY	Price
Thermocouple	1	$256.23
Pressure Switch	1	$267.82
Pressure Transmitter	1	$1,788.67
Heater Controller	1	$517.83
Dilution Valve Actuator	1	$3,083.33
Isolation Valve Actuator	1	$2,283.78

APPENDIX F

HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN

CALUMET MONTANA REFINERY
1900 10TH STREET
GREAT FALLS, MONTANA

Prepared for:
Calumet Montana Refinery, LLC
Great Falls, Montana

Prepared By:
Ramboll US Corporation
Chicago, IL

Date
September 2020

Project Number
1690015898-005

RAMBOLL

TABLE 1A: EMERGENCY RESPONSE TELEPHONE ROSTER		
	OFFICE	**CELL**
PERSONNEL		
Ramboll		
Principal-in-Charge (PIC): David Heidlauf	312-288-3823	312-282-1377
Project Manager (PM): Dan Price	314-590-2970	636-577-2357
PM: Aaron Hackman	913-553-5923	317-431-7459
Area of Concern (AOC)-16 Interim Measure PM: Scott Tarmann	262-901-0093	262-853-9964
Well Installation/Groundwater Monitoring Task Lead: Kit Carson	303-382-5482	630-849-9291
Designated Site Supervisor: Elaine Komm-Enge		406-565-1230
Designated Site Supervisor: Liz Borucki	262-901-3507	262-758-1488
AOC-16 Interim Measure Field Construction Manager: TBD	TBD	TBD
Health and Safety (H&S) Coordinator: Beth Richter	312-288-3856	314-630-7364
Corporate H&S Director: Kristen Heitman	312-288-3824	773-879-2235
Contractors		
GPRS Contact: Lisa Lippincott	214-471-9001	
GPRS Contact: Titus Adamson	303-552-8270	
M&D Construction Contact: Josh Picking	406-452-8825	406-781-1898
Cascade Drilling Contact: Ron Rider	253-883-5200	253-293-1910
Client/Security		
Site Contact: Joe Dauner	406-454-9887	406-217-3605
Alternate Site Contact: Justin Eiskant	406-454-9817	406-461-7219
Safety Superintendent: Jack Flannery	406-564-6904	
Main Security Gate	406-761-4100	
ONSITE EMERGENCY RESPONSE AGENCIES		
Control Room	406-454-9876	
Radio Channel #2		
OFFSITE EMERGENCY RESPONSE AGENCIES		
Hospital: Benefits Health System	911	
Emergency Fire: Great Falls Fire Department	911	
Emergency Police: Great Falls Police Department	911	
County Health Department: City-County Health Department	406-454-6950	

TABLE 1A: EMERGENCY RESPONSE TELEPHONE ROSTER		
	OFFICE	**CELL**
Ambulance Service: Great Falls Emergency Services	406-453-5300	
OTHER EMERGENCY ASSISTANCE		
CHEMTREC	800-424-9300	
National Response Center (oil and chemical spills)	800-424-8802	
Poison Control Center	800-222-1222	
Federal Emergency Management Agency	202-646-2500	
OFFSITE AGENCIES – NON-EMERGENCY PHONE NUMBERS		
Police: Great Falls Police Department	406-454-0495	
Medical Center: Great Falls Clinic	406-454-2171	
Hospital: Benefits Health System	406-455-5000	
Fire: Great Falls Fire Department	406-727-8070	
Ambulance Service: Great Falls Emergency Services	406-453-5300	
State Agency: Montana Department of Environmental Quality: Denise Kirkpatrick	406-444-3983	
Federal Agency: USEPA Region VIII: Jesse Newland	303-312-6353	

TABLE 1B: EMERGENCY SERVICES INSTRUCTIONS

For Emergency Medical Incidents, Emergency Fire Response or Hazardous Materials Incidents

Emergency Telephone Numbers:

NOTICE: In the case of an emergency onsite that requires medical assistance, contact the Control Room at **406-454-9876** or **Radio Channel #2**. The Control Room will contact 911 and other emergency response services on your behalf.

Remember to speak SLOWLY and CLEARLY. Do NOT hang up first: let the Control Room finish the call.

Provide the following information:

a. Location on the facility; and
b. Your name and phone number.

Describe nature of incident:

a. Emergency Medical Incident
    - How many victims;
    - Type of incident-physical injury, etc.;
    - Assessment of victims' condition if known (whether victim is conscious/unconscious, breathing/not breathing, pulse/no pulse, nature of injuries, first aid measures used, etc.); and
    - Where incident occurred.

b. Fire
    - Location of fire.

c. Hazardous Materials Incident
    - This is a hazardous materials incident requiring dispatch of hazardous material (HAZMAT) unit;
    - Type of incident (fire, explosion, spill, etc.);
    - Type of material (specific chemicals or general description); and
    - Whether there is also a medical emergency.

Give your location at the site.

Note: Unless otherwise directed by the Control Room, Security, Site Supervisor or designee must meet the emergency personnel at the staging area to brief them on the situation.

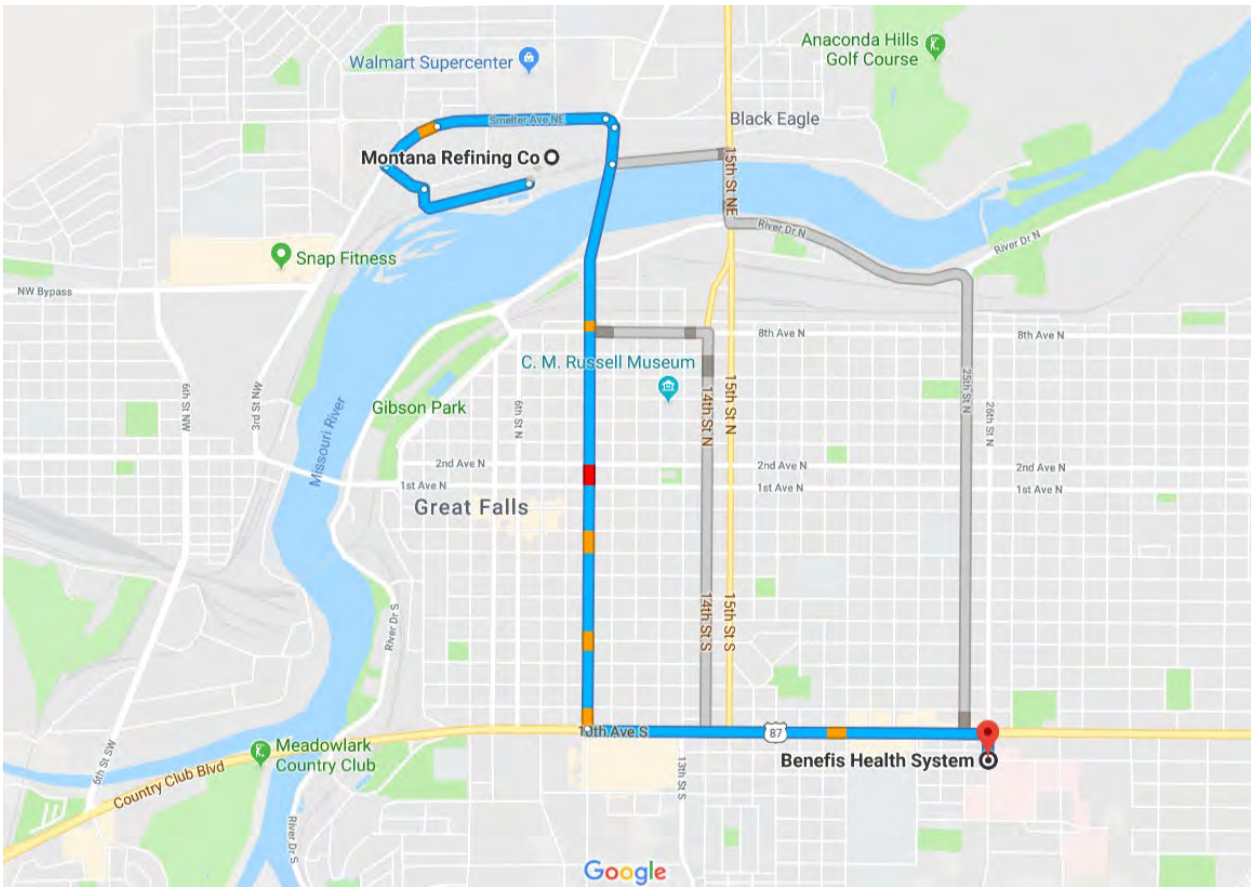
ROUTE DESCRIPTION AND MAP TO HOSPITAL

HOSPITAL INFORMATION

Benefits Health System
1101 26th St S
Great Falls, MT 59405
406-455-5000

DIRECTIONS TO AREA HOSPITAL

- Continue on 3rd St NW/Smelter Ave NE
- Take right 10th St
- Take first left on N River Rd
- Turn right at 15th St NE
- Turn left at River Dr N
- Turn right on 25th St N
- Turn left on 10th Ave S
- Take first right on 16th St S: 1101 26th St S, Great Falls, MT (Destination will be on the right)



RECORD OF CHANGE

SECTION(S) PAGE(S) AFFECTED	DESCRIPTION OF CHANGE	DATE CHANGE MADE	REASONS FOR CHANGE	NAME OF PERSON WHO MADE CHANGE

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CMR SUPPLEMENTAL DOCUMENTS

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Supplemental Document 2:	CMR Chemical Approval Form
Supplemental Document 3:	CMR Radio Channel List
Supplemental Document 4:	CMR Excavation Approval Form
Supplemental Document 5:	CMR Waste Labeling Procedures

ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental and Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
AOC	Area of Concern
APR	Air-purifying Respirator
ATV	All-terrain Vehicles
BBP	Bloodborne Pathogen
bgs	Below Ground Surface
C_2S	Carbon Disulfide
C	Ceiling Limit
CGI	Combustible Gas Indicator
CH4	Methane
CIH	Certified Industrial Hygienist
CMR	Calumet Montana Refinery, LLC
CO	Carbon Monoxide
COC	Constituents of Concern
CPR	Cardiopulmonary Resuscitation
dBA	Decibels on the A-weighted Scale
DPE	Dual-phase Extraction
EKG	Electrocardiogram
EL	Exposure Limit
EMR	Experience Modification Rate
ERP	Emergency Response Plan
FID	Flame Ionization Detector
FM	Factory Mutual
GFCI	Ground Fault Circuit Interrupter
GPR	Ground-penetrating Radar
H_2S	Hydrogen Sulfide
HA	Hazard Assessment
HASP	Health and Safety Plan
HAZMAT	Hazardous Material
HAZWOPER	Hazardous Waste Operator
HPDs	Hearing Protective Devices
H&S	Health and Safety
HR	Human Resource
HSIR	Health and Safety Incident Report
HSC	Health and Safety Coordinator
IDLH	Immediately Dangerous to Life and Health
IR	Infrared Spectrophotometer
JHA	Job Hazard Analysis
JSA	Job Safety Analysis
km	Kilometers
LEL	Low Exposure Limit
LOTO	Lockout/Tagout
LIF	Laser-induced Fluorescence
LNAPL	Light Non-aqueous Phase Liquids

ACRONYMS AND ABBREVIATIONS (CONT)

m	Meter
mg/kg	Milligrams per Kilograms
mg/m^3	Milligrams Per Cubic Meter
MTDT	Montana Department of Transportation
NA	Not Anticipated
NAICS	North American Industry Classification System
NE	Not Established
NEC	National Electrical Code
NESC	National Electrical Safety Code
NIOSH	National Institute for Occupational Safety and Health
O_2	Oxygen
O&M	Operations and Maintenance
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
ORC®	Oxygen Release Compound
OVA	Organic Vapor Analyzer
PC	Program Coordinator
PEL	Permissible Exposure Limits
PFD	Personal Flotation Device
PIC	Principal-in-Charge
PID	Photo Ionization Detector
PM	Project Manager
PPE	Personnel Protective Equipment
PPM	Parts Per Million
PTT	Passive Treatment Trench
RA	Remedial Action
Ramboll	Ramboll US Corporation
ROPS	Roll Over Protection Standards
SC	Site Coordinator
SCBA	Self-contained Breathing Apparatus
SDS	Safety Data Sheet
SIMOPS	Simultaneous Operations
SPI	Standard Practice Instruction
SSC	Subsurface Clearance
STEL	Short-term Exposure Limit
SVOC	Semi Volatile Organic Compounds
TCP	Traffic Control Plan
TWA	Time Weighted Average
UL	Underwriters Laboratories
USGS	US Coast Guard
USDHHS	US Department of Health and Human Services
USEPA	US Environmental Protection Agency
UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound

HEALTH AND SAFETY PLAN REVIEW AND APPROVAL

By signing below, it is acknowledged that this Health and Safety Plan (HASP) identifies the activities that are anticipated to be performed in the field. In addition, this HASP identifies the personal protective and monitoring equipment that may be necessary to be on site and be available for use. It is also understood that the provisions of this HASP will be updated if there is a change of a task and/or the addition of tasks and will be approved by the individuals listed below or their designee.

David Heidlauf PIC	Signature	Date
Dan Price PM	Signature	Date
Aaron Hackman PM	Signature	Date
Scott Tarmann Task Lead	Signature	Date
George "Kit" Carson Task Lead	Signature	Date
Elaine Komm-Enge Designated Site Supervisor	Signature	Date
TBD AOC-16 Interim Measures Field Construction Manager	Signature	Date
Liz Borucki Designated Site Supervisor	Signature	Date
Liz Borucki Designated HASP Preparer	Signature	Date
Beth Richter H&S Coordinator	Signature	Date

This form MUST be signed prior to starting the onsite work. In addition, a copy of this form should be returned to the office Health and Safety Coordinator prior to leaving for the field. After completion of the project, the original signed HASP must be retained in the project file

Author's Initials: LAB Typist's Initials: LAB

File Name: CMR Great Falls MT_HASP_091020

1. INTRODUCTION

This HASP was prepared to inform all Ramboll US Corporation (Ramboll) personnel working on investigative and remedial efforts at the Calumet Montana Refinery (CMR) (Site) of known or reasonably anticipated potential hazards and safety concerns at this Site. All personnel participating in field activities must be trained in the general and specific hazards unique to the job they are performing and, if applicable, meet recommended medical examination and/or training requirements. All Ramboll employees shall follow the guidelines, rules and procedures contained in this site-specific HASP. Ramboll personnel shall contact the PM if unexpected conditions are encountered at the site, including but not limited to new processes; changes in operation, products, services; additional or changes in the chemicals of concern; and/or unsafe conditions are encountered which were not previously addressed in this HASP.

For purposes of this HASP, subcontractors refer to those retained directly or indirectly by Ramboll and contractors refer to all other entities working on site. Each contractor, subcontractor and visitor shall be expected to review and understand the hazards, risks and control methods (including emergency procedures) as outlined in this HASP and sign off on the HASP. This can be accomplished either during the project planning stage or during the first safety briefing on site. In addition, a Job Safety Analysis (JSA) will need to be completed prior to the start of each day (see Appendix A). However, contractors and subcontractors will be required to prepare their own HASP to address site safety and work hazards associated with their proposed site activities prior to mobilization to the site. In addition, each subcontractor will be required to provide Ramboll with their site-specific HASP and communicate the types of hazards and control methods associated with their activities to Ramboll during the first safety briefing on site and as conditions change. Relevant Contractor information regarding the identification of hazards and appropriate control strategies for the hazards for their particular job tasks should also be presented and a site-specific HASP should be available for review by all parties. Each contractor or subcontractor must assume direct responsibility for its own employees' health and safety.

During the COVID-19 global pandemic, adherence to the Project Coronavirus Response Plan will be followed until further notice. This response plan provides guidance to reduce the Coronavirus risk at CMR. This plan is consistent with the approach currently utilized by Ramboll for our offices and is aligned with recommendations published by various public health organizations. Mitigation measure focus on communication, exposure risk management, case management and CMR requirements. Details outlining the mitigation measures required for this project site are found in the response plan (Appendix B).

Copies of the HASPs will be kept on site for review and reference during all site activities. Upon completion of the project, the finalized and signed copy of the HASP will be placed in the project file.

When retaining and working with subcontractors, the following minimum requirements shall be met:

- A properly executed Contractor/Subcontractor Terms and Conditions agreement with Ramboll in place prior to commencing work onsite.
- Insurance policies and limits are acceptable to Ramboll and all applicable insurance certificates are properly executed (i.e. Ramboll being named as additionally insured under such policies, including Professional and Pollution Liability, if applicable. This will also include adding Ramboll's client as being named as an insured party under the same policies).

- The roles and responsibilities of the subcontractor have been established, including the naming of the H&S point of contact (these should be clearly indicated in the applicable subcontractor HASP).
- Submission of illness and injury logs indicating a favorable total incident rate (i.e. for the previous calendar year the total incident rate is calculated by the total number of cases X 200,000 divided by the total hours worked by all employees of the subcontractor). This should be equal to or less than the industry average (i.e. for remediation services listed under the North American Industry Classification System (NAICS) 5629 the total incident rate must be equal or below 3.8).
- A favorable Experience Modification Rate (EMR) (i.e. a rate equal to or less than 1.0) or an explanation of why your company does not qualify for an EMR from the Contractors insurance company.

1.1 SITE DESCRIPTION

CMR is located at 1900 10th St in Cascade County of Great Falls, Montana. The Site is located on approximately 58 acres and consists of industrial land (roads, tanks, processing equipment and buildings) on the north side of the Missouri River as shown in Figure 1. The refinery processes crude oil to produce gasoline, middles distillates and asphalts through facility operations including fluid catalytic cracking, alkylation, catalytic reforming and hydrotreating. The main refinery area is gated and Ramboll personnel are required to obtain a facility badge and wear site-specific PPE as discussed in Section 7.4. Maps are included of the emergency evacuation routes, rally points and the general area that hearing protection is required (see Figures 2, 3 and 4, respectively). The Alkylation Unit is off-limits to Ramboll personnel at all times. The Truck Loading Rack Area (which includes AOC-16) is located to the east in a gated area outside the main refinery area and requires a facility access card. Commercial, municipal and residential land uses are present around the facility to within 1,500 feet from the Site. Stormwater generally collects in shallow depressions and evaporates or flows through a network of storm drains and discharges to an onsite permitted wastewater treatment plant.

1.2 SITE HISTORY

In 1922, the petroleum refinery began operations under the ownership of the America Refining Company. Several owners operated the refinery from 1922 to 1984, including the Rainbow Refining Company, Home Oil & Refining Company, WE Rice, AB Cobb, Wasatch Oil Company, Ada Oil Company, Philips Petroleum Company and Simmons Oil Company. From 1984 until 2006, the Montana Refining Company in partnership with Black Eagle, LLC, owned and operated the facility. In 2006, Connacher Oil & Gas Limited of Canada purchased the assets, as Montana Refining Company, LLC. Most recently, Calumet Specialty Product Partners, LP, purchased the assets of Montana Refining Company in 2012 and today operates as Calumet Montana Refining, LLC.

1.3 HISTORICAL DOCUMENTS

Information included in the HASP is from site visits, historical documents, Calumet site-specific documents and public information on the Calumet website.

1.4 SCOPE AND APPLICABILITY

Ramboll has been retained to conduct and/or manage investigative and remedial activities at the Site. This HASP addresses activities currently being conducted at the Site. Addendums will be added to this HASP to address activities at the site as they develop in the future. This HASP addresses site-solutions activities currently being conducted at the Site.

Ramboll views the implementation of a site-specific HASP as a critical management tool necessary to the safety, health and well-being of Site personnel and the community. Site operations will be performed in such a manner as to minimize the possibility of serious injury or accidents to site personnel, fire, explosion, or any unplanned or sudden release of contaminants into the environment that could adversely affect local receptors. This HASP is intended to be in compliance with all applicable state, federal and local regulations and is consistent with Ramboll's commitment to the health and safety of its personnel, contractors on the site and the surrounding community.

The HASP identifies potential hazards associated with the activities being conducted during field activities at the Site, establishes the minimum procedural and equipment requirements to protect onsite personnel from potential hazards and requires that onsite activities are conducted in a manner consistent with both accepted professional practice and applicable regulations. It also describes measures to minimize accidents and injuries that may occur during normal daily activities or during adverse conditions.

The HASP is based upon the currently available information regarding the Site. Operating conditions could potentially change as the work progresses, requiring some modification of the HASP. Any permanent modifications to the HASP, including changes necessary to correct any potential health and safety issues at the Site will be made only with permission by those individuals listed in Section 1 of this HASP. Approved changes will be added to the HASP as Addendums.

Applicability of this HASP extends to all personnel and visitors to the Site. However, Ramboll's subcontractors are ultimately responsible for the health and safety of their personnel and representatives and are required to furnish their own HASP. All personnel and visitors entering onsite active fieldwork areas are responsible for reading and complying with the HASP and must sign an agreement to comply with the requirements of the HASP.

1.5 SPECIFIC WORK ACTIVITIES

The principal features of the field activities currently underway or planned for the immediate future include the following work activities or tasks

- Task 1: Travel to and from the Site;
- Task 2: Site Security;
- Task 3: Full-time Onsite Project Support;
- Task 4A: Groundwater Sampling Traffic Control;
- Task 4B: AOC-16 Interim Measures Traffic Control;
- Task 5: Surface Geophysical and Subsurface/Overhead Utility Clearance;
- Task 6: Advancement of Soil Borings and Soil Sampling;
- Task 7: Installation, Development and Abandonment of Monitoring, Recovery and Extraction Wells;
- Task 8: Groundwater Gauging and Sampling;

- Task 9: Remediation Operation and Maintenance;
- Task 10: Dual-phase Extraction System Installation; and
- Task 11: Non-aqueous Phase Liquids Recovery Trench and Passive Treatment Trench Installation.

NOTICE: Prior to entering the refinery, all Ramboll personnel will be required to review the CMR Subcontractor Safety Manual (Supplement Document 1) and attend a site-specific training and will receive a badge which must be worn at all times. All Ramboll personnel must wear the appropriate personnel protective equipment (PPE) required at CMR (details are discussed in detail in Section 7.1). All Site personnel will be required to have a personal hydrogen sulfide (H_2S) monitor on their person at all times. In addition, personal breathing zone will be monitored using one or more monitoring devices as listed in Table 11 (Section 8), for tasks where gases, vapors, explosion hazards and/or oxygen deficient atmosphere can occur or are expected (drilling, trenching and remediation operations and maintenance). Specific areas are off-limits to Ramboll personnel due to special training, permits and PPE that include the Alkylation Unit is off-limits to Ramboll personnel and yellow and/or magenta barricades (i.e. tape or rope) which marks the boundary for radiation work.

It should also be noted that all chemical(s) brought onto the facility must be approved by CMR. If the chemical has not already been approved by CMR, then the Calumet Chemical Approval Form (Supplemental Document 2) must be filled out and approved.

Ramboll personnel must complete Occupational Safety and Health Administration (OSHA) drug and alcohol abuse training associated with SPI 25 (Appendix C). In the event of an incident on the facility, Ramboll personnel will complete a post-accident drug and alcohol test in Great Falls, Montana (see Incident Reporting in Section 5.6).

Each of these tasks are further described as follows:

Task 1: Transportation to and from the Site

This task includes air travel to the Site from a Ramboll office. In addition, the daily commute to the Site from temporary housing consists of driving a company-owned or rental vehicle. The commute is approximately 5-10 minutes each way from CMR to the hotel and will include travel on highways and paved side roads. Permission will need to be obtained prior to driving onto the areas of ongoing facility operations while following posted speed limits. Onsite parking requirements must be followed: engine off, keys left in the ignition, park, chocking of wheels and emergency brake set. If the engine is running, the driver must always be in attendance. In addition, all vehicles must have a fire extinguisher. **All vehicles used inside the plant must have a permit visible and displayed in the windshield.**

Travel to the site during the COVID-19 global pandemic must be approved by your immediate project manager and/or respective office managing principal prior to making any travel arrangements. It is important to remember that Ramboll's response and the recommendations published by various public health organizations may change through time regarding COVID-19 global pandemic. Submit the Project Coronavirus Response Plan (Appendix B) and any additional travel assessment forms, as required.

Task 2: Site Security

Ramboll personnel will be responsible for site-specific security and safety protocols. Ramboll will follow any site-specific documents involved Site-related incidents including: Emergency Response Plan and Spill Response Procedures. **Ramboll personnel will call the Control Room and NOT 911 when reporting any emergency-related incident**. The Control Room will contact 911 and any emergency response team, as needed. See Table 1B for further instructions.

Any facility-related emergency that requires evacuation will be sounded by a long whistle (with the exception at noon and 12:30 pm, as these loud blasts are performed daily). The primary rally point is in the east employee parking lot across 10th St NE. The secondary rally point is the West Entrance Gate #1. The rally point you go to is determined by the wind direction and your location within the refinery (i.e. do not go downwind or crosswind to go to a rally point). Windsocks throughout the facility help indicate wind direction and strength. Additional details are discussed in Section 12. A site map with muster point locations is shown in Figure 2.

The refinery has a no cell phone or camera policy while performing work on the Site. Therefore, Ramboll personnel will communicate via a site radio provided by CMR. A channel number list of various site operations is provided in Supplementary Document 3. However, Channel #2 will only be used in case of emergencies.

Task 3: Full-time Onsite Project Support

Ramboll will provide CMR, periodically, with an onsite individual through June 2020 and half-time thereafter through the remainder of calendar year 2020. The onsite individual will periodically support CMR to address project needs and act as an available resource, as needed. Ramboll personnel will undergo site-specific training. In addition, site personnel will review and follow all applicable safety protocols in the CMR Safety Contractor Manual. Additional paperwork will be completed at the start of work that includes Access Request Form, a picture of the employee and a vehicle decal form (see Section 5).

Site inspections will be performed on a frequency of a weekly basis and will at a minimum include the following areas: East and West Rail Area, AOC-16, Main Stormwater Sewer, Sewer Discharge Points into the Missouri River and for any visible petroleum seeps and/or sheens along the adjacent Missouri River. Ramboll personnel may periodically be in a lone worker situation. If so, please review Control Mechanism B35 in Appendix D or SPI 42 (Appendix E).

Site inspections and/or additional tasks conducted within 4 feet of the Missouri River will require water safety protocols to be implemented. All water work shall be performed in a two-person team. Ramboll personnel performing the work must wear an approved personal flotation device (PFD). **Ramboll personnel are prohibited from working in or near water by themselves.** For more information, Review Control Mechanism B21 in Appendix D or SPI 31 (Appendix F). Confined Spaces are present in the active refinery area accessed during Task 3. Ramboll staff must not enter these Confined Spaces.

Task 4A: Groundwater Sampling Traffic Control

This task involves the use of necessary traffic control measures in work areas that are within the public right-of-way that includes the utilization of traffic cones and temporary traffic signs during

groundwater sampling. In addition, the site workers are required to wear high-visual safety vests and clothing during the work.

To conduct groundwater sampling and/or drilling activities for monitoring wells located in North River Road, permits are required to be submitted to Cascade County and Montana Department of Transportation (MTDT). A traffic control plan (TCP) is also required to be submitted to the Cascade County and MTDT, which has been developed to safely close North River Road (Appendix G).

Task 4B: AOC-16 IM Construction Traffic Control

This task involves the use of necessary traffic control measures during installation of the dual-phase extraction (DPE) system, the passive treatment trench (PTT) and the LNAPL recovery trench. The proposed construction traffic route for both installations is included in Appendix G.

The PTT and LNAPL recovery trench work area falls within the public right-of-way and requires the utilization of traffic cones and temporary traffic signs. In addition, the site workers are required to wear high-visual safety vests and clothing during the work. For the planned trenching activities, permits are required to be submitted to Cascade County and Montana Department of Transportation (MTDT). A TCP is also required to be submitted to the Cascade County and MTDT and will be prepared by the construction contractor. Road closure is not anticipated.

Task 5: Surface Geophysical and Subsurface/Overhead Utility Clearance

Public and private utility locate will be performed. Geophysical survey for subsurface utilities (i.e. gas, electric, sewer, water, etc.) using ground penetrating radar and electromagnetic tools. For interior spaces, a handheld ground-penetrating radar (GPR) or equivalent will be used to identify rebar in the concrete. All soil boring locations will be cleared in accordance with SPI 27 (Appendix H). This includes ensuring drilling locations are proper distances away from overhead utilities. Additional measures (e.g. air knifing and/or hand-clearing) may be employed to clear certain drilling locations, as needed. The above will not be employed for laser-induced fluorescence (LIF) borings, as the sensors need undisturbed soil to function properly. In AOC-16, an electronic rover with locating technology will assist field staff with the identification of the storm sewer line. All subsurface activities will be discussed with knowledgeable Site personnel and Site utility maps and documentation will be consulted.

Task 6: Advancement of Soil Borings and Soil Sampling

Ramboll will complete a subsurface clearance at all drilling locations and required CMR Excavation Approval Form (Supplemental Document 4) and applicable work permits prior to the commencement of intrusive work. The proposed intrusive work will be drilled using a direct-push, hollow-stem auger, air-rotary, or sonic drilling rig operated by a licensed driller by the Montana Board of Water Well Contractors and supervised by an experienced Ramboll geologist or engineer. Vacuum excavation may be employed along utilities (e.g. storm sewer lines) to expose and inspect material in contact with the sewer. Soil cuttings will be placed in 55 gallon drums. Drums will be staged at a designated area identified by CMR. Waste must be labeled in accordance with the Waste Labeling Procedures included in Supplemental Document 5.

Nitrile gloves will be used when handling samples and sample bottles to protect the sampler from potentially impacted soil and spills of sample bottle preservatives. The drilling locations may include

areas such as railways and along roadway easements. Special health and safety protocols may be required in these locations.

A CMR owned railway spur parallels the Missouri River and comes onto the Site. Prior to any intrusive work near the railway spur, Ramboll personnel will work with CMR to implement appropriate safety protocols and a special coordination variance may be required.

Implementation of H&S measures are important during all stages of this task. For example, an injury occurred to the driller's assistant's ankle during the advancement of a soil boring in October 2019. Based on Ramboll's and Cascade's injury report, the injury was the result of poor ergonomics and the failure to utilize proper engineering controls. Cascade's Shared Learning document detailing the incident, root causes and corrective actions is found in Appendix I.

Task 7: Installation, Development and Abandonment of Monitoring, Recovery and Extraction Wells

Select borings will be converted to permanent monitoring wells to collect groundwater samples. The proposed construction for each monitoring well, monitoring well abandonment and replacement is discussed in the CMR Site-wide Groundwater Monitoring Plan. Well development water will be collected in a poly tank and transported and disposed via a sewer line that runs to the refinery's wastewater treatment plant.

Task 8: Groundwater Gauging and Sampling

Synoptic groundwater level measurements and total depth will be recorded prior to initiating purging and sampling activities. If observed, separate-phase hydrocarbon thickness measurements will be collected. Grab groundwater samples will be collected using a peristaltic pump using low-flow techniques. Purge water will be collected in 5 gallon buckets and transported and disposed via a sewer line that runs to the refinery's wastewater treatment plant.

Sampling of sand point wells conducted within 4 feet of the Missouri River will require water safety protocols to be implemented. All water work shall be performed in a two-person team. Ramboll personnel performing the work must wear an approved PFD. **Ramboll personnel are prohibited from working in or near water by themselves.** For more information, review control mechanism B21 in Appendix D or SPI 31 (Appendix F).

Task 9: Remediation Operations and Maintenance

Ramboll's onsite personnel will assist with remediation operation and maintenance (O&M) operations, as needed. Relevant O&M tasks that Ramboll will aid and/or provide oversight of CMR employees includes, but not limited to, investigation of recovery pumps issues, switching over nitrogen gas tanks that power recovery pumps and remove passive absorbent socks located within well vaults (less than 2 feet deep). Ramboll personnel will conduct weekly inspections. These activities will periodically place Ramboll personnel in a lone worker situation. When this occurs, please review Control Mechanism B35 in Appendix D or SPI 42 (Appendix E).

Task 10: Dual-phase Extraction System Installation

Dual-phase Extraction (DPE) System Installation includes oversight of:

- Oversight of Subsurface Clearance (discussed in Task 5);
- Oversight of Subsurface Drilling (discussed in Task 6 and Task 7);
- Pipe Trenching and Installation [down to 3 feet below ground surface (bgs)];
- Aboveground Equipment Installation (oxidizer and DPE enclosure);
- Electrical Service Installation; and
- Soil Drilling Waste Management (discussed in Task 6).

Ramboll will complete a subsurface clearance at all trenching locations and required CMR Excavation Approval Form (Supplemental Document 4) prior to the commencement of intrusive work. Pipe trenching will be conducted with a backhoe down to approximate 3 feet bgs. The excavated material will be stockpiled immediately next to the trenches and field screened with a PID. If no visible impacts or elevated PID readings are noted in the stockpiled material, the trench spoils will be used to backfill the remaining depth of the trench to the existing grade. Pipe bedding will be placed in 6-inch lifts. Lifts will be lightly compacted using hand tamping or a vibratory device. Excess spoils will be containerized labeled in accordance with the Waste Labeling Procedures included in Supplemental Document 5.

aboveground equipment installation (oxidizer and DPE enclosure) andelectrical service installation tasks will be provided prior to AOC-16 IM construction.

Task 11: Light Non-aqueous Phase Liquid Recovery Trench and Passive Treatment Trench Installation

PTT installation and LNAPL Recovery Trench installation includes:

- Oversight of Subsurface Clearance (discussed in Task 5);
- Traffic Control (discussed in Task 4B);
- Oversight of Trenching (anticipated to range between 10 and 15 feet bgs);
- Oversight of Well Installation – Recovery and Monitoring Wells (discussed in Task 7);
- Remediation Material [PetroFix] Delivery Storage and Application; and
- Oversight of Soil Boring and Drilling Waste Management (discussed in Task 6).

Ramboll will complete a subsurface clearance at all trenching locations and required CMR Excavation Approval Form (Supplemental Document 4) prior to the commencement of intrusive work. Trenching will be conducted with an excavator and trench box dragged along the length of the trench. The excavated material will be directly loaded into covered, US Department of Transportation (DOT)-compliant dump-trucks and transported to a landfill. The LNAPL recovery trench will be backfilled with coarse sand and eleven 6-inch diameter slotted PVC pipes will be installed within the trench during backfill activities. The PTT will be backfilled with a mixture of coarse sand and remediation material Petrofix. The sand and Petrofix will be placed in 1 to 2-foot lifts and mechanically mixed with the excavator bucket repeating until the top of the trench is reached. Alternate trenching and backfilling methods are being considered and additional details will be provided prior to AOC-15 IM Construction. All chemicals will need approval by CMR. Ramboll will complete the chemical approval form (Supplemental Document 2) and receive approval prior bringing Petrofix onsite.

Additional details regarding remediation material delivery andstorage tasks will be provided prior to AOC-16 IM construction.

1.6 APPLICABLE STANDARDS

The methods and procedures prescribed in this HASP are intended to conform to established professional practices and applicable federal, state and local occupational safety and health protection standards based on information that is currently available. Regulations serving as the technical compliance basis for this document may include but are not limited to the following:

- US Department of Labor, Occupational Safety and Health Standards for Construction (29 CFR 1926)
    - Hazardous Waste Operations and Emergency Response (29 CFR 1926.65)
    - Hearing Protection (29 CFR 1926.101 and 29 CFR 1926.52)
    - Eye and Face Protection (29 CFR 1926.102)
    - Respiratory Protection (29 CFR 1926.103)
    - Working Over or Near Water (29 CFR 1926.106)
    - Material Handling Equipment (29 CFR 1926.602)
- US Department of Labor, OSHA Standards for General Industry (29 CFR 1910)
    - Hazardous Waste Operations and Emergency Response (29 CFR 1910.120)
    - PPE General Requirements (29 CFR 1910.132)
    - Eye and Face Protection (29 CFR 1910.133)
    - Respiratory Protection (29 CFR 1910.134)
    - Head Protection (29 CFR 1910.135)
    - Foot Protection (29 CFR 1910.136)
    - Hand Protection (29 CFR 1910.138)
    - Medical Services and First Aid (29 CFR 1910.151)
    - Portable Fire Extinguishers (29 CFR 1910.157)
    - Hazard Communication Standard (29 CFR 1910.1200)
    - Control of Hazardous Energy *(LOTO)* (29 CFR 1910.147)
    - Excavation and Trenching (29 CFR 1926.650-652)
- US Department of Labor, Recording and Reporting Occupational Injuries and Illnesses (29 CFR 1904)

The following technical documents may have been utilized as references in the preparation of this HASP. However, the citation of these technical documents does not imply compliance with all aspects of these documents. The purpose of these citations is to aid in the interpretation of conflicting issues that may arise during the performance of Site activities. The following technical documents may include but are not limited to:

- National Institute for Occupational Safety and Health (NIOSH)/OSHA/US Coast Guard (USCG)/ US Environmental Protection Agency (USEPA), Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, (October 1985);
- US Department of Health and Human Services (USDHHS), NIOSH Sampling and Analytical Methods, DHHS (NIOSH) Publication 84-100;
- American National Standards Institute (ANSI), Emergency Eyewash and Shower Equipment, Z358.1 (1981);

- ANSI, Protective Footwear, Z41.1 (1983);
- ANSI, Practice for Occupational and Educational Eye and Face Protection, Z87.1 (1979); and
- ANSI, Protective Headgear for Industrial Workers-Requirements, Z89.1 (1986)

2. IDENTIFICATION OF KEY PERSONNEL

An efficient onsite operation requires that all key personnel be identified and that their roles and responsibilities be clearly defined. Below is a discussion of the management structure for this project.

2.1 PROJECT ORGANIZATION

Ramboll serves as the Project Coordinator for the Site. Ramboll is responsible for overseeing activities conducted by Ramboll personnel and Ramboll's subcontractors at the Site. Ramboll also is responsible for oversight of compliance with this HASP in the field by Ramboll personnel. Ramboll subcontractors may plan, manage and carry out activities at the Site, including environmental investigation and remediation tasks and will provide their own health and safety officers and HASP. As part of Ramboll's role as Site Coordinator, Ramboll will ensure that all subcontractors and Site workers are aware of the Ramboll HASP and its requirements.

2.2 RAMBOLL PERSONNEL

Assigned functions of key Ramboll project team members and subcontractors are described in Tables 2 and 3, respectively, located at the end of this section. The applicable responsibilities for these individuals are as follows:

2.2.1 PIC/PM

Responsibilities include overall coordination of site activities. The PIC and the PM have overall accountability and responsibility for the safety of operations and the health and safety of all personnel and for monitoring the work effort, schedule, costs, communication and will ensure that the activities of all Site personnel comply with the approved work plans and will recommend or provide disciplinary action, as appropriate, if non-compliances occur.

These individuals will also provide the focal point for communications between the regulatory authorities; state and local community, onsite contractors and project staff. This liaison activity will provide a clear line of communication between all parties to minimize the chance for misconceptions concerning any aspect of the project.

Any and all recommended revisions or changes in the HASP will be reviewed by the PIC, PM and Project Health and Safety Coordinator prior to final approval by the Corporate Health and Safety Director.

2.2.2 Corporate H&S Director

The Ramboll Corporate H&S Director will oversee all issues related to health and safety and will have final approval authority for any revisions or changes.

2.2.3 Project Health and Safety Coordinator

The project Health and Safety Coordinator (HSC), along with the Corporate H&S Director are resources for the development of the site-specific hazard assessments and control mechanisms. Any changes/modifications/additions that may need to occur to the HASP, the project HSC and/or the

Corporate H&S Director will be consulted. The Corporate H&S Director will make all final decisions regarding questions on the hazard assessment and/or the control mechanisms.

Any and all recommended revisions or changes in the HASP will be reviewed by the PIC, PM and project HSC prior to final approval by the Corporate H&S Director.

2.2.4 Designated Site Supervisor

The Ramboll Designated Site Supervisor is responsible for overseeing day-to-day Site activities performed by Ramboll and its subcontractors. The principal responsibility of the designated Ramboll Site Supervisor will be to coordinate and document all onsite work necessary to fulfill approved work plans. The Ramboll Site Supervisor and project HSC and/or officer may be the same individual.

The Ramboll Site Supervisor reports to the PIC and Corporate H&S Director. The Site Supervisor is responsible for ensuring compliance with all aspects of the HASP which include, but are not limited to, safe work practices, site access controls, work safety zones, proper PPE, review planned Site activities, implement safety procedures necessary to complete work safely, perform daily safety briefings, assist in onsite emergencies and act as technical liaison to regulatory agency personnel. The Site Supervisor will report all Site-related injuries to the PIC/PM and the project HSC and/or Corporate H&S Director and to any other necessary authorities. The Site Supervisor will ensure that all Site personnel understand their respective emergency response duties. In the instance of any emergency or non-emergency incidents concerning Site personnel, the Site Supervisor will be contacted and will be responsible for communicating any information regarding Site safety conditions to rescue or emergency personnel. The Site Supervisor will ensure that all activities at the Site comply with the approved HASP.

Any person working onsite has the authority to **stop work** if any operation threatens the health and safety of onsite workers or the surrounding community. In the event that such a situation occurs, the Site Supervisor shall be notified immediately. Ramboll’s Site Supervisor will update the Ramboll PIC/PM and on all project-related health and safety issues as they arise.

The Site Supervisor will be certified in first aid and cardiopulmonary resuscitation (CPR) by the American Red Cross, or equivalent. The Site Supervisor will also be hazardous waste operator (HAZWOPER) trained for Site work in accordance with applicable regulations and participate in a medical surveillance program.

In the event of an emergency, the Ramboll Site Supervisor will also function as the Site Emergency Response Coordinator and will implement and coordinate emergency response procedures described in this HASP.

2.2.5 Other Personnel

All other Ramboll personnel will be certified in first aid and CPR by the American Red Cross, or equivalent and will also be HAZWOPER trained for Site work in accordance with applicable regulations and participate in a medical surveillance program.

Ramboll's subcontractors, if needed, shall prepare their own company HASP which shall specifically govern the work performed by its employees. The contractor’s HASP shall be in conformance with Ramboll’s HASP.

All Subcontractors will also provide an HSC who will assist Ramboll's Site Supervisor. The subcontractor HSC will ensure that their personnel have received appropriate health and safety training and are participating in a medical surveillance program.

TABLE 2: RAMBOLL PERSONNEL CONTACT INFORMATION

COMPANY/TITLE	PERSONNEL	OFFICE	CELL
PIC	David Heidlauf	312-288-3823	312-282-1377
PM	Dan Price	314-590-2970	636-577-2357
PM	Aaron Hackman	913-553-5923	317-431-7459
AOC-16 Interim Measures PM	Scott Tarmann	262-901-0093	262-853-9964
Well Installation/Groundwater Monitoring Task Lead	George "Kit" Carson	312-288-3822	630-849-9291
Corporate H&S Director	Kristin Heitman	312-288-3824	773-879-2235
Project HSC	Beth Richter	312-288-3856	314-630-7364
Designated Site Supervisor	Elaine Komm-Enge		406-565-1230
Designated Site Supervisor	Liz Borucki	262-901-3507	262-758-1488
AOC-16 IM Field Construction Manager	TBD	TBD	TBD
Client Contact	Joe Dauner	406-454-9887	406-217-3605
Alternate Site Contact	Ray Martinich	406-564-9862	406-564-9769
Site Safety Officer	Paul Carlson	406-564-9945	
Main Security Gate		406-761-4100	

TABLE 3: CONTRACTOR/SUBCONTRACTOR CONTACT INFORMATION

COMPANY/TITLE	PERSONNEL	OFFICE	CELL
GPRS	Lisa Lippincott	214-471-9001	
GPRS	Titus Adamson	303-552-8270	
M&D Construction	Josh Picking	406-452-8825	406-781-1898
Cascade Drilling	Ron Rider	253-883-5200	253-293-1910

3. HAZARD EVALUATION

The Project Hazard Analysis below identifies the hazards anticipated to be encountered by the project team based on the tasks presented in Section 2.5.

TABLE 4: PROJECT HAZARD ANALYSIS		
Chemical Hazards Present: ☐ None	☒ Flammable/combustible ☒ Compressed gas ☒ Explosive ☐ Organic peroxide ☐ Oxidizer ☐ Water reactive ☐ Unstable reactive ☒ Dust/Fumes/Particulates	☒ Corrosive ☒ Toxic ☐ Highly Toxic ☐ Irritant ☐ Sensitizer ☒ Carcinogen ☐ Mutagen ☐ Other:
Site Hazards Present: ☐ None	☒ Heat ☒ Cold ☒ Severe weather ☒ Walking/working surfaces ☒ Noise ☐ Unexploded ordinances ☐ Close/abandoned mines ☒ Operational facility (traffic/docks/loading) ☐ Other:	☐ Ionizing radiation ☒ Non-ionizing radiation ☒ Confined spaces ☒ Live electrical equipment ☒ Poor lighting ☒ Overhead hazards ☒ Work near railroads ☒ Traffic mgmt. (vehicle, pedestrian interference)
Task Hazards Present: ☐ None	☒ Heavy machinery/drill rigs ☒ Trenching/excavation ☒ Vehicle use ☒ Work near/on water ☐ Elevated heights (<6 feet) ☐ Elevated heights (>6 feet) ☒ Overhead/underground utilities ☒ Power hand tools ☒ Electrically powered equipment	☒ Cutting devices/tools ☐ Lifting operations (cranes, rigging) ☒ LO/TO (electrical, pressure) ☒ Drums, cylinders, containers ☒ Material handling, ergonomics ☒ SIMOPs (Simultaneous operations) ☐ Other:
Biological Hazards Present: ☐ None	☐ Animal/human fluid, blood, tissue ☒ Poisonous/irritating plants ☒ Ticks, mosquitos	☐ Contaminated needles ☐ Live bacterial cultures ☒ Insects/rodents/snakes ☒ Other: COVID-19

TABLE 4: PROJECT HAZARD ANALYSIS		
Safety/Security: ☐ None	☒ Security issue ☐ Isolated area ☒ Employees working alone ☐ Seasonal hunting	☒ Employees working early/late ☐ Potentially dangerous wildlife ☐ Guard/stray dogs ☒ No/limited cell phone service ☐ Other:

3.1 SPECIFIC CHEMICALS OF CONCERN

The chemicals listed in the table below includes the identification of chemical contaminants known and/or suspected of being present onsite, the affected media, known concentrations (if applicable), the Permissible Exposure Limit (PEL) or Threshold Limit Value (TLV) and the Action Level (i.e. 50% of the PEL/TLV). This information will be inserted into Table 5A and Table 5B below. In addition, Appendix J contains specific hazardous property information for commonly encountered chemicals although a safety data sheet (SDS) (or equivalent) will also be included in Appendix J.

TABLE 5A: CHEMICALS OF CONCERN

CHEMICAL	ENVIRONMENTAL MEDIA[1]	HIGHEST MEASURED CONCENTRATION	PEL/TLV[2]
Benzene	GW/SO	10,900 µg/L 767 milligrams per kilograms (mg/kg)	1 ppm (PEL) 0.5 ppm (TLV)
Volatile Organic Compounds (VOCs)	GW/SO	NA	NA
Semi Volatile Organic Compounds (SVOCs)	GW/SO	NA	NA
Modified Skinner List (metals, inorganics)	GW/SO	NA	NA
Tetraethyl Lead	GW/SO	NA	0.075 milligrams per cubic meter (mg/m^3) (skin) (PEL) 0.1 mg/m^3 (skin) (TLV)

Notes:
[1] Codes for environmental media: SL=Sludge; GW=Groundwater; SW=Surface Water; LW=Liquid Waste; SO=Soil; A=Air; OTH= Other (Specify)
[2] PEL/TLV, use appropriate PEL/TVL which would be country or state specific or if one is not available may be from a recognized source.
µ/L: Micrograms per liter
mg/m^3: Milligrams per cubic meter
mg/kg: Milligrams per kilograms
ppm: Parts per million
%: Minimum percent allowed for personal entry into a space
NA: Not available

TABLE 5B: CHEMICALS OF CONCERN - FACILITY OPERATIONS

CHEMICAL	LOCATION	HIGHEST MEASURED CONCENTRATION	PEL/TLV[1]
Hydrofluoric Acid	Alky Unit	NA	3 ppm (PEL)/0.5 ppm (TLV)
Hydrogen Sulfide	Throughout the Facility	NA	20 ppm (ceiling) (PEL) 50 ppm (10 min max peak) (PEL) 10 ppm Time Weighted Average (TWA) (TLV)

Notes:
[1] PEL/TLV: Use appropriate PEL/TVL which would be country or state specific or if one is not available may be from a recognized source.
mg/m^3: Milligrams per cubic meter
mg/kg: Milligrams per kilograms
ppm: Parts per million
%: Minimum percent allowed for personal entry into a space
NA: Not available

4. HAZARD CONTROLS

In order to conduct a Task in the safest possible manner, the hazard(s) associated with a task need to be identified so that appropriate hazard control(s) can be implemented and used by personnel conducting these task(s). This process is called a Job Hazard Analysis (JHA) or Job Safety Analysis (JSA). To aid in the JHA/JSA process, the associated task(s) (as outlined in Section 1.3) are correlated against the anticipated hazards. A Relative Hazard/Risk Rating is also provided in order to identify which hazards pose the greatest risk to personnel but more importantly, what hazard controls should be implemented.

TABLE 6: CONTROL OF HAZARDS SUMMARY

TASK NUMBER(S)	HAZARDS	RELATIVE HAZARD/RISK RATING*	HAZARD CONTROLS APPENDIX AND/OR HASP SECTION
3-11	Chemical Hazards	NA☐ Low☐ Medium☒ High☐	B1 Chemical
2-11	Dust/fumes/particulates	NA☐ Low☒ Medium☐ High☐	B2 Dust/Particulates/Fumes
2-11	Job zone control	NA☐ Low☐ Medium☒ High☐	B3 Job Zone Control
2-11	Heat	NA☐ Low☐ Medium☒ High☐	B4 Heat
2-11	Cold	NA☐ Low☐ Medium☒ High☐	B5 Cold
1-11	Severe weather	NA☐ Low☒ Medium☐ High☐	B6 Severe Weather
2-11	Walking/working surfaces	NA☐ Low☐ Medium☒ High☐	B7 Safe Walking Surfaces and Work Areas
2-11	Noise	NA☐ Low☐ Medium☒ High☐	B8 Noise
NA	Unexploded ordinances	NA☒ Low☐ Medium☐ High☐	B9 Unexploded Ordinances
NA	Closed/abandoned mines	NA☒ Low☐ Medium☐ High☐	B10 Closed/Abandoned Mines
2-11	Operational facility (traffic/docks/loading)	NA☐ Low☐ Medium☒ High☐	B11 Operational Facility
NA	Ionizing radiation	NA☒ Low☐ Medium☐ High☐	B12 Radiation
NA	Non-ionizing radiation	NA☐ Low☒ Medium☐ High☐	B12 Radiation
3, 9	Confined spaces	NA☐ Low☒ Medium☐ High☐	B13 Confined Spaces
2-11	Live electrical equipment	NA☐ Low☐ Medium☒ High☐	B14 Live Electrical Equipment
1-11	Poor lighting	NA☐ Low☐ Medium☒ High☐	B7 Safe Walking Surfaces and Work Areas
3, 5-11	Overhead hazards	NA☐ Low☐ Medium☒ High☐	B15 Overhead Hazards
4-11	Work near railroads	NA☐ Low☐ Medium☒ High☐	B16 Work Near Railroads
1-11	Traffic management (vehicle, pedestrian interference)	NA☐ Low☐ Medium☒ High☐	B17 Traffic Management

TABLE 6: CONTROL OF HAZARDS SUMMARY

TASK NUMBER(S)	HAZARDS	RELATIVE HAZARD/RISK RATING*	HAZARD CONTROLS APPENDIX AND/OR HASP SECTION
4, 6, 7, 9-11	Heavy machinery/drill rigs	NA☐ Low☐ Medium☒ High☐	B18 Heavy Machinery/Drill Rigs
10-11	Trenching/excavation	NA☐ Low☐ Medium☒ High☐	B19 Trenching/Excavation
1-11	Vehicle use	NA☐ Low☐ Medium☒ High☐	B20 Vehicle Use
3, 8	Work near/on water	NA☐ Low☐ Medium☒ High☐	B21 Work Near/On Water
NA	Elevated heights (<4 feet)	NA☒ Low☐ Medium☐ High☐	B22 Working from Heights (<4 feet)
NA	Elevated heights (>4 feet)	NA☒ Low☐ Medium☐ High☐	B23 Working from Heights (>4 feet)
5-11	Overhead/underground utilities	NA☐ Low☐ Medium☒ High☐	B24 Overhead/Underground Utilities
3, 5-11	Powered hand tools	NA☐ Low☒ Medium☐ High☐	B25 Electrically Powered Equipment and Tools
3, 5-11	Electrically powered equipment	NA☐ Low☒ Medium☐ High☐	B25 Electrically Powered Equipment and Tools
3, 6-11	Cutting devices/tools	NA☐ Low☒ Medium☐ High☐	B26 Cutting Devices/Tools
NA	Lifting operations (cranes, rigging)	NA☐ Low☐ Medium☒ High☐	B27 Lifting operations (cranes, rigging)
3, 6, 7, 9-11	Lock Out/Tag Out (LOTO (electrical, pressure)	NA☐ Low☒ Medium☐ High☐	B28 LOTO (electrical/ pressure)
6-11	Drums, cylinders, containers	NA☐ Low☒ Medium☐ High☐	B1 Chemical
2-11	Material handling, ergonomics	NA☐ Low☒ Medium☐ High☐	B29 Material Handling/Ergonomics
1-11	Simultaneous Operations (SIMOPS)	NA☐ Low☐ Medium☒ High☐	B30 SIMOPS
NA	Animal/human fluid/blood/tissue	NA☒ Low☐ Medium☐ High☐	B31 Bloodborne Pathogens
3-11	Poisonous/irritating plants	NA☐ Low☒ Medium☐ High☐	B32 Plants and Animals
NA	Contaminated needles	NA☒ Low☐ Medium☐ High☐	B31 Bloodborne Pathogens
NA	Live bacterial cultures	NA☒ Low☐ Medium☐ High☐	B31 Bloodborne Pathogens
3-11	Insects/rodents/snakes	NA☐ Low☒ Medium☐ High☐	B32 Plants and Animals
3-11	Ticks, mosquitos	NA☐ Low☒ Medium☐ High☐	B32 Poisonous Plants, Animals and Insects

TABLE 6: CONTROL OF HAZARDS SUMMARY

TASK NUMBER(S)	HAZARDS	RELATIVE HAZARD/RISK RATING*	HAZARD CONTROLS APPENDIX AND/OR HASP SECTION
2-11	Security issues	NA☐ Low☒ Medium☐ High☐	B33 Job Safety
NA	Isolated area	NA☒ Low☐ Medium☐ High☐	B34 Personal Safety
3	Employees working alone	NA☐ Low☒ Medium☐ High☐	B35 Working Alone
NA	Seasonal hunting	NA☒ Low☐ Medium☐ High☐	B36 Seasonal Hunting and Dangerous Wildlife
2-11	Employees working early/late	NA☐ Low☒ Medium☐ High☐	B34 Personal Safety
NA	Potentially dangerous wildlife	NA☒ Low☐ Medium☐ High☐	B36 Seasonal Hunting and Dangerous Wildlife
NA	Guard/stray dogs	NA☒ Low☐ Medium☐ High☐	B33 Job Safety
2-11	No/limited cell phone service	NA☐ Low☐ Medium☒ High☐	B34 Personal Safety B35 Working Alone

NOTE:
A single hazard may be listed under several Tasks. In this case, use the highest severity ranking of the tasks evaluated as the overall ranking.
* Relative Hazard/Risk Rating: When evaluating a Task against a specific hazard, the evaluator should:

- Determine how frequently you will be conducting the Task and generally be exposed to the Hazard while onsite;
- Determine the duration (i.e. the amount of time) you will spent conducting the Task; and
- Determine the Severity that the Task/Hazard may cause using Table 5. When assessing the severity, assume the hypothetical injury was a result of the task being conducted improperly and that PPE was not being worn:
  - **Minimal Severity** would require first aid and/or the property/equipment damage is limited to minor wear and tear, scratches, dents (still functional);
  - **Moderate Severity** requires professional medical attention and/or the property/equipment damage necessitates repair but not replacement; and
  - **High Severity** requires immediate medical attention/life threatening and/or the property/equipment damage is significant and requires replacement.

TABLE 7: RELATIVE RISK RATING DECISION TABLE

THE HAZARD…	HAS NO SEVERITY	HAS MINIMAL SEVERITY	HAS MODERATE SEVERITY	HAS HIGH SEVERITY
Is Not Present (i.e. 0% of your onsite time does not expose you to this Hazard)	NA	NA	NA	NA
Is Rarely Present (i.e. <25% of your onsite time exposes you to this Hazard)	NA	LOW	LOW	MED
Is Sometimes Present (i.e. 25%-<50% of your time exposes you to this Hazard)	NA	LOW	MED	HIGH
Is Frequently to Constantly Present (i.e. 50% to 100% of your time exposes you to this Hazard)	NA	MED	HIGH	HIGH

4.1 GENERAL SITE SAFETY

All activities will be conducted in a manner that minimizes hazards and employee exposures to such hazards. The following are some general safety rules that must be followed while onsite.

NOTICE: Ramboll personnel conduct all activities with a general safety awareness while following the protocols discussed in this HASP and in the CMR Subcontractor Safety Manual. Field activities will be conducted at a large active refinery with simultaneous operations and other contractors present onsite. In the case of an emergency, call the Control Room further discussed in Table 1B.

- All personnel who perform onsite operations with the potential for exposure to hazardous substances are required to meet personnel training requirements and medical surveillance criteria, which are described in this HASP.
- All hazardous substances and contaminated soils, liquids and other residues shall be handled, transported, labeled and disposed of in accordance with accepted material handling procedures.
- Personnel will wear PPE as required.
- All work onsite will be planned and supervised by the appropriate personnel to prevent injuries.
- All injuries and accidents will be reported.
- Supervisors will ensure that their employees observe and obey all safety rules and regulations required for the safe conduct of work.
- Alcoholic beverages and illegal drugs will not be allowed onsite. Possession of either will be grounds for disciplinary actions.
- No employee will be assigned to a task without first having been instructed on proper methods of carrying out the task.
- All posted safety signs will be obeyed.
- Space around onsite emergency and fire-fighting equipment will be kept clear.

- All trash and discarded materials will be staged in an orderly fashion and regularly removed from the Site.
- Approval to perform work operations alone must be preapproved by the Site PM/PIC and a communication plan must be established.
- Smoking, eating, drinking and chewing gum or tobacco will not be permitted within the work zones and will follow applicable decontamination procedures prior to eating, drinking and/or smoking.
- Personnel should keep track of weather conditions and wind direction to the extent they could affect potential exposure.
- Personnel should be alert to any abnormal behavior on the part of other workers that might indicate distress, disorientation, or other ill effects.
- Personnel should never ignore symptoms that could indicate potential exposure to chemical contaminants. These should be immediately reported to their supervisor or the Site Health and Safety Officer.
- Visible indicators of potentially immediate danger to life and health (IDLH) conditions include:
    - Large containers and tanks that must be entered;
    - Enclosed spaces such as buildings or trenches that must be entered;
    - Potentially explosive or flammable situations (indicated by bulging drums, effervescence, gas generation, or instrument readings);
    - Extremely hazardous materials (such as cyanide, phosgene, or radiation sources);
    - Visible vapor clouds; and
    - Areas where biological indicators such as dead animals or vegetation are located.

4.2 SPECIFIC SSC REQUIREMENTS

The hazards posed by the presence of underground and overhead services are significant. Where there is a requirement for ground penetrating activity, the work shall be thoroughly vetted prior to commencing subsurface work. No intrusive work is to be conducted until the hazards associated with the possible presence of underground and overhead services have been properly identified and safe locations for intrusion marked and agreed upon. This applies to any intrusive site work (i.e. any work which will involve the disturbance or penetration of the ground or manmade surface by mechanical or manual means, including trial pit excavations, borehole excavations (shell and auger, rotary, hydraulic, percussive), gas spiking, manual excavations, hand digging, intrusion into vertical, indoor, or below ground surfaces and/or any other onsite activity where disturbance of the ground surface is required). If conducting intrusive activities, the following tasks must be completed and documented prior to initiating ground disturbance activities (each is summarized in the following).

4.2.1 Historical Site Information Review

Obtain the most recent as-built drawings and/or site plans [including underground storage tank (UST), product and vent lines], as available. Consider requesting any other site plot plans, surveys, photographs and information that might be instructive from the client or other sources. Site information reviewed shall be specified in Table 8 Subsurface Clearance (SSC) Actions.

4.2.2 Plot Plan

Develop a plot plan the accurately reflects all available information and site conditions as accurately as possible, including the number of facilities/pipelines or utilities, locations and alignments. The plot plan shall be updated as SSC activities commence to properly capture site-conditions or visual indicators. Intrusive activities shall not proceed without an updated plot plan or drawing.

4.2.3 Pre-Marking Ground Disturbance Locations

Whenever feasible, ground disturbance locations and/or areas shall be pre-marked using white stakes, white paint or white flags (or black in cases where snow is on the ground) prior to the public and/or private utility mark-outs. Pre-marking provides the line locators with visual boundaries as guidance in clearing locations and placing marks.

4.2.4 Line Location Services

In areas where public and private resources are available, **Ramboll will contact both public and private utility locate services for any project that involves intrusive activities.** In order to give line operators sufficient time to respond to a request to locate, a minimum of 72 business hours is required prior to the planned start of work. In the event that the driller/excavator retains these services, Ramboll will conduct a follow-up to confirm utility locate information.

Meet directly with the private locator and provide them with location plans, if possible. If an onsite meeting with the private locator is not possible, you MUST contact the private locator so that they understand the scope of the proposed subsurface work and the extent of their activities.

4.2.5 Site Walkover-Visual Indicators

The designated person MUST conduct site walk-over and complete the SSC Field Checklist (Appendix K) for all projects that involve ground disturbance. The site walk-over and visual inspection is most effective when completed during locating activities, but, at a minimum, must be completed PRIOR to ground disturbance. The main intent of the SSC Field Checklist is to identify aboveground indicators which may identify the potential existence of subsurface issue. It will also be used to confirm that common utilities have been accounted for, located and verified. Any potential underground utilities should be marked on a site plot plan and the site walkover should be documented utilizing Ramboll's SSC Field Checklist.

4.2.6 Utility Mark-out

All known pipelines and utilities, as noted on the plot plan, pipeline map or drawing, that pass within the search zone must be located, identified and marked to indicate location and alignment.

A qualified and competent line locator shall conduct line-locating practices utilizing available pipeline maps or plot plans for all areas within the search zone. Direct connection (clamping on) to all possible nearby underground services should be undertaken whenever possible to increase the success rate/reliability in locating. **The specific ground penetration location must be cleared to the edge of the critical zone** [5 feet or 1.5 meter (m) area surrounding intrusive locations/areas in every direction] using a search and sweep method to verify maximum detection capabilities.

If anticipated services are not identified or located, drilling or ground disturbance will not occur until the service is visually identified.

Commonly used utility mark-out colors and identifiers are listed below:

WHITE - Proposed Excavation

PINK - Temporary Survey Markings

RED - Electric Power Lines, Cables, Conduit, and Lighting Cables

YELLOW - Gas, Oil, Petroleum, or Gaseous Materials

ORANGE - Communication, Alarm or Signal Lines, Cables or Conduit

BLUE - Potable Water

PURPLE - Reclaimed Water, Irrigation and Slurry Lines

GREEN - Sewer and Drain Lines

Upon completion of their work (whether you are onsite or not), the private locator MUST contact you to present their results. In addition to providing you with an overall summary of their work, they must also inform you of any unique circumstance(s) which limited their ability in locating the potential presence of underground utilities (e.g. the existence of overhead electrical lines); if they encountered any abnormalities (e.g. concrete surfaces with reinforced rebar); and/or any other condition which may have diminished the validity of their results and efforts.

Where doubt exists over the location of a service, request a site visit from the appropriate utility provider or abandon locations in the immediate area and contact the PM and/or PIC.

4.2.7 Clearance of Ground Disturbance Locations and Critical Zones

After anticipated utilities have been located and marked, use the available information along with regulatory requirements and project objectives to select final ground disturbance locations.

Each specific ground penetration location must be cleared to the edge of the critical zone (5 feet or 1.5 m area surrounding intrusive locations/areas in every direction) using a search and sweep method to verify maximum detection capabilities. Ensure that all detected services and those featured on location plans are outside of the critical zone of EACH location where intrusive work will occur, using a sweep and search method.

The critical zone takes into account minimum tolerance distances from facility lines (which vary by location) and uncertainties introduced by onsite conditions, human factors and equipment. **No intrusive activities shall take place within a critical zone with which utilities or visual indicators intersect**. When known utilities intersect ground disturbance critical zones, boring and/or excavation location criteria should be reevaluated by the designated person and PM and if possible, moved to a pre-cleared alternate location.

In the event that work is required to be conducted in a critical zone containing a marked utility or visual indicator, approval MUST be obtained from the PIC, PM and Corporate H&S Director prior to ground penetrating activities.

4.2.8 Overhead Lines

Ensure that any ground penetrating activities are located a minimum of 28 feet (9 m) horizontally from any overhead electric cable supported wooden poles, or 50 feet (15 m) horizontally in the case of those supported on metal poles/towers. Where this cannot be achieved, contact relevant electricity provider for guidance as well as the PIC/PM and Corporate H&S Director.

4.3 SSC SUMMARY

If the tasks presented in this HASP involve ground penetrating work, Table 8 and the specific procedures outlined in Section 4 are applicable and must be followed. Table 8 summarizes the steps required to be completed, including justification of any exceptions. This table must be completed in its entirety prior to conducting subsurface work. If certain requirements are not applicable, describe reason for exemption.

TABLE 8: SSC CLEARANCE ACTIONS

SSC Pre-Project Planning Checklist
Document the steps that must be followed and justify any exceptions.
This checklist MUST be completed in its entirety.

SSC REQUIREMENTS	YES	NO	NA	COMMENTS
Prequalification of contractor for capability of ground disturbance work performed (see Section 4)	☐	☐	☐	Name of subcontractor(s)
Designated person for SSC work assigned (must be onsite)	☐	☐	☐	Name of Designated Person Signature of Designated Person
Historical Site Information Review, Discussion with Site Personnel	☐	☐	☐	Specify what information was reviewed (e.g. maps, figures, photos, as-built drawings)
Development of site-specific plot plan	☐	☐	☐	Denote where a copy can be found (i.e. Attachment D to project HASP, Specific project file name)
Ground penetrating location marked prior to locate(s) and alternate locations chosen	☐	☐	☐	Describe reason for exception if not performed or not applicable

TABLE 8: SSC CLEARANCE ACTIONS

SSC Pre-Project Planning Checklist
Document the steps that must be followed and justify any exceptions.
This checklist MUST be completed in its entirety.

SSC REQUIREMENTS	YES	NO	NA	COMMENTS
Service notifications provided to clear/locate **public** utilities	☐	☐	☐	List companies notified for public locate (for example): Electric: Ameren Telephone: AT&T Cable: Comcast Gas: Marathon List who contacted One Call: List One Call #: List locate ticket #:
Private locate contracted for onsite utilities	☐	☐	☐	Name of subcontractor(s)
Designated person present during private locating	☐	☐	☐	Describe reason for exception if not performed or not applicable
Underground utilities identified prior to commencement of intrusive activities as reasonably feasible	☐	☐	☐	Describe any non-conformity or unexpected condition discovered during locate(s)
Site walkover conducted to assess utility locations, visual indicators and complete SSC Field Checklist	☐	☐	☐	Describe when the site walkover and SSC Field Checklist will be conducted/completed
Ground penetration locations(s)/area(s) and critical zones (i.e. the 5 feet or 1.5 m distance surrounding intrusive activities in every direction) cleared	☐	☐	☐	Describe results of locate(s): Were alternate ground disturbance location(s) needed due to utility and/or indicator presence?

5. PERSONNEL TRAINING REQUIREMENTS

All personnel performing onsite operations with the potential for exposure to hazardous substances or health hazards will meet the personnel training requirements in accordance with applicable regulations. The training policies and procedures will ensure that personnel can recognize hazards, understand emergency response procedures and have the knowledge necessary to enable them to perform their assigned jobs in a manner that ensures employee and public safety. Completion of appropriate health and safety training, as described below and participation of medical surveillance will be required to gain access to onsite areas other than the Support Zone. Documentation of training includes initial 40-hour H&S training, 8-hour annual refresher training, 8-hour supervisor training, supervised field experience, first aid training and CPR certification.

NOTICE: CMR has site-specific training requirements prior to contractors performing work while onsite. In addition, drug and alcohol abuse training will be completed by Ramboll personnel. This is discussed further in Section 1.5.

5.1 INITIAL TRAINING

Basic H&S Training

A minimum of 24 hours of initial H&S training offsite is required to obtain onsite access to areas other than the Support Zone. All personnel engaged in or supervising activities in the Exclusion Zone or Contamination Reduction Zone will have a minimum of 40 hours of initial H&S training offsite, meeting the in accordance with applicable regulations.

Supervised Field Experience

All personnel with 24 hours of initial H&S training are also required to have a minimum of one day of field experience under the direct supervision of an experienced supervisor. Personnel with 40 hours of initial H&S training are required to have a minimum of three days of field experience under the direct supervision of an experienced supervisor.

Supervisor Training

All onsite managers and supervisors directly responsible for or who supervise personnel engaged in invasive site activities will have received the initial 40 hour H&S training and at least eight additional hours of specialized offsite training consistent with in accordance with applicable regulations. This specialized training will include topics such as, but not limited to, regulatory compliance, management of onsite H&S hazards and recognition of special personnel training needs.

H&S Officer Training

H&S officers will be trained to a level required by their job function and responsibility. This will include training in implementation of HASPs and compliance with applicable H&S requirements.

First Aid and CPR Training

Ramboll personnel will maintain first aid and CPR training as certified by the American Heart Association (or equivalent) to render first aid and CPR.

5.2 REFRESHER TRAINING

All personnel who have received 40 hours of initial H&S training will receive eight hours of refresher training annually, as specified in accordance with applicable regulations. Topics to be covered in this training program will include those specified in the initial 40-hour H&S training and/or those specified in the supervisory training course, as well as a critique of incidents that could serve as training examples.

Project-specific refresher training will be provided when the project scope is changed and/or when the hazards change.

Site Safety Briefings

Site safety briefings will be conducted prior to the start of each workday or work shift to discuss H&S issues changes in work procedures, exposure incidents and other relevant information. A JSA (Appendix A) and applicable CMR work permits will be completed at the start of each workday and will be signed by everyone involved. Prior to each change in operations, the meetings will address PPE use and maintenance, physical safety hazards from machinery, protection from chemical hazards, decontamination procedures, protection from heat/cold stress and specific safety requirements associated with the new operations. During safety meetings, onsite personnel qualified to perform first aid and CPR will be identified. All changes in the HASP will be reviewed during the morning safety briefing. A record of the meeting will be written daily and signed by all participants and included in Section 13 of this HASP.

Visitor's Briefing

Visitors will not be permitted to enter areas other than the Support Zone unless documentation of training, as described above, is presented to the Ramboll Site Supervisor. This includes reviewing the CMR Subcontractor Safety Manual (Supplemental Document 1). The visitor will have to sign a form verifying they have read the safety manual and understand the potential hazards at the facility. All visitors will be provided with applicable site-specific information including but not limited to hazard recognition, personnel hygiene and Site safety rules, use of PPE and emergency response procedures. Visitors requesting onsite access to areas other than the Support Zone will be required to review and sign off on the HASP to ensure understanding and compliance with the provisions in the HASP. All personnel, contractors and site visitors will receive information contained in this HASP and any site-specific hazard awareness prior to entry into the site, as applicable. The training will ensure that personnel can recognize hazards, understand emergency response procedures and have the knowledge necessary to enable them to perform their assigned jobs in a manner that ensures employee and public safety. All personnel will be required to sign an attendance sheet (see section 13.0 in this HASP) verifying that they received and participated in a training briefing. Individuals refusing to sign the sheet will not be allowed to work on the Site.

Compliance with Hazard Communication Standard is required for work at this Site. SDSs are part of Appendix J. Personnel shall receive training for the identification of hazards associated with the materials in use and the safe use of these materials, as applicable. Any hazardous chemical products brought to the Site (other than standard fuels) for use during field activities must be reviewed by the Site Supervisor. Contractors are responsible for having their own hazard communication program. Contractors will supply SDS to the Site Supervisor for all products to be used onsite.

In addition, any employee who is or is expected to be directly involved with intrusive sampling of contaminated environmental media or other sampling activities that could reasonably lead to chemical exposure is subject to appropriate training and standards, including but not limited to 40-hour HAZWOPER (and 8-hour refresher training), respiratory protection, first aid and CPR training. This would include any employee that visits exclusion zones of hazardous waste sites or remediation sites.

5.3 FACILITY H&S REQUIREMENTS

Working at an active industrial facility such as the refinery involves protocols separate from the environmental compliance work being performed. Yet these protocols affect the daily activities of the project team since they address the physical chemical hazards inherent at a refinery. Calumet Great Falls Refinery's requirements regarding some issues are discussed below. Others, such as requirements associated with hand tools, are addressed in the specific section of this HASP.

Calumet Great Falls Refinery has specific procedures for both contractors and visitors, including:

- Unless escorted by trained personnel, all contractor personnel will complete the Site Orientation Program prior to initiating fieldwork. Field personnel will not be allowed to work without completing Site Orientation.
- All visitors who have not completed the Site Orientation Program must be escorted at all times by a qualified person.
- Ramboll must conduct a Safety Tailgate Meeting on applicable topics at the beginning of any field work that will be conducted on Calumet property. This meeting will include all members involved in the field work and documented along with participant's signatures.

5.3.1 Permits

Permits must be obtained from CMR prior to initiating any work at the refinery. Permit duration shall not exceed 12 hours. Permits expire at operations shift change. These include the following:

- **Safe Work Permit:** Required for all work completed in process areas or tank farms at CMR. It is issued on a daily basis. Work that does not include an ignition source. Any job requiring hand or non-powered equipment, painting, installing or removal of insulation, steel erection, scaffold work, opening of plant vessels, towers, drums exchangers, coolers, filters, heaters and tanks, installing electrical lockouts, opening of piping by breaking flanges and unions and installing blinds/blanks, etc.
- **Hot Work:** Required for all work in an operational unit or tank farm where a vehicle or ignition source may be used (i.e. generator, groundwater pump, etc.). Contractors need additional training from CMR. Scaffolding is not planned for this scope of work.
- **Confined Space Entry:** Required for all permit and non-permit confined space entries. This work also requires additional contractor training. Confined space entries are not anticipated for this project. Only the Safety Department can issue confined space permit.
- **Excavation Permit:** Work that requires excavation work by equipment. Approvals for excavation work include environmental, maintenance, safety and operations departments. Only the Safety Department can issue an excavation permit.

- **HF Safe Work Permit:** No person, or persons, other than regularly assigned Zone 1 operators, are permitted to enter the Alky Unit without prior approval and a completed HF Safe Work Permit. All work in the Alky Unit must be approved by the chief operator.

5.4 HAZARD COMMUNICATION

The following procedures related to hazard communication are applicable to this site. All employees will be briefed on this program.

5.4.1 Container Storage

All containers received on site will be inspected to ensure that there is no damage that compromises the integrity of the steel drum(s). Ramboll personnel will coordinate with CMR to store the drums in safe and secure location.

5.4.2 Container Labeling

All CMR employees and contract employees are required to follow the Waste Labeling Procedures that provides guidance for properly labeling waste for storage and offsite disposal. Every waste container requires a completed Waste Label. Waste labeling procedures are found in Supplement Document 5.

5.4.3 Employee Training and Information

Prior to starting work, each employee will attend an H&S orientation and will receive information and training on the following:

- An overview of the requirements contained in the Hazard Communication Standard;
- Hazardous chemicals present in their workplace operations;
- Location and availability of a written hazard communication program;
- How to read labels and review SDSs to obtain appropriate hazard information;
- Locations of SDS files and the hazardous chemical inventory;
- Physical and health effects of the hazardous chemicals;
- Methods and observation techniques used to determine the presence or release of hazardous chemicals;
- How to lessen or prevent exposure to these hazardous chemicals through usage of control/ work practices and personal protective equipment; and
- Emergency procedures to follow if they are exposed to these chemicals.

Ramboll employee(s) will inform its subcontractor(s) the hazardous chemicals brought onsite by Ramboll. Likewise, subcontractors shall inform Ramboll employees the same. All chemicals will need approval by CMR. Ramboll will complete the chemical approval form (Supplemental Document 2) and receive approval prior to being brought onsite.

5.5 DISCIPLINARY ACTIONS

In the event that personnel do not follow the H&S safety rules and/or are conducting operations that are hazardous to themselves or their fellow workers, disciplinary actions will be implemented in accordance with Ramboll's policies.

5.6 INCIDENT REPORTING

Each contractor is responsible for maintaining injury and illness records in accordance with applicable regulations and supplying Ramboll with applicable records in a timely fashion upon request. With respect to incidents, the following types of H&S incidents are to be reported.

NOTICE: CMR may have Ramboll personnel perform a post-accident drug and alcohol test. Ramboll personnel will conduct the test at the following facility address: Benefis Injury Center, 1401 25th Street South, Great Falls, Montana 59405.

- All employee injuries and illnesses that include first aid, doctor/hospital visits which may or may not involve restricted work and/or lost time;
- Environmental incidents and exposures, such as spills or other unplanned releases to the environment or nonconformance to operating procedures;
- All evacuations (false or real);
- Any property damage;
- Near miss incidents which could have resulted in an injury, an accident, environmental impact or significant loss of facilities; and
- Public/third party liability-Incidents that involve injury, illness or property damage due to the actions of any non-Ramboll employee arising out of, or in connection with the Firm's contracted scope of work, operations, products or premises

As a rule of thumb, all of the incident types outlined above MUST be communicated by the Ramboll Site Supervisor to the designated CMR representative, either the PIC/PM and the Corporate H&S Director and/or project HSC immediately following the incident, either in person or via phone, e-mail or text messaging. The contacted person will then ensure that the other core project members are informed either in person or via phone, e-mail or text messaging, regardless of time of day. As soon as possible after the incident but no later than 72 hours after the event, the first page of the Incident Investigation Report form will be completed by the Site Supervisor or his/her designee and sent the core project members (i.e. the PIC/PM, Corporate H&S Director, project HSC), for preliminary root cause analysis. The root cause analysis will not be deemed complete until input from all individuals involved in the incident, applicable witnesses and input from the core team has been obtained. Similarly, the implementation of any corrective/preventive actions will NOT be implemented until input from the Corporate H&S Director (and others as necessary) has been obtained.

6. MEDICAL SURVEILLANCE AND RECORDKEEPING

The goals of the medical surveillance program are to monitor the health of potentially exposed personnel through the use of medical examinations and diagnostic laboratory testing, to provide medical care for occupational injury or illness, to keep accurate records for future reference and to ensure the selection of personnel physically able to safely perform the work assigned. The medical surveillance program supports and monitors the effectiveness of the primary H&S goal of controlling worker exposure to hazardous substances. Medical examinations will be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine.

In general, all employees who may be exposed to hazardous substances above the permissible limits; who wear a respirator; or who are injured, become ill, or develop signs or symptoms due to possible overexposure to hazardous substances from hazardous waste operations must be medically monitored. Ramboll's requirement is for all employees to be subject to Medical Surveillance Program as well as any employee who may wear a respirator, regardless of the during of use.

Each employee enrolled in the Medical Surveillance Program will be subject to periodic medical exams, the frequency of which will vary depending on the extent and duration of exposure, the type of chemicals involved and the individual employee's medical profile. These personnel will receive a medical examination at least once per calendar year.

Documentation of current participation in a medical surveillance program and fitness for duty, including ability to wear respiratory protective equipment, will be necessary for all personnel who work onsite in areas other than the Support Zone. However, all specific medical information and examination results obtained in the course of administration of the medical surveillance program will be maintained by the examining physician as confidential.

6.1 BASELINE MEDICAL EXAMINATIONS

The baseline medical examination serves two major purposes: (1) it determines the individual's fitness for duty, including the ability to work while wearing a respirator; and (2) it provides baseline data for comparison with future medical data. The baseline medical examination will include, at a minimum, the following:

- Complete occupational and medical history;
- Physical examination;
- Blood count and chemistry profile;
- Urinalysis with microscopic review;
- Chest x-ray;
- Pulmonary function tests;
- Resting electrocardiogram (EKG); and
- Cardiac stress test (at physician's discretion).

Certification of fitness for duty and ability to wear personal protective equipment must be provided to gain access to onsite areas other than the Support Zone. However, all specific medical information obtained in the course of administration of the medical surveillance program will be maintained as confidential.

6.2 PERIODIC MEDICAL EXAMINATIONS

Each individual enrolled in the medical surveillance program will be subject to periodic medical surveillance examinations. In general, personnel involved in field activities with a frequency of greater than 30 days per year will receive medical examinations at least annually. Periodic medical examinations should include the parameters included in the baseline examination, with the exception of the chest x-ray and EKG, which are repeated after the baseline examination at the physician's discretion and with agreement of the individual.

6.3 SPECIAL MEDICAL EXAMINATIONS

Special medical examinations or consultations will be arranged for personnel exposed in an emergency situation to hazardous substances at concentrations above the PELs without adequate protection. This will be done as soon as possible after the overexposure has been determined by the Site Supervisor, in consultation with the Corporate H&S Director.

Special medical examinations shall also be arranged upon notification by the individual that he/she has developed signs or symptoms indicating a possible overexposure to hazardous substances, or if the examining physician determines that a more frequent medical examination is necessary.

6.4 SPECIAL CIRCUMSTANCES

Any individual who is on a medication that may interfere with the ability to perform his/her job function, or who may require special medical attention, must notify the Site Supervisor of these circumstances prior to commencing work at the Site.

6.5 H&S RECORDS

H&S records for onsite Ramboll personnel including but not limited to training, medical clearances, fit testing and any monitoring will be kept on file by the Corporate H&S Director and onsite by the Site Supervisor, as applicable. Subcontractor and contractor H&S records shall be maintained by the applicable subcontractor and/or contractor and provided to the Site Supervisor. Ramboll Personnel Training and Medical Records are maintained by Ramboll. **RECORDS WILL BE MAINTAINED ONSITE AS NECESSARY.**

7. PPE

This section of the HASP is a reference of selection for different levels of PPE. The protective equipment will be selected based on the contaminant type(s), concentration(s) in air (if any), standing liquid (if any), or other applicable matrix and the known route(s) of entry into the human body. In situations where the type of materials, their concentrations, or exposure potentials are unknown, a decision based on professional judgment regarding the assignment of personal protective equipment will be made by the HSC.

7.1 SELECTION OF PPE

The selected PPE should be able to resist degradation, penetration and permeation by the contaminants present at the Site. In selecting the appropriate protective material, the following should be considered:

- Chemical resistance;
- Tear and puncture resistance;
- Flexibility;
- Thermal stress;
- Cleanability; and
- Durability.

In addition, site requirements for the Site will be taken into account.

PPE will be selected, used and maintained in accordance with applicable regulations.

Levels of PPE

The four levels of PPE are Levels A, B, C and D, with Level A providing the highest available level of respiratory, skin and eye protection. A summary of the basic PPE ensemble for Levels A, B, C and D is provided below. PPE selection for operations at the Site will be tailored to address specific task conditions.

Level A

Level A PPE provides the maximum degree of respiratory, skin and eye protection. A Level A PPE ensemble should include:

- Full-face piece self-contained breathing apparatus (SCBA) or full-face piece supplied air respirator with escape SCBA;
- Fully encapsulating, chemical-resistant suit, safety boots and inner gloves; and
- Hard hat (if overhead or bump hazards exist).

Level B

Level B PPE provides the maximum level of respiratory protection. Since chemical-resistant clothing is not considered gas, vapor, or particulate tight, Level B PPE does not provide the maximum skin protection. However, a good quality, hooded, chemical-resistant one-piece garment with taped wrists and ankles provides a reasonable degree of protection against splashes of liquids and lower

concentrations of chemicals in ambient air. It is the minimum level recommended for confined space entries and initial Site entries until the hazards have been further identified. Level B PPE should be used when any one of the following criteria is met:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection but less skin protection. This includes atmospheres with IDLH concentrations of specific substances that do not represent a severe skin hazard or atmospheres that do not meet the criteria for use of air-purifying respirators.
- Atmosphere contains less than 19.5% oxygen.
- Presence of incompletely identified vapors or gases is indicated by air monitoring instruments but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.

Level C

Level C PPE provides the same level of skin protection as Level B PPE, but a lower level of respiratory protection. Air-purifying respirators can be used only if the substance has adequate warning properties; the individual passes a qualitative fit-test for the mask; an appropriate cartridge/canister is used and its service limit concentration is not exceeded; and Site operations are not likely to generate unknown compounds or excessive concentrations of already identified substances. Level C PPE can be used when all of the following conditions are met:

NOTICE: If respirators are required to be used at the Site, CMR requires the use of combination respirator cartridges. If used, these cartridges must be replaced daily.

- Oxygen concentrations are not less than 19.5%;
- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any exposed skin;
- Types of air contaminants have been identified, concentrations measured and a cartridge or canister is available that can remove the contaminant;
- Atmospheric contaminant concentrations do not exceed IDLH levels; and
- Job functions do not require SCBAs.

CMR Site-specific Level D

Site-specific Level D PPE is required at CMR. Below is a list of PPE requirements provided in the CMR Subcontractor Safety Manual.

- Flame-resistant clothing (rating HRC2);
- Leather steel-toed boots with a defined heal;
- Hearing protection (a minimum of 25 dB) (see Figure 3 for the area that hearing protection is required);
- Hard hat;
- Safety glasses with side shields;
- Safety goggles, required to be on-person at all times;
- Leather gloves and glove clips, as needed;

- Personal H_2S monitoring device;
- Flame-resistant high visibility safety vest (rating HRC2), as needed; and
- Flame-resistant coat and/or rain gear (rating HRC2), as needed.

7.2 RESPIRATOR FIT TEST

A respirator fit test will be conducted on all Site personnel who will perform work operations in areas other than the Support Zone. Prior to the initiation of any fit testing, personnel must be certified as medically able to wear a respirator. The respirator fit test is conducted to ensure proper face piece-to-face seal. A secure fit is important with positive-pressure equipment and is essential to the safe functioning of negative-pressure equipment, such as most air-purifying respirators. Personnel will receive instruction on proper wear and maintenance of the respirator.

Qualitative fit tests will be conducted annually in accordance with the ANSI Practices for Respiratory Protection, Z88.2-1989. In addition, a negative and positive fit check will be performed each time an employee dons the air-purifying respirator (APR). Documentation of annual respirator fit tests will be kept in the Support Zone.

7.2.1 Negative and Positive Fit Check

The negative and positive pressure fit check will be performed each time an employee dons the APR. The negative pressure fit check involves closing off the inlet openings to the APR cartridges by covering with the palms of the hands. If an inward leakage of air is detected, the APR should be checked for material defects and refitted or replaced with another APR.

The positive pressure fit check is performed by placing the palm of hand over the exhalation valve and gently exhaling for 10 seconds to create positive pressure inside the facepiece. If an outward air leak is detected, the APR should be readjusted. If after readjustment leakage still occurs, another APR should be used.

7.3 PPE INSPECTION CHECKLIST AND MAINTENANCE

PPE inspections will be conducted upon receipt of PPE from the factory or distributor; when it is issued to workers; after use or training; and prior to maintenance. Periodic inspections of stored equipment will be conducted routinely, whenever a question arises concerning the appropriateness of the selected equipment, or when problems with similar equipment arise. At a minimum, PPE inspection should include the following.

Clothing

Before use determine that the clothing material is correct for the specified task.

Visually inspect for:

- Imperfect seams;
- On-uniform coatings;
- Tears;
- Malfunctioning closures; and
- Hold up to light and check for pinholes.

Flex product:

- Observe for cracks; and
- Observe for other signs of shelf deterioration.

If the product has been used previously, inspect inside and out for signs of chemical breakthrough or deterioration, such as:

- Discoloration;
- Swelling; and
- Stiffness.

During the work task, periodically inspect for:

- Evidence of chemical attack such as discoloration, swelling, stiffening and softening. Keep in mind that chemical permeation can occur without any visible effects.
- Closure failure.
- Tears.
- Punctures.
- Seam discontinuities.

Gloves

Before use, pressurize glove to check for pinholes. Either blow into glove, then roll gauntlet towards fingers or inflate glove and hold under water. In either case, no air should escape.

Respirators

SCBA/supplied air/air-purifying:

- Inspect SCBA/supplied air/air-purifying respirators before and after each use, at least monthly when in storage and during cleaning. Air-purifying respirators should be inspected before each use to be sure they have been adequately cleaned.
- Check all connections for tightness, inspect air lines prior to each use for cracks, kinks, cuts, frays and weak areas.
- Check for proper setting and operation of regulators and valves (according to manufacturer's recommendations) and check operation of alarms.

Check material conditions for:

- Signs of pliability;
- Signs of deterioration; and
- Signs of distortion.

Check face shields and lenses for:

- Cracks;
- Crazing; and
- Fogginess.

Examine cartridges or canisters to ensure that:

- They are the proper type for the intended use;
- The expiration date has not passed; and
- They have not been opened or used previously.

7.4 TASK SPECIFIC PPE

This section of the HASP is used for the selection of the appropriate PPE. The protective equipment will be selected based on the contaminant type(s), concentration(s) in air (if any), standing liquid (if any), or other applicable matrix (e.g. soil, sludge, sediment, etc.) and the known route(s) of entry into the human body. Table 9 presents the general level of protection to be used for each task that is anticipated to be conducted on this project.

Table 10 identifies the specific PPE items that are required or recommended to be used on this project. This includes identifying the specific type of hand and body protection (as applicable) for the chemicals that may be encounter while conducting the tasks outlined in this HASP.

TABLE 9: TASK SPECIFIC PPE

TASK DESCRIPTION AS DEPICTED IN SECTION 2.5	LEVEL OF PROTECTION			
	A	B	C	CMR MOD D
Task 2: Site Security	☐	☐	☐	☒
Task 3: Full-time Onsite Project Support	☐	☐	☐	☒
Task 4: Traffic Control	☐	☐	☐	☒
Task 5: Surface Geophysical and Subsurface/Overhead Utility Clearance	☐	☐	☐	☒
Task 6: Advancement of Soil Borings and Soil Sampling	☐	☐	☐	☒
Task 7: Installation, Development and Abandonment of Monitoring, Recovery and Extraction Wells	☐	☐	☐	☒
Task 8: Groundwater Gauging and Sampling	☐	☐	☐	☒
Task 9: Remediation O&M	☐	☐	☐	☒
Task 10: DPE System Installation	☐	☐	☐	☒
Task 11: LNAPL Recovery Trench and PTT Installation	☐	☐	☐	☒

Key:
CMR Site-Specific Level D: FR Long sleeve shirt*; FR long pants*; hard hat with safety googles; eye protection; hearing protection; safety shoes; leather gloves; and a personal H_2S monitoring device. FR rain jacket and high-vis vest, as needed.
Level C: Level D (Modified) protection plus negative pressure respiratory protection with appropriate cartridges; chemical protective coveralls in lieu of general coveralls; use of inner and outer sets of hand protection.
Level B: Level C protection plus Pressure-demand supplied air respirator with escape bottle in lieu of negative pressure respirator; chemical resistant coveralls with hood; chemical resistant boots.
Level A: Level B protection plus fully encapsulating (gas tight) chemically resistant suit.
*Fire Resistant Clothing (FRCs) must always be worn as your outer layer of clothing while working at the facility.

TABLE 10: PPE AND SUPPLIES

EQUIPMENT	REQ	REC	NA	EQUIPMENT	REQ	REC	NA
Flame Retardant Coveralls or Clothing	☒	☐	☐	Outer Chemical Gloves (Type) (nitrile as needed)	☐	☒	☐
Hearing Protection	☒	☐	☐	Inner Chemical Gloves (Type)	☐	☐	☒
Steel-toe Boots	☒	☐	☐	SCBA	☐	☐	☒
Hard Hat	☒	☐	☐	Full-face Airline Respirator	☐	☐	☒
Safety Glasses with Side Shields	☒	☐	☐	Full-face Negative Pressure Resp.	☐	☒	☐
Vented (Splash proof) Goggles	☒	☐	☐	Half-face Negative Pressure Respirator	☐	☐	☒
Personal H_2S Monitor	☒	☐	☐	Powered APR	☐	☐	☒
Flame Retardant Safety Vest	☒	☐	☐	First Aid Kit	☒	☐	☐
Leather Gloves	☒	☐	☐	Fire Extinguisher	☒	☐	☐
Outer Disposable Boots	☐	☐	☒	Mobile Phones	☐	☐	☒
Tyvek Suit	☐	☐	☒	Walkie Talkies	☐	☒	☐
Poly-coated Tyvek/Saranex Suit	☐	☐	☒	Water or Other Fluid Replenishment	☒	☐	☐
Fully Encapsulated Chemical Suit	☐	☐	☒	Eye Wash	☐	☒	☐
Flame Resistant Long Sleeve Shirt and Pants	☒	☐	☐	Sunscreen	☐	☒	☐
Other: Flame Resistant Coat and/or Rain Gear	☒	☐	☐	Insect Repellent	☐	☒	☐
Other: Site Training Badge	☒	☐	☐	Other:	☐	☐	☐

Key:
Req = Required
Rec = Recommended
NA = Not Applicable

8. AIR MONITORING/SAMPLING PROCEDURES

Air samples may be collected during the project to identify and quantify airborne contaminants in order to delineate areas where PPE may be needed; determine the level of PPE necessary; document onsite employees' exposures; assess the potential health effects of exposure; determine the need to implement engineering controls or evacuate the work zone or Site; and determine the need for specific medical monitoring. Some commonly used devices include the following:

- **H_2S Monitoring Device**: A single-gas detector is designed to measure atmospheric conditions in a range of environments and extreme temperatures. The device runs continuously and factory-calibrated to last 24 months. There is no need for calibration, sensor replacement, battery replacement or battery recharging during the lifespan of the monitoring device. Periodic bump checks should be performed to test and verify the performance of the H_2S detector.
- **CGI:** Examples include O2/LEL meter. A CGI measures the concentration of a combustible gas or vapor. Its accuracy is, in part, dependent upon on the difference between the calibration and sampling temperatures; oxygen-deficient atmospheres also affect accuracy; filament can be damaged by silicones, halides and tetraethyl lead; and the sensitivity is a function of the difference in the chemical and physical properties between the calibration gas and the unknown.
- **Flame Ionization Detector (FID):** Examples include Organic Vapor Analyzer (OVA). Depending on mode, it may detect many organic gases and vapors. A FID will not detect inorganic gases and vapors, has reduced reliability in high humidity conditions and should not be used when temperatures are below 40°F (4.4°C).
- **Ultraviolet (UV) Photo Ionization Detector (PID)**: Examples include HNU. Detects a number of organic and some inorganic gases and vapors. A PID does not detect methane; does not detect a compound if the probe used has a lower energy than the compound's ionization potential; does not readily ionize fully chlorinated materials; high humidity affect readings; low humidity affects operation; response is sensitive to dust or moisture on the lamp; and responses will fluctuate when gases are mixed.
- **Infrared Spectrophotometer (IR):** Examples include Miran. Measures concentrations of many gases and vapors in the air but designed to quantify one- or two-component mixtures. Not approved for use in hazardous conditions; must make repeated passes to achieve reliable results; and somewhat bulky/heavy.
- **Direct-Read Colorimetric Tubes:** Examples include Drager. The compound reacts with the indicator chemical in the tube, producing a stain whose length is proportional to the compounds' concentration. Results are affected by temperature, pressure and humidity; many similar compounds interfere with results.
- **Personal Air Monitoring:** Quantitative air sampling for nuisance dust, metals, organic and inorganic compounds. Samples are collected using personal air sampling pumps and the appropriate sampling media. All personnel samples will be collected in the employees breathing zone over the duration of the work shift. The specific methods to be utilized for the collection of personal air samples will require the involvement of a Certified Industrial Hygienist (CIH) if this type of sampling will be conducted.

8.1 USING MONITORING DEVICES

Conducting an applicable task may necessitate using one or more monitoring devices as listed in Table 11, particularly if gases, vapors, explosion hazards and/or oxygen deficient atmosphere can occur or are expected. If a monitoring device will be utilized, the corresponding device letter should be placed in the column labeled Monitoring Instrument Required in Table 12. In addition, you MUST record the following information in the field logbook if you are going to use a monitoring device:

- Instrument name and serial number;
- Date of calibration;
- Frequency/duration of monitoring;
- The monitoring results; and
- The actions taken based on the results, even if no actions are required to be taken.

TABLE 11: MONITORING DEVICES AVAILABLE

A	PID (10.6 eV)	**H**	Summa Canister
B	PID (11.7 eV)	**I**	Heat Stress Monitor
C	FID	**J**	Air Sampling: H_2S monitoring device
D	OVA	**K**	Air Sampling:
E	CGI/LEL	**L**	Radiation Detector
F	Colorimetric Indicator Tubes	**M**	Gas Multimeter
G	Dust Monitoring	**N**	Other Device:

With respect to Table 11, also insert the task and the applicable Action Level in the appropriate box using 50% of the most restrictive (lowest) PEL or TLV as the trigger. For example, if the most restrictive PEL for a particular VOC is 50 ppm, use 25 ppm as the trigger value.

TABLE 12: REQUIRED MONITORING

	CONSTITUENT	TASK(S)	TRIGGER (ACTION LEVEL)	MONITORING INSTRUMENT REQUIRED
REQUIRED MONITORING **If monitoring is necessary to identify that a risk is at or above tolerable limits and/or is used in controlling a risk on site, document the task and the maximum allowable exposure or trigger and the monitoring instrument required to be used.**	Oxygen (O_2)	3-11	19.5% to 23.5%	M
	Carbon Monoxide (CO)	3-11	25 ppm	M
	H_2S	3-11	5 ppm	J, M
	Carbon Disulfide (C_2S)			
	Methane (CH_4)		0.5% or 5000 ppm	
	VOCs: Total	5-11	0.5 ppm	B
	SVOCs:			
	Metals			
	Dusts			
	Low Exposure Limit (LEL)	3-11	10 ppm (low) 20 ppm (high)	M

8.2 ACTION LEVEL GUIDANCE

In general, this HASP must address site-specific chemicals as noted in Tables 11 and 12. However, there are chemicals commonly encountered in the workplace that may not be a chemical targeted for sampling but nonetheless will have adverse health effects. These chemicals are listed in Table 13 below.

TABLE 13: ACTION LEVELS FOR COMMONLY ENCOUNTERED COMPOUNDS

COMPOUND	ACTION LEVEL
VOC (as Benzene)	0.5 ppm MAXIMUM
Methane (CH_4)	0.5% MAXIMUM or 5,000 ppm
CO_2	0.25% OR 2,500 ppm MAXIMUM
CO	25 ppm MAXIMUM
H_2S	5 ppm MAXIMUM
O_2	19% MINIMUM–23.5% MAXIMUM

8.2.1 Volatile Organic Compound

An action level for each chemical or group of chemicals should be based on 50% of the most restrictive (lowest) PEL or TLV. If a sustained (i.e. 1 minute sampling period) total volatile organic compound (VOC) reading within the breathing zone as determined by a PID is above the action level,

site personnel shall attempt to mitigate the situation through the use of engineering controls (i.e. move upwind, increase air circulation) as indicated in Table 14. If the action level still cannot be met, personnel shall leave the area and contact the PM and HSC for further instructions.

TABLE 14: VOC

INSTRUMENT	CALIBRATION GAS STANDARD	FREQUENCY/ DURATION OF AIR MONITORING	ACTION LEVEL[1] ABOVE BACKGROUND (BREATHING ZONE)	ACTION
PID calibrated daily	100 ppm isobutylene	Every 5-10 minutes, take a 1 minute reading	> 0.5 ppm above background level	Introduce engineering controls (i.e. blower fans) (Level D) Evaluate controls (see below)
AFTER INTRODUCTION OF ENGINEERING CONTROLS				
PID calibrated daily	100 ppm isobutylene	Every 5-10 minutes, take a 1 minute reading	< 0.5 ppm	Continue work (Level D)
			0.5-5 ppm above background level	Don respirator (Level C); contact HSC to evaluate
			> 5 ppm above background level	Discontinue work (Level C)

Note:
[1] Action Levels for "known contaminants" should be based upon each contaminant's PEL or TLV.

8.2.2 Hydrogen Sulfide Gas

CMR requires Site personnel to have an H_2S monitoring device on them at all times. As discussed in Section 8.2.1, the action level is determined by 50% of the most restrictive (lowest) PEL or TLV. The action level and steps to be taken to mitigate the situation through the use of engineering controls as shown in Table 15. If the action level still cannot be met, personnel shall leave the area and contact the PM, HSC and CMR facility personnel for further instructions.

TABLE 15: H_2S GAS

INSTRUMENT	CALIBRATION GAS STANDARD	FREQUENCY/ DURATION OF AIR MONITORING	ACTION LEVEL[1] ABOVE BACKGROUND (BREATHING ZONE)	ACTION
H_2S Monitoring Device	H_2S gas (bump test)	Continuous	> 10 ppm (1.4 µg/m^3) above background level	Introduce engineering controls (i.e. blower fans) (Level D) Evaluate controls (see below)

TABLE 15: H_2S GAS				
INSTRUMENT	**CALIBRATION GAS STANDARD**	**FREQUENCY/ DURATION OF AIR MONITORING**	**ACTION LEVEL[1] ABOVE BACKGROUND (BREATHING ZONE)**	**ACTION**
AFTER INTRODUCTION OF ENGINEERING CONTROLS				
Factory calibrated last 24 months	H_2S gas (bump test)	Continuous	< 10 ppm (1.4 µg/m^3)	Continue work (Level D)
			> 10 ppm above background level	Discontinue work; Contact Operations to report H_2S alarm
Note: [1]Action Levels for "known contaminants" should be based upon each contaminant's PEL or TLV.				

8.2.3 Combustible Gas Indicator/Oxygen Meter

TABLE 16: COMBUSTIBLE GAS INDICATOR (CGI)/OXYGEN METER	
METER RESPONSE	**ACTION/RESPIRATORY PROTECTION**
CGI response <10% LEL	Continue normal operations with regular, periodic monitoring
CGI response > 10% LEL	Discontinue operations; evacuate personnel and prohibit entry; allow to vent until readings are <10%.
Oxygen level <19.5% or >23.5%	Retreat from work area; consult with PM and HSC about upgrading to Level B respiratory protection, adding mechanical ventilation, or possible changes in work practices.

8.2.4 Odors

If strong odors are encountered or if personnel develop headaches, dizziness or other potential exposure symptoms, the personnel shall leave the work area to a well-ventilated area and contact the PM and HSC for further instructions.

8.2.5 Dusts

The permissible exposure levels for total and respirable dusts are 15 and 5 mg/m^3, respectively. In general, at these concentrations you will not be able to read the face of a wristwatch (with your arm extended) when the total dust concentration reaches 15 mg/m^3. Particles of dust in the respirable size range cannot be seen without the aid of a microscope but in aggregate, may be perceived as a haze. More importantly and with few exceptions, when dust is noticeable in the air, more respirable particles will exist than larger particles.

Typically, controlling dusty investigative activities through the use of a water sprayer will control potential exposures. However, in the event that dusty conditions exist that are not related to

investigative/remedial activities (dry, uncovered soils with high winds), personnel shall leave the area and contact the PM and HSC for further instructions.

Nonetheless, to determine the likelihood of exposure from dusts, a theoretical Total Dust concentration in mg/m^3 can be calculated to estimate the total dust concentration in which the concentration of the contaminant in the soil could equal and/or exceed its established exposure limit (EL). This equation is as follows:

$$\text{Total Dust } (mg/m^3) = (10^6 \text{ mg/kg}) \text{ (EL } mg/m^3)/(\text{Conc. of contaminant in soil mg/kg}) \text{ (SF)}$$

Where:

EL = Exposure limit of the contaminant of concern (e.g. its PEL or TLV in mg/m^3).

SF = Safety factor, a number between one and 10. Used to account for the degree of confidence in the characterization data (a 10 would represent a poor degree of confidence, for example only one soil sample was collected/analyzed to characterize the site).

The SF is based upon the following assumptions:

- The concentration of the contaminant in the airborne dust is the same as its concentration in the sample matrix;
- The soil data depicts a representative "worst-case" scenario;
- The monitoring instrument used, accurately measures the ambient concentration of particulate matter in the air; and
- A single contaminant of concern is present.

As an example, assume that Lead (with an EL of 0.05 mg/m^3) is the contaminant of concern and a soil concentration of 25,000 mg/kg has been identified. Depending on the SF used, the theoretical total dust concentration will range between 2 to 0.2 mg/m^3. This means that when the in-situ particulate monitoring device is registering a concentration within 2 to 0.2 mg/m^3 range, there is a high probability that this dust contains enough lead to equal and/or exceed the EL. Hence, the level of PPE used would be increased until engineering controls are determined to be effective as documented by personal monitoring.

9. CONFINED SPACE ENTRY

RAMBOLL'S H&S POLICY PROHIBITS UNAUTHORIZED ENTRY INTO CONFINED SPACES. In the event that entry into a confined space is required, prior to entering a confined space, Ramboll employees (or its subcontractor's employees) will need additional training. Without confined space training, entry into confined spaces is prohibited. In addition, entry authorization will only be given after Ramboll management has reviewed the nature of the confined space, the hazards present and the measures needed to ensure safety. Under these circumstances, Ramboll will work with the host facility/client to determine training requirements, sampling requirements, written program requirements and equipment needed to safely enter the confined space.

It is not anticipated that confined space entry will be required for this project and/or the tasks listed in this HASP. If confined space entry is required, this HASP will be modified accordingly and all applicable regulations will be adhered to.

10. SPILL RESPONSE

Upon discovery of a hazardous substance spill, Ramboll personnel will immediately move to a safe location and summon help by notifying the Environmental Department (i.e. CMR Client Contact or CMR Alternate Client Contact). Remain on the radio and/or cell phone – DO NOT HANG UP – and update the Environmental Department of any new observations. Ensure the safety of nearby personnel and if anyone is seriously injured, immediately contact CMR employees on Radio Channel #2.

As specific training is required to be involved in spill response at CMR, Ramboll will not be directly involved in the except for those step(s) noted above.

11. DECONTAMINATION

11.1 SAMPLING AND CONSTRUCTION EQUIPMENT DECONTAMINATION

Decontamination involves the orderly controlled removal of contaminants. All undedicated sampling equipment and sampling meters (if applicable) will be cleaned prior to and between each use. All onsite equipment will be decontaminated and allowed to air dry before leaving the site. Decontamination maybe accomplished using an approved cleaner, water and steam. Subcontractors will be responsible for decontamination of their own equipment used during field operations, as well as disposal of the decontamination fluids. Decontamination fluids and soil cuttings will be temporarily stored in sealed and labeled 55 gallon drums, staged at a safe location which is mutually acceptable to Ramboll and the host facility, pending offsite disposal. The decontamination methods will be as follows:

NOTICE: CMR practices good housekeeping to minimize the possibility of a fire. If a solvent is needed for cleaning tools and equipment, a high flash solvent and/or approved cleaning product should be used. Always provide adequate ventilation. See the CMR Subcontractor Safety Manual for more information.

11.2 PERSONNEL DECONTAMINATION

All site personnel should minimize contact with contaminants. At a minimum, the gross removal of contaminants from PPE shall occur in a designated area. Non-disposal PPE must be decontaminated, particularly safety boots. Any PPE that cannot be decontaminated should be disposed of along with the waste generated from field operations. Personnel should wash their hands and face prior to departing from the site and prior to eating, drinking, smoking and/or applying cosmetics. The decontamination methods will be as follows:

Modified Level D Personnel Decontamination

Where activities are performed in modified Level D PPE personnel will perform decontamination using the following guidelines:

- Place tools, instruments, samples and trash at an appropriate location. The equipment drop area should be clean and dry and at a minimum, plastic bags should be available for trash. Waste PPE will not be placed in the same containers as general trash.
- Inspect equipment, samples and if applicable, tools for signs of residual amounts of contamination or excessive soil buildup. If present, soils and contamination must be completely cleaned off of equipment, samples and tools prior to removal from the decontamination areas.
- Personnel will visually check themselves for signs of excessive soils and possible contamination. If observed, soils and contamination will be completely removed before further decontamination is performed.
- Remove outer work gloves and place in an appropriate container specified for waste PPE.
- Remove outer Tyvek coveralls if used and place them in an appropriate container specified for waste PPE.

- Remove inner protective gloves and place them in an appropriate container specified for waste PPE.
- Remove inner protective gloves and place them in an appropriate container specified for waste PPE.
- Wash hands using soap and water (separate from other decontamination cleaners/solutions).

Level C Personnel Decontamination

Personnel involved in activities that require the use of Level C PPE will observe the following decontamination guidelines:

- Place tools, instruments, samples and trash at an appropriate location. There areas should be clean and dry and at a minimum contain plastic bags for trash. Waste PPE will not be placed in the same containers as general trash.
- Inspection equipment, samples and if applicable, tools for signs of residual amounts of contamination or excessive soil buildup. If present, soils and contamination must be completely cleaned off of equipment, samples and tools prior removal from the decontamination areas. Personnel will visually check themselves for signs of excessive soils and possible contamination. If observed, soils and contamination will be completely removed before further decontamination is performed.
- Untape wrists and ankles.
- Remove outer work gloves and place them in an appropriate container specified for waste PPE.
- Remove outer Tyvek coveralls and place them in an appropriate container specified for waste PPE.
- Wipe off and remove respirator mask (also goggles if worn).
- Remove inner protective gloves and place them in an appropriate container specified for waste PPE.
- Wash hands using soap and water (separate from other decontamination cleaners/solutions).

During emergencies, the need to quickly respond to an accident or injury must be weighed against the risk to the injured party from chemical exposure. It may be that the time lost decontaminating an individual may cause greater harm to the individual than from the potential for chemical exposure, particularly if the injury is life-threatening. In these instances, a non-injured person needs to inform responding emergency personnel of the potential for chemical contamination on the victim, specifically mentioning the type and expected concentrations.

11.3 INVESTIGATION-DERIVED MATERIAL DISPOSAL

Investigation-derived materials will also be handled appropriately and will be temporarily stored in sealed and labeled 55 gallon drums, staged at a safe location which is mutually acceptable to Ramboll and the host facility, pending offsite disposal. The storage methods will be as follows:

- Drill cuttings: Onsite in properly labeled drums; and
- Purge water: Purge water will be transferred to the onsite wastewater treatment system.

12. EMERGENCY RESPONSE PLAN

The Emergency Response Plan (ERP) describes contingencies and emergency response procedures. The ERP defines the responsibilities of key personnel in planning, prevention and response to emergency situations and identifies agency contacts and medical care procedures. The ERP addresses measures to prevent and respond to emergency situations, such as fire or explosion; spill or release of hazardous material; personnel injury or illness; or other adverse events. General emergency guidelines are as follows:

NOTICE: CMR has specific emergency evacuation protocols that Ramboll personnel will follow. In the event of an emergency, the refinery will blast a loud whistle to indicate what area of the refinery is being evacuated (with the exception at noon and 12:30 pm, as these loud blasts are performed daily).

Code	Interpretation
Long Single Whistle Blast	Refinery Wide Evacuation
One Whistle Blast	Emergency in Zone 1
Two Whistle Blast	Emergency in Zone 2
Three Whistle Blast	Emergency in Zone 3

In the event of an emergency, leave the area immediately (walk, do NOT drive) to either the primary or secondary rally point. The primary rally point is in the east employee parking lot across 10th St NE. The secondary rally point is located at the West Entrance Gate #1. The rally point you go to should be determined by (1) wind direction and (2) your location within the refinery. The wind direction can be determined by windsocks that are throughout the facility. A site map with the evacuation routes and rally points is shown in Figure 2, respectively.

12.1 STOP WORK AUTHORITY

All Ramboll employees have the authority and obligation to stop any task or operation where concerns and/or questions regarding the control of H&S risk exist, are not clearly established, or are not understood. Management is responsible for creating a culture where Stop Work Authority is exercised freely and without fear of retribution or intimidation.

When an unsafe condition is identified, a Stop Work intervention will be initiated and treated as a "near miss." As such, an incident report will be completed in accordance with Standard Practice Instruction 19 entitled "Incident Reporting" so that the unsafe condition can be documented, reviewed and corrective actions and preventative measures be implemented as applicable.

These actions will be coordinated by the Site Supervisor, with support from the PM/PIC and the HSC and all affected personnel will be notified of the Stop Work issue. No work will resume until all Stop Work issues and concerns have been adequately addressed. Most issues can be resolved in a timely manner at the job site, but occasionally additional investigation and corrective actions may be required. Work may resume when it is safe to do so.

12.2 PERSONNEL INVOLVED IN EMERGENCY RESPONSE

Key personnel involved in Site emergency response include the CMR Control Room, PM, Site Supervisor, the Ramboll PIC and contractor PMs. Clear lines of authority have been established for implementing emergency response procedures and for ensuring safety compliance. **All emergencies**

and personal injuries will be immediately reported to the Control Room. The Control Room will immediately report the incident to the 911 and related emergency response teams. Ramboll personnel will follow the instructions from the Control Room prior to contacting the PIC/PM and Corporate Health and Safety Director.

12.3 EMERGENCY RESPONSE TELEPHONE ROSTER

The Emergency Response Telephone Roster consists of persons and organizations both onsite and offsite who would be involved in the ERP. This roster, provided as Table 1A, will be kept in Ramboll site vehicle, a list of onsite personnel who are trained in first aid and CPR will also be kept in the file. All Site personnel will be familiar with the Emergency Response Telephone Roster and will understand the proper chain of command. A listing of onsite and offsite emergency contacts and key personnel and their alternates will be posted in the Site office.

12.4 EMERGENCY COMMUNICATIONS

The external communication system between onsite and offsite emergency response personnel is necessary to report and coordinate emergency response. Ramboll personnel will communicate with CMR by radio and CMR will notify offsite emergency response agencies and to request assistance.

12.5 EMERGENCY MEDICAL CARE AND TREATMENT

Every injury and exposure will be reported according to the procedures outlined in Appendix N, regardless of whether the incident appears to be serious or not, or whether any adverse health effects or symptoms are apparent after the exposure. Universal precautions to bloodborne pathogen (BBP) shall be observed while administering first aid.

12.6 LIFE-THREATENING EMERGENCY RESPONSE

Incidents are possible that would result in emergencies beyond the onsite emergency response capabilities. Such incidents might include:

- Life-threatening injuries or injuries/exposures requiring medical treatment; and
- Fires progressing beyond incipient stage.

12.7 EVACUATION ROUTES AND PROCEDURES

During site operations and in the event of an evacuation, a safe location (muster point) has been identified in Figure 2. Any facility-related emergency that requires evacuation will be sounded by a long whistle (with the exception at noon and 12:30 pm, as these loud blasts are performed daily). The primary rally point is in the east employee parking lot across 10th St NE. The secondary rally point is the West Entrance Gate #1. The rally point you go to is determined by the wind direction and your location within the refinery. Windsocks throughout the facility help indicate wind direction and strength. As part of the Site orientation, all onsite personnel will be informed of the evacuation plan and Rally points. For purposes of a safe and efficient means of vehicular egress, all vehicles will be backed into their designated parking location.

If evacuation is necessary, personnel will determine wind direction. Whenever possible, evacuation should be in the direction perpendicular to the wind direction without passing through the plume or smoke cloud and/or spilled material, if applicable. Personnel will report to their designated Rally point.

In the event that a workers' evacuation to their primary rally point is hindered by emergency conditions, workers shall evacuate to the secondary rally point. If the onsite PM is not involved in emergency response activities, he/she will assist in accounting for all Site personnel, otherwise their designated back-up will account for all personnel and will report this information to the Site Supervisor.

12.8 TRAINING

All Site personnel will review the information in this HASP on the emergency response procedures and the location and use of onsite emergency equipment and will have received emergency response training. During the Site orientation and/or Site safety briefings, Site personnel will be trained in emergency response procedures, onsite communication systems and evacuation routes, as stated in this HASP. Visitors will be briefed on hazard recognition, safe work practices and basic emergency procedures by the Site Supervisor.

12.9 FIRST AID PROCEDURES

If an employee is injured, general first aid will be administered. If safety concerns or hazardous conditions are still present (e.g. incipient fire, falling debris), the individual shall be moved to avoid further injury or risk. In the event that an employee is injured in a contaminated area, general first aid will be administered and then the employee will be moved to the support zone for decontamination (if applicable), additional first aid and preparation for transportation, giving due consideration to which risk will be greater; the spread of contamination or the health/safety of the individual.

First aid kits will be maintained on site at each project location. The type of first aid kit to be maintained will be for minor emergencies, such as cuts and skin abrasions. Where applicable, first aid supplies will be stored in a water-proof container. The Site Supervisor or designated person will ensure that adequate first aid supplies (listed below) are maintained.

MINIMUM LIST OF FIRST AID SUPPLIES	
(1) First Aid Guide*	(6) Burn treatment applications
(1) Absorbent Compress >4"x8"	(4) 3"x3" Sterile gauze pads
(16) 1"x3" Adhesive bandages	(2) Pair medical exam gloves
(1) Adhesive tape 2.5yard roll	(1) Triangular bandage >40"x40"x56"
(10) Antiseptic treatment applications	(6) Antibiotic ointment applications
* Please see Appendix M First Aid Guidance, print and store with ANSI approved First Aid kit onsite.	

RECOMMENDED LIST OF FIRST AID SUPPLIES	
Analgesic (oral, non-drowsy)	Eye covering >1/4" thick
Bandage compress >2"x2"	Eye/face wash
Breathing barrier, single use	Roller bandage >2"x4yards
Cold pack >4"x5"	Hand sanitizer

The contents of the first aid kits shall be checked before being sent out to each job and at least weekly on each job to ensure that expended items are replaced. Where the eyes or body of any employee may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be available for use.

12.10 UNCOVERING AN UNDERGROUND SERVICE (INTACT)

In the event of any damage or dislocation of any underground facility/pipeline or utility in connection with ground disturbance activity, work activities shall cease in the area of the damaged facility. The Designated Person shall immediately call CMr on Radio Channel #2 while inside the facility. Off the facility, Ramboll personnel may call emergency services. Then, the affected utility and One Call service shall be notified, if applicable. The One Call service may be able to assist with contact numbers for notifying member companies in the event of any damage. NO ONE should attempt to repair, clamp or constrict the damaged utility.

Always assume that any underground pipe or subsurface line is live!

- Stop work; remove tools if safe to do so;
- Clear all persons from the scene;
- Call the Control Room;
- Contact the One Call/utility member for guidance, if applicable; and
- Contact the PM and/or PIC so they can contact the facility Client, Corporate H&S Director and HSC.

12.11 STRIKING AN UNDERGROUND ELECTRICAL/TELECOM CABLE

- Stop work;
- Evacuate Ramboll employees from the immediate area to a safe distance as site conditions warrant, giving consideration to employees which may not be able to immediately evacuate (e.g. operator seats in excavators are normally electrically isolated, whereas other parts of the excavator may be energized);
- Call the Control Room;
- In the event of injuries provide first aid and summon medical assistance;
- Contact the One Call/utility member for guidance, if applicable;
- Contact the PM and/or PIC so they can contact the facility Client, Corporate H&S Director and HSC; and
- Do not allow anyone to enter the area until the electricity/utility provider has made the cable safe.

12.12 STRIKING A PRESSURIZED GAS PIPELINE

- Stop work, leave tools in-place but shut off any running equipment, including engines;
- Evacuate the immediate area to a safe distance as site conditions warrant;
- Ensure there are no sources of ignition in the area;
- Call the Control Room;

- Contact the pipeline owner and/or One Call, if applicable;
- Contact the PM and/or PIC so they can contact the facility Client, Corporate H&S Director and HSC; and
- Do not re-enter the immediate area until safe to do so.

12.13 STRIKING A PRESSURIZED WATER MAIN

- Stop work, remove tools and confine jetting water if safe, necessary and appropriate to do so;
- Evacuate immediate area;
- Ensure that water flowing away is not creating potential hazards (e.g. electrical shorting, flooding, contaminant migration etc.) and where possible warn those likely to be affected;
- Call the Control Room;
- Contact the water utility and/or One Call, if applicable;
- Contact the PM and/or PIC so they can contact the facility Client, Corporate H&S Director and HSC; and
- Do not re-enter the immediate area until safe to do so.

12.14 FOLLOW-UP PROCEDURES

If a site employee is injured on site and immediate medical treatment beyond first aid is needed, the designated site supervisor is instructed to call the Control Room and then report the incident.

Any SSC work that results in an injury, illness, incident, near miss or unsafe act or condition MUST be verbally communicated by the affected employee or a Ramboll employee witnessing the incident to either the local HSC, PM or PIC immediately following the incident. Notification to the regional Human Resource (HR) representative, Director of HR and the Corporate H&S Director MUST also be made for incidents involving any employee injury and/or illness that happened while on company time including first aid and doctor/hospital visits which may or may not involve restricted work and/or lost time.

As soon as possible after the incident but no later than 72 hours after the event, Page One of the Incident Reporting Form in SPI 19 Incident Reporting (Appendix N) is to be completed by the employee and a witness that was involved in the incident and/or observed the incident.

Post-incident investigations and root cause analysis will be conducted by the Corporate H&S Director to discover the exact circumstances and cause of the incident. Amendments to the HASP will be approved and implemented by the project HSC and the Corporate H&S Director, as needed. All Site personnel will be informed of any revisions to the site-specific HASP and the resolution of any outstanding safety concerns prior to returning to their Site functions. The necessary steps to ensure that operations can safely resume include:

- Ensure that all emergency equipment (fire extinguisher, communication system, first aid kits and first aid station) is in functional order;
- Clear all incident-caused debris from the Site, if safe to do so; and
- Inspect area and equipment.

NOTE: Specific emergency contact information is contained in the first and last pages of this HASP. Applicable directions to the nearest medical facility are contained in the last page to this HASP. In the event that an emergency situation occurs, SECURE the safety of yourself and those working under your direction and then contact appropriate site and Ramboll representatives that are referenced in Table 1A of this HASP.

13. HASP FIELD TEAM SIGNATURES

Sign off sheet attesting that the HASP has been made available and reviewed by the individual prior to entry into the site.

Project Personnel List and Safety Plan Distribution Record

Ramboll Employees

All project staff must sign indicating they have read and understand the Site Health and Safety Plan. A copy of this Site Health and Safety Plan must be made available for their review and readily available at the job site.

EMPLOYEE NAME/ JOB TITLE	DATE DISTRIBUTED	SIGNATURE

Contractors, Subcontractors

A copy of this HASP shall be provided to contractors and subcontractors who may be affected by activities covered under the scope of this site HASP for their information only, although the contractors and subcontractors remain responsible for the safety of their own employees. All contractors and subcontractors must comply with applicable country, state and local government rules and regulations.

FIRM NAME	CONTACT PERSON	DATE DISTRIBUTED

H&S Meeting

All personnel participating in the project must receive initial H&S Orientation. Thereafter, a brief tailgate safety meeting is required as deemed necessary by the Site H&S Officer (or at least once every 10 working days).

DATE	TOPICS	NAME OF ATTENDEE	EMPLOYEE FIRM NAME	INITIALS

Visitor

It is Ramboll's policy that visitors must furnish their own personal protective equipment. All visitors are required to sign the visitor log and comply with HASP requirements. If the visitor represents a regulatory agency concerned with site health and safety issues, the Site H&S Officer shall also immediately notify HSC.

NAME OF VISITOR	FIRM NAME	DATE OF VISIT	SIGNATURE

14. SAFETY MEETING CHECKLIST

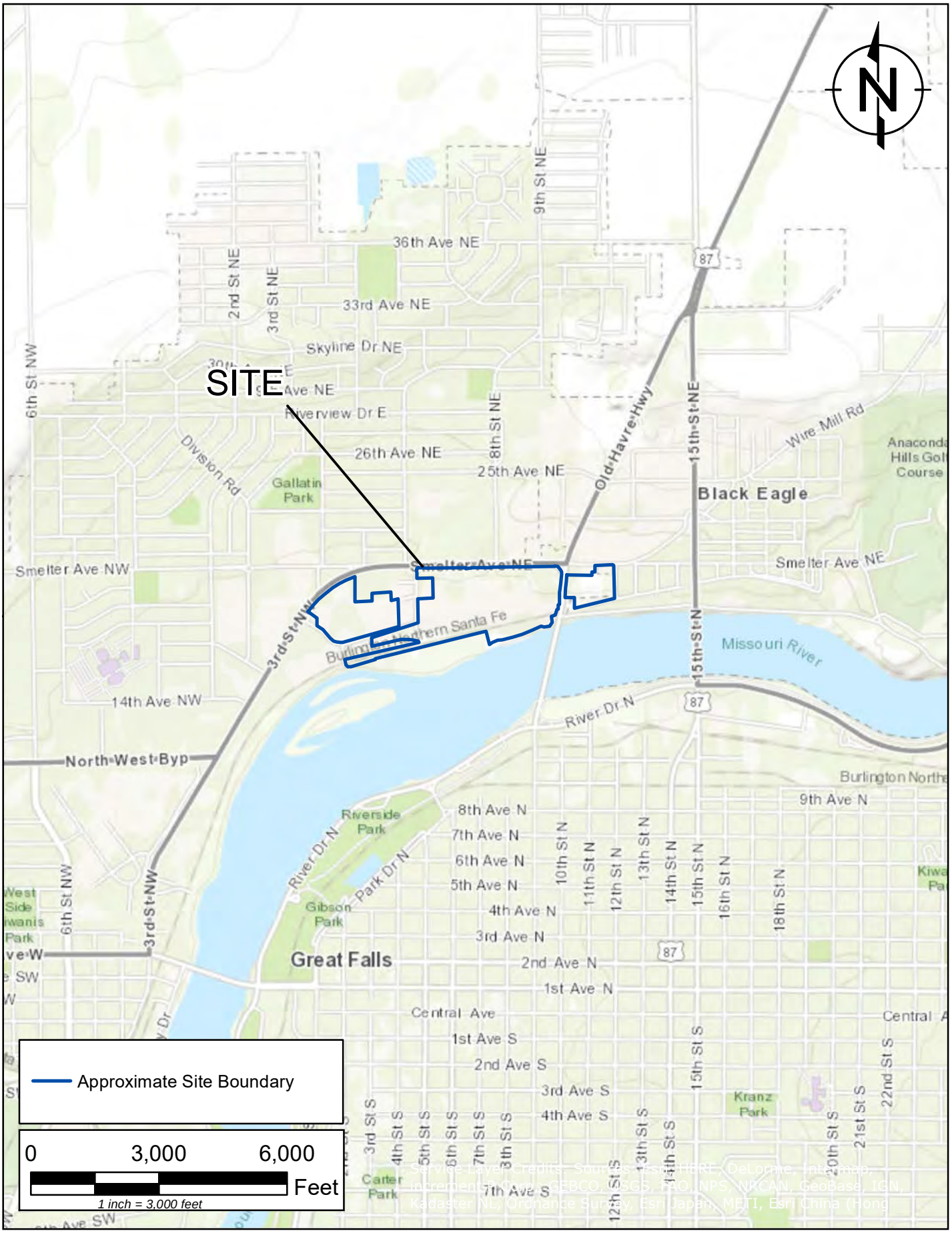
The Site Supervisor should consider discussing the following topics with all field personnel conducting work as part of this HASP, as applicable.

Date and Time of Meeting:
Conducted By:
Check Topic(s) Discussed:

HASP CONTENT	HASP CONTENT
☐ Chemicals of Concern	☐ Personnel Onsite (Introductions)
☐ Tasks to be Performed	☐ Responsibilities
☐ Location of Tasks	☐ Monitoring equipment (H_2S monitor)
☐ Hazards/Risks of Tasks	☐ Other CMR Subcontractor Safety Manual
☐ Site Limitations (e.g. cell phone use)	☐ Other _____
FIRST AID	**INDUSTRIAL SANITATION AND HYGIENE**
☐ Facilities	☐ Drinking water
☐ Location of Safety Showers	☐ Restrooms/Porta toilets
☐ Reporting and Records	☐ Personal Cleanliness
PPE	**HOUSEKEEPING**
☐ Glasses, Goggles and Shields	☐ PPE/Decon
☐ Hard Hats	☐ Waste Containers
☐ Respirators	☐ Waste Materials
☐ Gloves	☐ Other _____
☐ Fire-Retardant Clothing	☐ Other _____
EMERGENCY PROCEDURES	**FIRE PREVENTION**
☐ Communications	☐ Extinguisher Locations
☐ Evacuation Route/Windsock Locations (wind direction)	☐ Designated Smoking Areas
☐ Primary Rally Point:	☐ Hot Work
☐ Secondary Rally Point:	☐ Flammable Liquids Present
☐ Headcount	☐ Explosives Present
☐ Hospital Location/Route	☐ Other _____
SPECIAL TOOLS/EQUIPMENT	**VEHICLES/HEAVY EQUIPMENT**
☐ Chain saws/Chop saws	☐ Transportation of Employees
☐ Other _____	☐ Operation and Inspection
☐ Other _____	☐ Preventative Maintenance
WEATHER	**REFINERY ACTIVITIES**
☐ Inclement Conditions	☐ Other on-going site activities

DISCUSSION

FIGURES



K:\KCData (K)\GIS\PROJECT\2018\CALUMET\DOCS\Figure 1.mxd

RAMBOLL

DRAFTED BY: DFM

Date: 8/13/2018

Site Location

CALUMET MONTANA REFINING, LLC

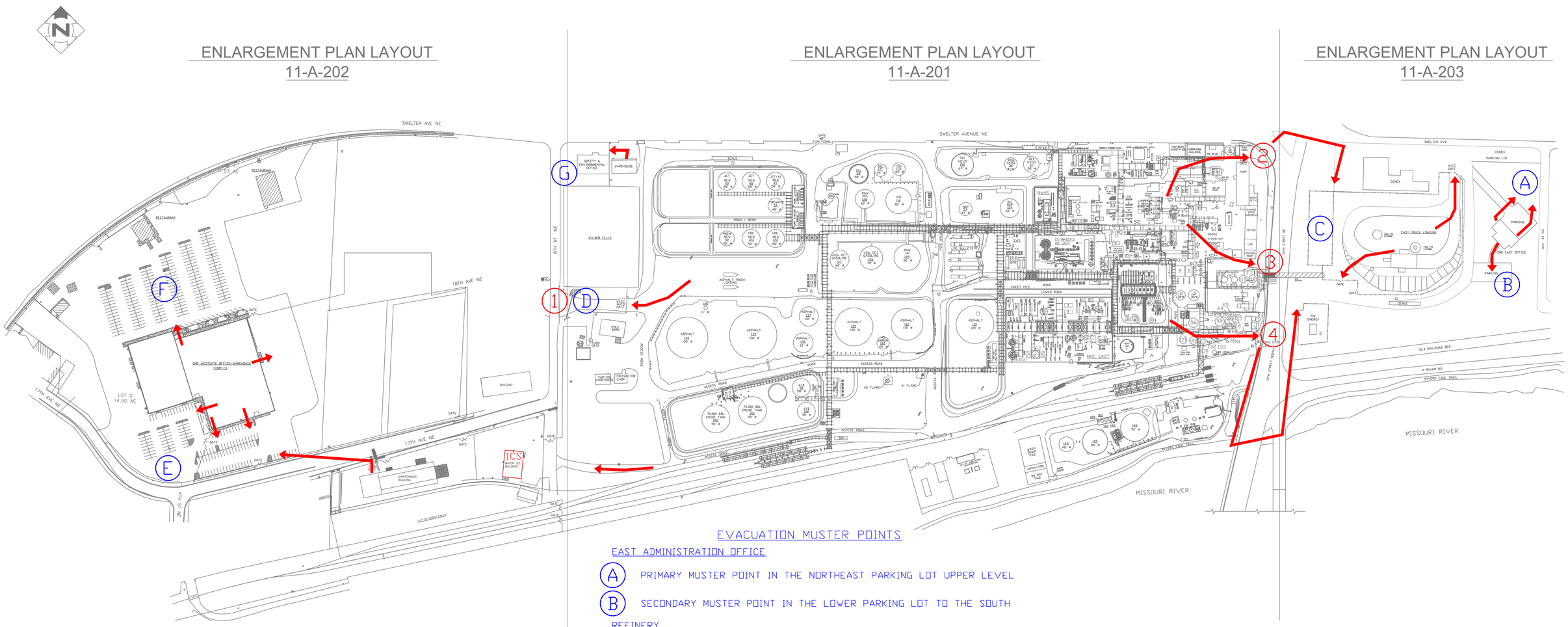
1900 10TH STREET NORTHEAST

GREAT FALLS, MT

FIGURE

1

PROJECT: 1690013825



EVACUATION MUSTER POINTS

EAST ADMINISTRATION OFFICE

- (A) PRIMARY MUSTER POINT IN THE NORTHEAST PARKING LOT UPPER LEVEL
- (B) SECONDARY MUSTER POINT IN THE LOWER PARKING LOT TO THE SOUTH

REFINERY

- (C) PRIMARY MUSTER POINT IN THE EAST EMPLOYEE PARKING LOT ACROSS 10TH STREET NE
- (D) SECONDARY MUSTER POINT IS AT THE WEST ENTERANCE GATE #1

WESTGATE/MAINTENANCE OFFICES/SHOP

- (E) PRIMARY MUSTER POINT IS IN THE SOUTHWEST PARKING LOT BY 4TH STREET NE
- (F) SECONDARY MUSTER POINT IS IN THE NORTH PARKING LOT BY PIZZA HUT

SAFETY/ENVIRONMENTAL OFFICE

- (G) PRIMARY MUSTER POINT IS IN THE WEST PARKING LOT BY 6TH STREET NE

SECONDARY MUSTER POINT IS MUSTER POINT D

EVACUATION ROUTES

1. WEST ENTERANCE GATE - 1827 6TH STREET NE
2. OLD MAINTENANCE SHOP/NE CORNER GATE - 1900 10TH STREET NE
3. CONTROL ROOM GATE - 1900 10TH STREET NE
4. STOCK/RAILROAD SE CORNER GATE - 1900 10TH STREET NE

EMERGENCY SIGNALS

IN THE EVENT OF AN EMERGENCY, THE REFINERY WHISTLE WILL BE USED TO INDICATE WHAT AREA OF THE REFINERY IS BEING EVACUATED AS IDENTIFIED BELOW:

LONG SINGLE WHISTLE BLAST - REFINERY WIDE EVACUATION
SERIES OF SINGLE (1) WHISTLE BLAST - EMERGENCY IN ZONE 1
SERIES OF DOUBLE (2) WHISTLE BLAST - EMERGENCY IN ZONE 2
SERIES OF TRIPLE (3) WHISTLE BLAST - EMERGENCY IN ZONE 3

IF AN EMERGENCY OCCURS IS ANOTHER AREA, THE WHISTLE MAY BE SOUNDED AS DESCRIBED ABOVE TO ALERT PERSONNEL TO THE SECOND EMERGENCY

TIPS FOR SAFE EVACUATION

1. BE AWARE OF WIND DIRECTION
2. CHOOSE A SAFE ROUTE UPWIND AND CROSSWIND AWAY FROM THE INCIDENT THAT LEADS TO A SAFE EXIT GATE OR DOORS
3. KNOW ALL EXIT DOORS FROM BUILDINGS AHEAD OF TIME
4. EXIT IN A CONTROLLED SAFE MANNER. DO NOT RUN UNLESS YOU HAVE TO
5. IF YOU CANNOT GET TO A PRIMARY MUSTER POINT, USE SECONDARY
6. SAFELY CROSS ROADS AT CROSSWALKS, IF POSSIBLE
7. REMAIN AT MUSTER POINT UNTIL "ALL CLEAR" IS GIVEN

0 100' 200' 300' 400' 500' 600'
SCALE:

REF. DWG. NO.	REFERENCE DRAWING DESCRIPTION	NO.	DATE	DWN.	REVISION	BY	CHK'D.	APP'D.	DATE
		7	6/7/17	EH	ADDED HEARING PROTECTION REQUIRED AREA	EH			
		6	1/19/17	EH	ADDED EVACUATION LAYER	EH			
		5	12/13/16	EH	ADDED PIV VALVE @ TK-117 INCIDENT 4153/GFMT000186	EH			
		4	9/20/16	HJC	ADDED GATE NUMBERS	HJC			

LOCATION
ENG. JOB No.
P.O. No.
APP'N No.
DRAWN BY CLB
DATE 12/14/15
SCALE NOTED
11-A-202
REV. 7

CALUMET
MONTANA REFINING, LLC
PLOT PLAN
SITE MAP

6/7/2017 2:16 PM BASE MAP 001 Rev 7.dwg

Site Health & Safety Orientation Map (Hearing Protection Areas)

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

RAMBOLL

Figure 3

DRAFTED BY: DFM	DATE: 4/6/2020	PROJECT: 1690009181

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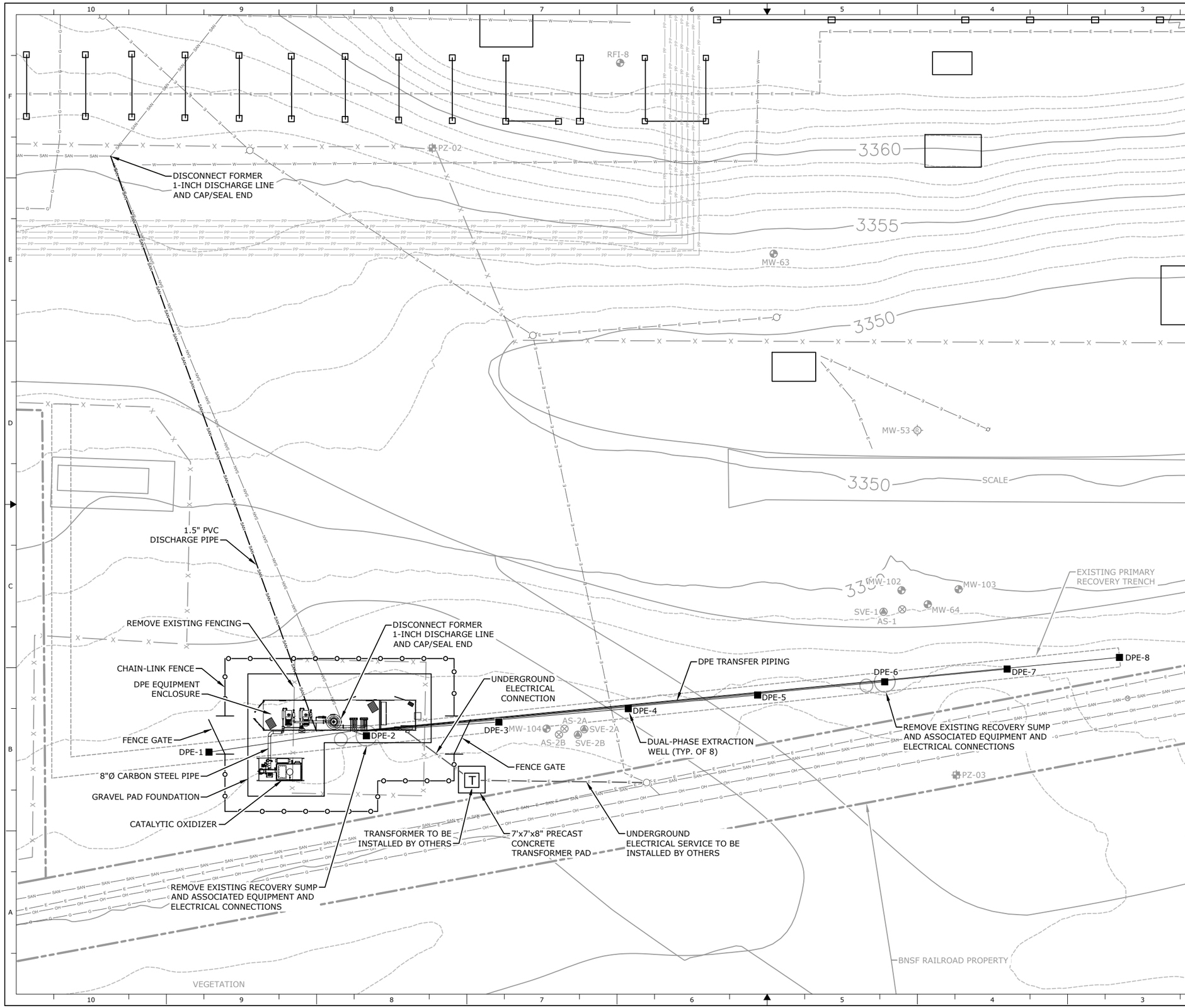

LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

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DRAFTED BY: HJW
DATE: 9/11/2020
DESIGNED BY: AS/PL
APPROVED BY: ST

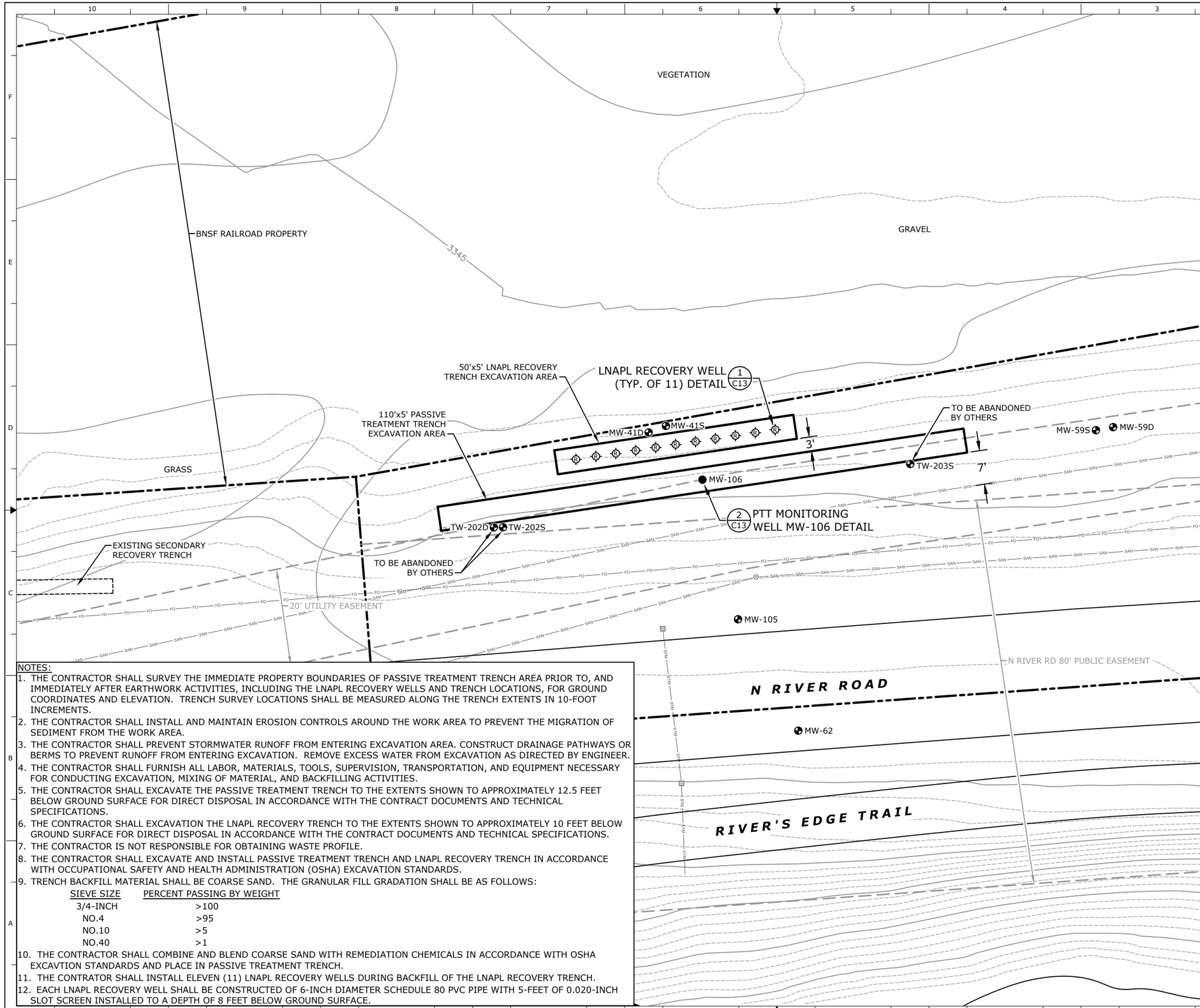
RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

DUAL-PHASE EXTRACTION EQUIPMENT LAYOUT

PROJECT# 1690014124-003

Figure 4



NOTES:

1. THE CONTRACTOR SHALL SURVEY THE IMMEDIATE PROPERTY BOUNDARIES OF PASSIVE TREATMENT TRENCH AREA PRIOR TO, AND IMMEDIATELY AFTER EARTHWORK ACTIVITIES, INCLUDING THE LNAPL RECOVERY WELLS AND TRENCH LOCATIONS, FOR GROUND COORDINATES AND ELEVATION. TRENCH SURVEY LOCATIONS SHALL BE MEASURED ALONG THE TRENCH EXTENTS IN 10-FOOT INCREMENTS.
2. THE CONTRACTOR SHALL INSTALL AND MAINTAIN EROSION CONTROLS AROUND THE WORK AREA TO PREVENT THE MIGRATION OF SEDIMENT FROM THE WORK AREA.
3. THE CONTRACTOR SHALL PREVENT STORMWATER RUNOFF FROM ENTERING EXCAVATION AREA. CONSTRUCT DRAINAGE PATHWAYS OR BERMS TO PREVENT RUNOFF FROM ENTERING EXCAVATION. REMOVE EXCESS WATER FROM EXCAVATION AS DIRECTED BY ENGINEER.
4. THE CONTRACTOR SHALL FURNISH ALL LABOR, MATERIALS, TOOLS, SUPERVISION, TRANSPORTATION, AND EQUIPMENT NECESSARY FOR CONDUCTING EXCAVATION, MIXING OF MATERIAL, AND BACKFILLING ACTIVITIES.
5. THE CONTRACTOR SHALL EXCAVATE THE PASSIVE TREATMENT TRENCH TO THE EXTENTS SHOWN TO APPROXIMATELY 12.5 FEET BELOW GROUND SURFACE FOR DIRECT DISPOSAL IN ACCORDANCE WITH THE CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS.
6. THE CONTRACTOR SHALL EXCAVATION THE LNAPL RECOVERY TRENCH TO THE EXTENTS SHOWN TO APPROXIMATELY 10 FEET BELOW GROUND SURFACE FOR DIRECT DISPOSAL IN ACCORDANCE WITH THE CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS.
7. THE CONTRACTOR IS NOT RESPONSIBLE FOR OBTAINING WASTE PROFILE.
8. THE CONTRACTOR SHALL EXCAVATE AND INSTALL PASSIVE TREATMENT TRENCH AND LNAPL RECOVERY TRENCH IN ACCORDANCE WITH OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) EXCAVATION STANDARDS.
9. TRENCH BACKFILL MATERIAL SHALL BE COARSE SAND. THE GRANULAR FILL GRADATION SHALL BE AS FOLLOWS:

SIEVE SIZE	PERCENT PASSING BY WEIGHT
3/4-INCH	>100
NO.4	>95
NO.10	>5
NO.40	>1

10. THE CONTRACTOR SHALL COMBINE AND BLEND COARSE SAND WITH REMEDIATION CHEMICALS IN ACCORDANCE WITH OSHA EXCAVTION STANDARDS AND PLACE IN PASSIVE TREATMENT TRENCH.
11. THE CONTRATOR SHALL INSTALL ELEVEN (11) LNAPL RECOVERY WELLS DURING BACKFILL OF THE LNAPL RECOVERY TRENCH.
12. EACH LNAPL RECOVERY WELL SHALL BE CONSTRUCTED OF 6-INCH DIAMETER SCHEDULE 80 PVC PIPE WITH 5-FEET OF 0.020-INCH SLOT SCREEN INSTALLED TO A DEPTH OF 8 FEET BELOW GROUND SURFACE.

LEGEND

- MONITORING WELL
- PROPOSED MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
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- FENCE
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- SANITARY SEWER
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- STORM/SANITARY MANHOLE
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SCALE IN FEET

DRAFT

DATE
SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\C10_Passive Treatment Trench Plan.dwg

DRAFTED BY: HJW
DATE: 9/9/2020
DESIGNED BY: AS/PL
APPROVED BY: ST

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

PASSIVE TREATMENT TRENCH PLAN

PROJECT # 1690014124-003

Figure 4

APPENDIX A
Job Safety Analysis

Job Safety Analysis (JSA) Form

Company Name: **Date:** **JSA No.**

Unit Name: **Permit to Work: Yes** ☐ **No** ☐ **Work Order:**

Supervisor: **Approved By:**

Activity:

Key coaching point: in building a JSA, list key job steps first, then look at inherent risks, then the mitigating factors.
Job Name, Existing Procedure:

2nd coaching point: Do not be invasive during the task, just watch and listen……no words.
3rd coaching point: Understand fluently the task being performed both administratively as well as technically.
4th coaching point: Conduct JSA's on unfamiliar tasks. Example: have an electrician do the JSA for a welder.
5th coaching point: follow in depth every detail and think to yourself why?

Activity List the tasks required to perform the activity in sequence they are carried out. **JOB TASKS**	**Hazards** Against each task list the hazards/inherent risks that could cause injury when the task is performed. **INHERENT RISK**	**Risk Mitigation Measures** List the mitigation measures required to eliminate or minimize the risk of injury from the identified hazard. **SYSTEM FIX - MITIGATION**	**Who Is Responsible?** Write the name of the person responsible (supervisor or above) to implement the mitigation measure identified.

Remember: Each JSA must be site specific and include all workers in the development of this JSA

Distribution for Lessons Learned:

Consider for new or revised procedure:

Most Probable Safety Risks:

Most Severe Safety Risks:

APPENDIX B
Project Coronavirus Response Plan

Project Coronavirus Response Plan

Project Name:	Calumet Montana Refinery
Project Location:	Great Falls, Montana
Project Owner:	David Heidlauf
Project Manager:	Dan Price
On-Site Coordinator:	Elaine Komm-Enge

Ramboll's fundamentals require that "we put health and safety first through a zero-harm culture." In that context, Ramboll is providing guidance to reduce the Coronavirus risk at this project site. This plan is consistent with the approach currently utilized by Ramboll for our offices and is aligned with recommendations published by various public health organizations. Mitigation measures focus on the following four elements:

- **Communication** – Notify employees, subcontractors and other visitors of Ramboll's expectations related to reducing the risk of Coronavirus at our project sites.
- **Exposure Risk Management** – Identify measures to be implemented to reduce exposure risk.
- **Case Management** – Outline notifications and response if a confirmed or suspected case of COVID-19 occurs in our workplace.
- **Calumet Montana Refinery Requirements –** Describes Calumet's COVID-19 Guidelines and Requirements for Ramboll staff that are performing tasks at their facility.

The Project Owner and Project Manager are responsible to implement this plan in a manner that is commensurate with the size and complexity of their project. Please contact Maureen Warren, Mark Watka, or a member of the HSS Americas team with any questions.

Communication

- The Project Manager will **notify** the client, subcontractors, and other visitors that persons who are ill with flu-like symptoms or have a significant risk of coronavirus exposure must not travel to Ramboll work locations. A sample notification is provided for this purpose and should be sent to key contact(s) for each of Ramboll's business partners (clients, subcontractors, vendors, etc.)
- The Project Owner and Project Manager will **read Coronavirus updates** distributed by the Americas Coronavirus Task Force and adapt this plan (if necessary) to the latest guidance. Guidance related to Coronavirus may change suddenly including changes to countries or regions designated as "high risk" travel destinations by public health organizations or Ramboll.
- Ramboll communications are **aligned to public health organization recommendations** at a minimum, but more stringent recommendations may be implemented if deemed necessary to protect employees, business partners, and the public.
- The Ramboll PO/PM should **communicate regularly with the client** to understand the priority of Ramboll's work at the site. The intent is to know if the client classifies Ramboll's work as "critical" which must continue through the Coronavirus pandemic or is classified as "non-critical" where site operations may be suspended. For projects deemed non-critical and suspended by

the client, the PO/PM may have to identify temporary work assignments for project team members.

- The PO/PM will ensure **effective and continued communications** to both the client and project teams with respect to implementation of this plan including changes to the plan and the occurrence of COVID-19 cases (suspected or confirmed).
- The Project Manager will **monitor project team morale and anxiety** levels. Human Resources can provide guidance to help managers address fear and anxiety in their teams.

Exposure Risk Management

- **Implement respiratory etiquette and hand hygiene practices** which have been communicated by public health agencies as well as Ramboll Group and the Americas Coronavirus Task Force. Refer to Ramboll's *Prevent Infection* poster (**Attachment 1**).
- **Post respiratory etiquette and hand hygiene requirements** on the job site as a reminder to employees, subcontractors, clients, and visitors. Refer to Ramboll's *Prevent Infection* poster (**Attachment 1**).
- Implement **Social distancing** precautions such as not shaking hands, eliminating non-essential site meetings, eliminating site visits by non-essential persons, reduce the number of persons attending meetings in-person, and increase the use of virtual communications (e.g., WebEx, Skype, telephone, and other mobile communication technologies).
- **Keep field offices clean**. All frequently touched surfaces such as workstations, doorknobs, phones, and table tops will be cleaned daily. Use normal cleaning agents routinely associated with these surfaces. Ensure that routine housekeeping is maintained so that project offices, conference rooms, break rooms, and other frequently accessed areas remain clean and free from excessive dirt, debris, and trash. Poor routine housekeeping means that disinfection is much more difficult if it becomes necessary.
- **Minimize risk during travel to and from projects**. Avoid public transportation (planes, buses, and trains) if possible. If not possible, implement feasible social distancing precautions and follow proper hand hygiene.
    - If you become sick with flu-like symptoms while traveling, avoid public transportation and seek medical attention at that location.
    - If you have been in direct contact with someone diagnosed with COVID-19 or suspected of having COVID-19 (exhibiting flu-like symptoms) while travelling, avoid public transportation if possible. If not possible but you are asymptomatic, then implement social distancing and hand hygiene practices during your travel to protect others. Notify your supervisor to self-quarantine for 14 days or until a negative Coronavirus test (if available) is obtained.
    - Employees may bring their own cleaning supplies (alcohol wipes) as an additional precaution to wipe down frequently contacted surfaces in hotels, airplanes, buses, etc. as an additional precaution.

Case Management

- All project personnel are required to notify Ramboll site supervisor if they been diagnosed with COVID-19 or have been in close contact with a person diagnosed with COVID-19 or suspected of having COVID-19.
- Ramboll site supervisor will notify project personnel, the Ramboll Project Manager, and the client or facility owner of possible exposure to COVID-19.
- If a Ramboll employee is diagnosed with COVID-19 or suspected of having COVID-19, then the Project Manager will follow actions for the "Line Manager" outlined in the Ramboll "*Continuity Action Plan – Coronavirus*" (**Attachment 2**).
- In addition to infected (or potentially infected) individuals, exposed individuals direct contact will also be removed from the project site and instructed to protect others through self-isolation for 2 weeks or until a negative test (if available) is obtained. Although the definition of direct contact may vary, it should include working with within 6' for an extended duration of at least an hour. This plan will be updated as more information and guidance are provided by public health agencies.
- Individuals suspected of having COVID-19 should also avoid public transportation should be avoided unless otherwise advised by public health recommendations or an affected person's healthcare provider. Symptomatic individuals should wear a mask for the protection of others along with frequent hand washing.
- Surfaces that may have been touched by the affected individual will be sanitized with EPA-approved sanitizers and following manufacturer-recommended contact times and safety recommendations.
    - Approved disinfection products are posted on EPAs "Selected EPA-Registered Disinfectants" page. Scroll down to "List N" for SARS-CoV-2. These are update regularly. Have a container on-site along with gloves and safety glasses should post-case sanitization is necessary.
    - If commercial cleaners are not available (out-of-stock), then dilute bleach solutions may be used. Mix 1/3 cup per gallon or 4 teaspoons per quart of water which about 1 part bleach to 50 parts water. Wear latex or nitrile surgical gloves and safety glasses even though bleach is a common household chemical.
    - Clean all frequently touched surfaces including field office/trailer floors, tools, and heavy equipment controls, and similar surfaces
    - Do not use the above cleaning products or solutions for air sanitization since they have only been proven effective on surfaces.
    - Soft surfaces such as rugs, towels, or drapes should be discarded or laundered with cleaners appropriate for these materials at the warmest appropriate water temperature. Handle with care to avoid creating airborne dust.
- Persons affected by seasonal allergies should take care to obtain and administer allergy medication to prevent potential false positive symptoms which are associated with COVID-19.

- Anxiety levels will be high following a confirmed case of COVID-19 at a project site. The Project Manager will address this issue through open discussions with the team and engage their Human Resources professional for guidance and support.

Calumet Montana Refinery Requirements

Calumet's COVID-19 Guidelines and Requirements for contractors/vendors such as Ramboll that are performing tasks at the refinery are provided in **Attachment 3**. The requirements for Ramboll pre-approved employee(s) to gain to the refinery site are as follows:

- Submit a health questionnaire (Page 3 from the above attachment) before coming on to the site. Either send an email to Jeff Pallister <Jeff.Pallister@calumetspecialty.com> or leave a copy of the form at the front desk at Westgate.
- Take your temperature and sign off at the beginning of each day at the Westgate that they are healthy.
- Upon signing in as healthy each morning, report to work at the HSE building or report to gate 1 for entry into the refinery.
- ***DO NOT REPORT TO WORK TO THE REFINERY IF YOU ARE SICK.***
- Immediately report to Calumet if you fit scenarios 1, 2, 3 and 6 in attachment as outlined below.

1. **Employee is confirmed C19 positive**
2. **Employee is sick with flu symptoms but is not confirmed C19 positive**
3. **Employee lives in same household with a confirmed C19 positive person**
6. **Employee becomes systematic at work**

Attachments:

Attachment 1: Ramboll's Prevent Infection Poster

Attachment 2: Ramboll's Continuity Action Plan – Coronavirus

Attachment 3: Calumet's COVID Manager Guidelines with CMR temperature log

ATTACHMENT 1: Ramboll's Prevent Infection Poster

PREVENT INFECTION

Protect yourself and others with these pieces of advice.

Wash your hands and use hand sanitizer

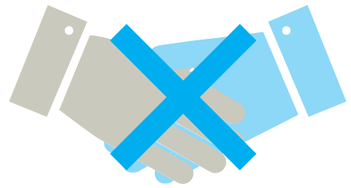
Wash your hands frequently and thoroughly.

Use hand sanitizer when you are unable to wash your hands with soap and water.

Cough or sneeze in your sleeve

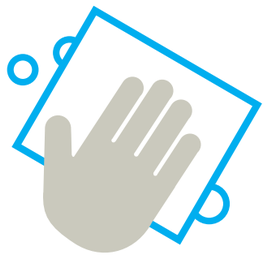
Cover your mouth and nose when coughing or sneezing.

Use a paper tissue or your sleeve and not your hand.



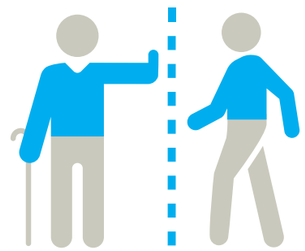
Limit physical contact

Avoid handshakes, kisses and hugs.



Keep clean

At home and at work.



Be considerate

Are you elderly or chronically ill – ask for others to be considerate.

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ATTACHMENT 2: Ramboll's Continuity Action Plan - Coronavirus

CONTINUITY ACTION PLAN – CORONAVIRUS

"We put health and safety first through a zero-harm culture and safety in design."

Employee

Ramboll PBU management team*

Preventive actions

- Maintain a high level of hygienic behaviour
- Take your laptop home after work
- Stay home when you don't feel well

Preventive actions

- Ensure communication and encourage hygienic behaviour (e.g. hand washing, use of sanitisers)
- Read this continuity action plan and prepare for local context
- Follow Ramboll's guidance on Rambla and local authorities' guidance
- HSEQ Lead to establish local taskforces: H&S, Management, FM, Communication, HR, IT, Legal
- Review and if needed upgrade IT infrastructure to be able to potentially have all employees working from home
- Review and identify potential issues in delivering work when working from home should be raised to management (MD)
- Assess possible precautions to limit virus transmission in the office environment and align with landlord and other relevant stakeholders (e.g. hand sanitisers, food delivery, etc.)
- Prepare and plan for full-office close-down, including review of local legislation on employees rights when working from home

Suspicion of case

- Go home and bring your laptop
- Call a doctor – follow the instructions
- Inform your line manager

Suspicion of case *(See definition on Rambla page)*

- Line manager: Send suspected person home. Remember to bring home laptop
- Line manager: Ask department and people in close contact to stay home until further notice. Remember to bring home laptop
- Line manager: Involve your local Management team (incl. MD and HSEQ Lead)
- Line manager: Inform Ramboll Group (e.g. e-mail to AskHowWeAct@ramboll.com)
- Line manager: Stay connected with the suspected person
- Management (MD): Remind all employees to bring home laptop when going home from work
- Taskforce: Contact local authorities, tell what you have done and get guidance
- Taskforce: Develop a communication plan and for both, negative and positive scenarios
- Taskforce: Start communication
- Taskforce: Consider to take extra precautions for vulnerable people

Confirmed disease case

- Follow the instructions from doctor/local authorities
- Inform your line manager

Confirmed disease case

- Line manager: Inform your local Management (incl. MD) team and HSEQ Lead
- Line manager: Inform Taskforce
- Taskforce: Continue collaboration with local authorities – follow the instructions
- Taskforce: Continue communication (employees, reception, clients, media, etc.)
- Taskforce: Stay connected and support the infected person, family and colleagues
- Inform landlord, and other relevant stakeholders (e.g. other firms you share office with)
- Ensure the facility is disinfected
- Consider full-office close in consultation with the local authorities

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* The Geographic PBU is responsible to prepare and act accordingly. Where a Geographic PBU does not have a presence, the market PBU has the responsibility to prepare and act.

ATTACHMENT 3: Calumet's COVID Manager Guidelines with CMR temperature log

COVID-19 GUIDANCE TO OPERATIONS – Revised May 6, 2020

- Call the Calumet hotline 1-443-569-6879 to inform the executive team of COVID-19 issues.
- Call Daphne Thomerson (Eldon Fink and Mike Tilton as backups) for additional guidance if the situation does not meet this guidance.
- This document may change frequently due to changing requirements of the health authorities.

SCENARIO	CALUMET ACTIONS	EMPLOYEE ACTIONS
1. Employee is confirmed C19 Positive	• Collect required exposure information per COVID-19 Exposure Questionnaire • Employee home isolation until resolution of symptoms and negative result from a nasal pharyngeal specimen • New CDC guidance allows for three paths to RTW 1) two confirmed negative tests, 2) a single confirmed negative, and 3) both three days symptom free and 10 days from onset of symptom. • Nurse Case Manager communicates clearance in all RTW determinations.	• Notify plant of illness, at onset • Monitor through Calumet Nurse Case Manager (NCM)electronically • Conform to medical requirements (monitored and instructed through CDC/Health Dept./physician) • Medical clearance from NCM • Screen at plant with temperature clearance

2. Employee is sick with flu symptoms but is not confirmed C19 Positive	• Employee to stay home
	• Collect exposure information per COVID-19 Exposure Questionnaire
	• Log temp and symptoms 2X/day
	• Eligible for return to work
	  o 3 full days of no symptoms without meds for fever reduction/ symptoms
	  o Temp <100.4, no cough/shortness of breath
	  o And 10 days after symptoms first appear
	• Requires NCM clearance
		• Notify plant of illness, at on-set
		• Monitor through Calumet NCM (electronically)
		• Conform to medical requirements
		• Screen at plant with temperature clearance

3. An employee lives in the same household as or visits a household with a person with confirmed positive COVID-19 infection	• Collect exposure information per COVID-19 Exposure Questionnaire • Employee to remain at home and self-quarantine for 14 days • Take and log temperature and symptoms 2X daily • If employee develops symptoms, notify CLMT and treat employee as scenario 1 or 2, as appropriate.	• Notify plant of household illness, at on-set • Monitor through Calumet NCM (electronically) • Conform to medical requirements • Screen at plant with temperature clearance
4. An employee lives in the same household as or visits a household with a person who is sick with flu-like symptoms but is not confirmed positive with COVID-19 infection	• Log of temperature and symptoms 2X/day • Employee eligible for work as long as asymptomatic • If employee develops symptoms, notify CLMT and treat employee as scenario 1 or 2, as appropriate	• Notify plant if symptoms develop • Stay home if symptomatic • Monitor through Calumet NCM (electronically) while symptoms persist. • Screen at plant with temperature clearance
5. An employee returns from a DEFINED high-risk area	• Collect exposure information per COVID-19 Exposure Questionnaire • Employee to remain at home and self-quarantine for 14 days • Take and log temperature and symptoms 2X daily • If employee develops symptoms, notify CLMT and treat employee as scenario 1 or 2, as appropriate.	• Notify plant of travel prior to reporting for work • Monitor through Calumet NCM (electronically)
6. An employee lives with a household member or visits the home of a person	• Log temp and symptoms 2X/day	• Follow Scenario 3 or 4, as appropriate

who has returned from a DEFINED high-risk area	• If household member develops symptoms, treat as Scenario 3 or 4 as appropriate	
7. An employee becomes symptomatic at work	• Treat as C19 until medical diagnosis per Scenario 1 (including COVID-19 Questionnaire) • If C19 not confirmed, see Scenario 2	• Follow Scenario 3 or 4, as appropriate
8. An employee has direct and prolonged contact with a co-worker who becomes symptomatic at work	• Direct contact is defined as within 6 feet of a symptomatic employee • Prolonged contact is defined by Calumet as 2 hours or more in any shift • Handle per Scenario 3 until medical diagnosis of symptomatic employee • If symptomatic employee not confirmed C19, then treat as Scenario 4	• Follow Scenario 3 or 4, as appropriate
9. Employee works in a common work area with an employee that becomes symptomatic but does not meet BOTH direct AND prolonged contact (e.g. in same control room but not consistently within 6 feet for greater than two hours)	• Dispense surgical-type mask to employee • Length of time to wear surgical-type mask will be determined based on medical information from symptomatic employee	• Wear surgical-type mask for recommended duration
10. Employee has no significant interaction with a person who becomes symptomatic at work (e.g. passing in hall, in same break room for a brief period, etc.)	• No additional precautions needed	• Maintain personal health log
11. Employee is designated to report to work at a Calumet location	• All employees who are, or may be, required to report to work at a CLMT location to maintain a log 2X/day of health measures (temperature, cough yes/no difficulty breathing yes/no). These measures should be without use of symptom relieving medications such as Tylenol or cough medicine. • Employee is asked to sign an affirmation of health at pre-entry.	• Log health parameters twice daily • Inform supervisor prior to reporting to the worksite if temperature is approaching 100.4 degrees or beginning cough or difficulty breathing
Notes:		
On-Site Isolation Area	See separate guidance provided for Workplace Isolation requirements and actions	
Contractors	• Contractors are not to report to a CLMT work site if they are sick • Contractor to provide CLMT with its program to ensure only healthy employees are provided to CLMT • Contractors are to immediately report to CLMT of any contractor employees that fit scenarios 1, 2, 3 and 6. • Contractors to daily sign affirmation of health at pre-entry using Contractor COVID-19 Questionnaire • CLMT site receiving notification of an ill contractor employee per above is to call the CLMT hotline to report	

CALUMET

Covid-19 (Coronavirus) Screening Questionnaire

In order to minimize exposure of employees and contractors to the disease, early and effective detection of suspected cases must occur. We request your cooperation in completing the questions listed below.

Please circle the appropriate responses in the survey below:

Name: _____ **Employee** **Visitor** **Contractor** (Please Circle)

Contact #: _____

Visitor / Contractor Company: _____

1. **Do you have any of the following symptoms?**

Fever, chills	Yes / No	Cough	Yes / No
Shortness of breath	Yes / No	Difficulty breathing	Yes / No

2. **Have you traveled outside of the United States in the last 14 days?** Yes / No

If yes, Where? _____

3. **Have you traveled inside the United States in the last 14 days?** Yes / No

If yes, Where? _____

4. **Have you been in direct contact with anyone confirmed to have Covid-19 within the last 14 days? (Hand shake, etc.)** Yes / No
5. **Who have you been in direct contact (within six feet for two hours or more) with at the plant within the last 7 days?**

_____ _____ _____ _____

_____ _____ _____ _____

6. **What meeting rooms or other common work areas have you been in within the last 7 days?**

_____

Employees, contractors, visitors are not allowed in the plant if they have cough, shortness of breath, breathing difficulties **OR** sore throat **AND** fever (100.5 degrees f. or 38 C)

Recommendations for employees exiting worksite:

- ☐ Ensure the employee's supervisor is aware the employee is going home due to illness
- ☐ Offer surgical mask if available, to the individual when preparing to leave the facility
- ☐ If he/she feels well enough to drive, they may, or they can call a friend or relative to pick them up.
- ☐ If transportation to the hospital is needed, contact the site Emergency Response team or call 9 1 1

CALUMET

Screening Questionnaire

The safety of our employees, customers, families, and visitors remains Calumet's overriding priority. As the coronavirus disease 2019 (COVID-19) outbreak continues to evolve and spread globally, Calumet EHS and HR Departments are monitoring the situation closely and will periodically update company guidance based on current recommendations from the Center for Disease Control and the World Health Organization.

To prevent the spread of COVID-19 and reduce the potential risk of exposure to our employees and visitors, we are conducting a simple screening questionnaire. Your participation is important to help us take precautionary measures to protect you and everyone at Calumet.

Visitor's Name:	**Personal Phone Number (mobile/home):**
Visitor's Company/Organization:	**Name of Calumet Host:**
Visitor's Location:	

Self-Declaration by Visitors	
1	**Have you traveled internationally or on a cruise within the past 14 days?** **□ Yes □ No** **If yes, where (include all cities/countries and airports):**
2	**Have you had close contact with or cared for someone diagnosed with COVID-19 within the past 14 days?** **□ Yes □ No**
3	**Have you been in close contact with anyone who has traveled internationally or on a cruise within the past 14 days?** **□ Yes □ No** **If yes, where have they traveled:**
4	**Have you experienced any symptoms of COVID-19 within the past 14 days (i.e. cough, sore throat, shortness of breath, respiratory illness, difficulty breathing, AND 100.4 or greater fever)?** **□ Yes □ No**

If the answer is "yes" to any of the above questions, access to the facility will be denied.

Signature (visitor): _____ Date: _____

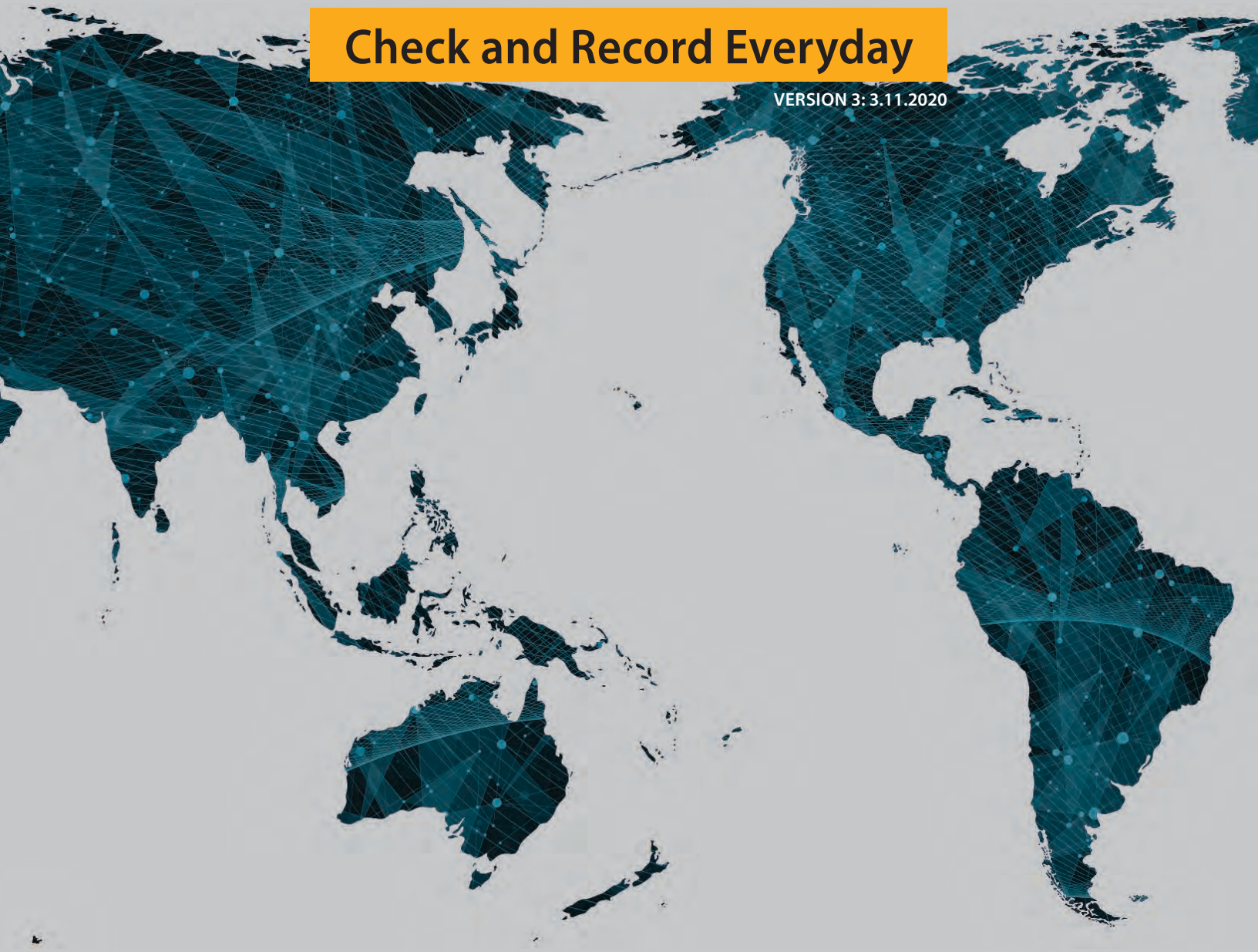
Note: If you plan to be onsite for consecutive days, please immediately advise Calumet if any of your responses change. The information collected on this form will be used to determine your access rights to Calumet. For more information, contact EHS.

Access to facility (circle one): Approved / Denied

CARE

Check and Record Everyday

VERSION 3: 3.11.2020



U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

CS314925U MAR 12, 2020 10 AM

You have received this booklet of important health information because you traveled from a country with an outbreak of COVID-19. COVID-19 is a respiratory illness caused by a virus that can spread from person to person.

If you have returned from a country where quarantine orders are required such as Hubei Province China, you will be monitored by the public health department in your destination state. Monitoring will include agreements or legal orders such as a quarantine order.

Under these agreements or quarantine orders:

- You must stay at your home, or at a location chosen by your state or local health department or the U.S. government for a 14-day period from the time.
- Follow the directions in the quarantine order and the directions provided by your health department and the U.S. government.

If you have returned from a country with widespread transmission of COVID-19, stay home and self-monitor for 14 days from the time you left the country. Take these steps to monitor your health:

1. Take your temperature with a thermometer two times a day and watch for cough or difficulty breathing (see instructions in this booklet).
2. Stay home from school.
3. Do not take public transportation, taxis, or ride-shares.
4. Avoid crowded places (such as shopping centers and movie theaters) and limit your activities in public.
5. Keep your distance from others (about 6 feet or 2 meters).
6. If you get sick with fever, cough, or trouble breathing, follow instructions on page 3.
7. If you need to seek medical care for other reasons, such as dialysis, call ahead to your doctor and tell them about your recent travel.

Your health department may have specific instructions for you to follow that may be more restrictive than described above.

If you have a medical emergency, call 911. Tell them you've traveled from a country with an outbreak of COVID-19.

Connect with Your Health Department

Connect with your health department upon return from travel (phone list included in this booklet). They will let you know:

- If you should report your health checks to the health department
- How often you should report your health checks
- Who to contact if you get sick with symptoms of fever, cough, or trouble breathing
- What else you should do if you develop symptoms
- Who to contact if you have questions

When you connect with the health department, ask them for the following contact information. Keep track of this important information by writing it below.

The contact information for staff at the health department is:

Name(s):

Phone Number:

After-hours phone number:

Email or website:

Other method:

Use the space below to write important information given to you.

Do I report my health checks?

How often should I report my health checks?

If I get sick, what does the health department want me to do?

Who do I contact if I have additional questions?

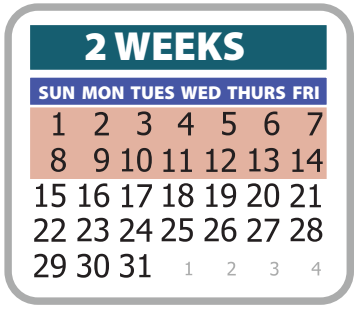
If you have been exposed to a person with COVID-19, it may take up to 14 days to know if you will get sick. It is important to check your health two times each day for 14 days after you leave. Follow the steps below to check and record your health.

Step 1 Do health checks every morning and every night:

- Take your temperature and/or that of family members who traveled with you and cannot do so themselves.
- In addition to fever, be alert for any other symptoms of COVID-19, including cough or difficulty breathing.
- Write your temperature and any symptoms in the log included in this booklet.
- Write family members' temperatures and symptoms in their own booklets.

Family members who did not travel with you do not need to be monitored.

Step 2 If your health department asks you to report your temperature and any symptoms, follow their instructions.



Step 3 If you have fever (fever is 100.4°F/38°C or higher), cough, or trouble breathing:

1. Do not go out in public.
2. Call the phone number listed for your health department in this booklet. Remind them that you are self-monitoring.
3. If you can't reach your health department, seek medical advice – call ahead before you go to a doctor's office or emergency room. Tell them about your recent travel, your symptoms, and guidance received from the health department.
4. Avoid contact with others.
5. Do not travel while sick.
6. Cover your mouth and nose with a tissue or your sleeve (not your hands) when coughing or sneezing.
7. Wash hands often with soap and water for at least 20 seconds to avoid spreading the virus to others.
8. Wash your hands with soap and water immediately after coughing, sneezing, or blowing your nose. If soap and water are not readily available, you can use an alcohol-based hand sanitizer that contains 60%-95% alcohol. Always wash hands with soap and water if hands are visibly dirty.

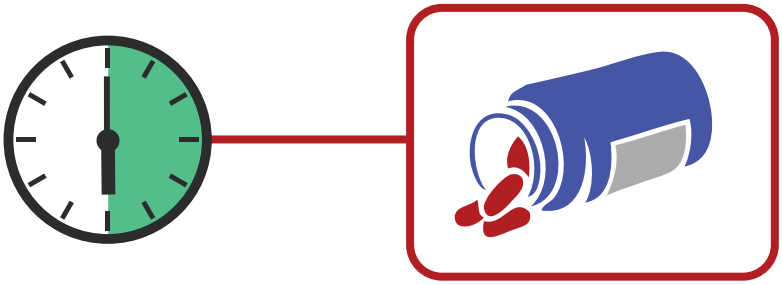
If you have a medical emergency, call 911. Tell them you've traveled from a country with an outbreak of COVID-19.

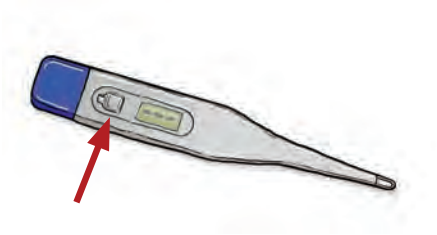
Before you take your temperature:

Wait 30 minutes after eating, drinking, or exercising.

Wait at least 6 hours after taking medicines that can lower your temperature, like:

- Acetaminophen, also called paracetamol
- Ibuprofen
- Aspirin





1. Turn the thermometer on by pressing the button near the screen.

2. Hold the tip of the thermometer under your tongue until it beeps. Do not bite the thermometer.

3. Read your temperature on the screen. If your temperature is 100.4°F/38°C or higher, you have a fever.

4. Write your temperature in the 14-Day Symptom and Temperature Log in this booklet.

5. Clean your thermometer with soap and water and dry it well.

PLEASE NOTE: For infants and children younger than 4 years old, use an age-appropriate thermometer such as an ear thermometer. If you do not have one, use a regular thermometer by placing it under the child's arm in the center of the armpit.

For the armpit method, if the child's temperature is 99.4°F/37.4°C or higher, they have a fever. Tell the public health worker that you are taking the child's temperature this way.

Two times a day (morning and night), write down your temperature and any COVID-19 symptoms you may have: feeling feverish, coughing, or difficulty breathing. Do this every day for 14 days.

1. Fill in the dates on the log, starting with Day 0 and ending with Day 14. Day 0 is the day you left the country with an outbreak of COVID-19.
2. Start recording your temperature and symptoms, beginning with today's date. **Fever is 100.4°F/38°C or higher.**
3. If you get sick, contact your health department. Be sure to tell them that you traveled from a country with an outbreak of COVID-19, your symptoms, and that you are selfmonitoring.
4. Your daily health checks are complete 14 days after the day you left the country with an outbreak of COVID-19, or as indicated by public health authorities.

DAY	DATE	SYMPTOMS	TEMP
DAY 0	Feb 1, 2020	Day 0 is the day you left the country with an outbreak of COVID-19.	
DAY 1	Feb 2, 2020	No Symptoms	97.4 F
		No Symptoms	98.6 F
DAY 2	Feb 3, 2020	No Symptoms	96.9 F
		No Symptoms	98.6 F
DAY 3	Feb 4, 2020	No Symptoms	98.0 F
		No Symptoms	98.6 F
DAY 4	Feb 5, 2020	No Symptoms	97.3 F
		No Symptoms	98.6 F
DAY 5	Feb 6, 2020	No Symptoms	96.5 F
		No Symptoms	98.6 F

SAMPLE

Symptom and Temperature Log

CARE

Write your symptoms and temperature in the space below every day for 14 days.

DAY	DATE	SYMPTOMS	TEMP
DAY 0		Day 0 is the day you left the country with an outbreak of COVID-19.	
DAY 1			
DAY 2			
DAY 3			
DAY 4			
DAY 5			
DAY 6			
DAY 7			
DAY 8			
DAY 9			
DAY 10			
DAY 11			
DAY 12			
DAY 13			
DAY 14			

If you get sick, contact your health department as instructed and remind them you traveled from a country with an outbreak of COVID-19, your symptoms, and that you are self-monitoring. Your daily health checks are complete at 14 days, or as indicated by public health authorities.

If you have a medical emergency, call 911. Tell them you've traveled from a country with an outbreak of COVID-19.

Phone Numbers for State and Local Health Departments

CARE

This is a list of telephone numbers for health departments across the United States that travelers can use to connect with the health department in their destination state or the state they are in. These phone lines are monitored at all times, and travelers may call 24 hours a day and 7 days a week unless noted. Members of the public with general questions about COVID-19 should call their state health department's main daytime telephone number or they can contact CDC at www.cdc.gov/cdc-info or 1-800-CDC-INFO (800-232-4636) or TTY 888-232-6348.

State	Phone Number
Alabama	1-800-338-8374
Alaska	1-800-478-0084 or 1-907-269-8000
Arizona	1-480-303-1191
Arkansas	1-800-554-5738
California *If you are in L.A. County, call:*	1-800-852-7550 *Ask for the CDPH Duty Officer* 1-213-288-8707 *Available from 8:00am-5:00pm*
Colorado	1-303-370-9395
Commonwealth of the Northern Marian Islands	1-670-234-8950
Connecticut	1-860-509-8000
Delaware	1-302-744-4700
District of Columbia	1-202-576-1117
Florida	1-850-245-4401
Georgia	1-866-782-4584
Hawaii	2-1-1 or 1-808-586-4586
Idaho	1-208-334-5939
Illinois *If you are in Chicago, call:*	1-800-889-3931 3-1-1 *(inside city limits)* or 1-312-744-5000
Indiana	1-317-233-1325
Iowa	1-800-362-2736
Kansas	1-877-427-7317
Kentucky	1-888-973-7678
Louisiana	1-800-256-2748
Maine	1-800-821-5821
Maryland	1-410-795-7365
Massachusetts	1-617-983-6800
Michigan	1-517-335-9030
Minnesota	1-651-201-5414
Mississippi	1-601-576-7725 or 1-601-576-7400 *(after hours, holidays, and weekends)*

State	Phone Number
Missouri	1-800-392-0272, Ext.1
Montana	1-406-444-0273
Nebraska	1-402-444-3400 *Available from 8:30am-4:00pm CT*
Nevada	1-775-400-0333
New Hampshire	1-603-271-4496
New Jersey	1-800-222-1222
New Mexico	1-505-827-0006
New York *If you are in New York City, call:*	1-866-881-2809 1-347-396-7990
North Carolina	1-866-462-3821
North Dakota	1-701-328-2270
Ohio	1-614-722-7221
Oklahoma	1-405-271-4060
Oregon	1-971-673-1111
Pennsylvania *If you are in Philadelphia, call* *If you are in Pittsburgh, call*	1-877-724-3258 1-215-686-4514 1-412-687-2243
Puerto Rico	1-787-765-2929, Ext.3552 or 3551 or 1-787-692-6276
Rhode Island	1-401-222-2577 or 1-401-276-8046 *(after hours)*
South Carolina	1-888-847-0902
South Dakota	1-800-592-1861
Tennessee	1-615-741-7247
Texas	1-512-776-7111
Utah	1-888-374-8824
Vermont	1-802-863-7240
Virgin Islands *If you are in St. Thomas, call:* *If you are in St. Croix, call:*	See below. 1-340-774-9000 *Available from 9:00am-5:00pm* 1-340-718-1311 *Available from 9:00am-5:00pm*
Virginia	1-877-ASK-VDH3 (1-877-275-8343)
Washington	1-800-525-0127
West Virginia	1-304-558-5358, Ext. 1
Wisconsin	1-608-258-0099
Wyoming	1-888-996-9104

If you have a medical emergency, call 911. Tell them you've traveled from a country with an outbreak of COVID-19.

Basic Steps for Corona Virus Isolation in the Workplace

Signs and Symptoms of Covid 19:

a. Fever
b. Cough
c. Shortness of breath

Isolation Area:

1. Establish a predesignated, and segregated, location in the event an individual exhibits signs and symptoms of Covid19.

2. Isolation area requirements:
   a. Away from individuals and other medium to high occupancy areas (e.g. Control Rooms, Break-Lunch Rooms).
   b. Minimal furnishings.
   c. All furnishings hard surface or non-porous, if possible.
   d. Remove the phone from the area.
   d. Enclosed, isolated by a doorway or other means (i.e. Not in a cubicle).
3. If possible, the isolation area should be near a bathroom, or accessible to one without moving through occupied areas.

Isolation Precautions:

1. Immediately escort the individual to the isolation area.
2. Maintain separation between the individual, the escort, and others. Six (6') minimum.
3. Isolate the individual in the area until they exit the site.
4. Advise the individual to seek immediate medical attention.
5. Offer to call the individuals personal physician or emergency room.

   Note: CDC recommendation on calling prior to arrival to screen and test for Covid19.

   Emergency Room Contact Number:_____.

   Be prepared to provide the following:
   1. Individuals name,
   2. Your name and relationship (e.g. Co-worker, Company Name),
   3. Individuals signs and symptoms, and
   4. Individuals personal physician information.

6. If possible, have the individual self-transport to seek medical attention or call emergency medical services.
7. If self-quarantining advise the individual to go immediately home.
8. Provide the individual with the:
   a. CDC Corona Virus Guide.
   b. CDC Wash Your Hands Fact Sheet.
9. Advise the employee that
   a. If the employee becomes positive for COVID-19, a doctor will determine when they are eligible to return to work
   b. If not positive for COVID-19 , the employee must be free of fever and cough (without the use of symptom-altering medications such as Tylenol, Advil, cough suppressant, etc.) for at least 24 hours prior to returning to work.

Isolation Area Disinfecting and Cleanup:

1. After the isolation area has been used, it must be cleaned prior to re-use or returned for general site use.
2. Cleaning shall consist of, at a minimum;
   a. Disinfectant wiping of all surfaces (e.g. diluted bleach or disinfectant wipes), for a minimum of 4 minutes of cleaning agent contact, or
   b. Isolation for 72 hours, if not being re-used.

3. If bodily fluids must be cleaned, the area must be cleaned in accordance with the site Bloodborne Pathogen procedure.
4. All personnel shall wear, at a minimum, gloves and a filtration mask (e.g. N95).
5. All cleaning materials shall be disposed of in accordance with Bloodborne Pathogen recommendations.

APPENDIX C
Standard Practice Instructions 25 – Substance Abuse

Prepared By:
Ramboll Environment & Health
333 W. Wacker Drive, Suite 2700
Chicago, Illinois

Implementation Date
September 2017

Revision Date
September 2020

Version Number
2017 Version 8

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STANDARD PRACTICE INSTRUCTION 25

SUBSTANCE ABUSE

RAMBOLL

STANDARD PRACTICE INSTRUCTION 25

IMPLEMENTATION DATE: September 2017

REVISION DATE: September 2020

SUBJECT: Substance Abuse Policy

REGULATORY STANDARDS: Best Management Practices

BASIS: Ramboll expects every employee to work unimpaired by alcohol or drugs. The Company particularly is concerned about employees who may operate potentially dangerous equipment or motor vehicles while under the influence of alcohol or drugs. These employees pose a significant risk to their own safety and the safety of others.

GENERAL: This Standard Practice Instruction (SPI) is designed to meet the unique needs of employees designated as "Operations" employees and those that are working at sites where alcohol and/or drug testing is required as a contract condition. This may include employees classified as Site, and/or Facility employees, including full-time, part-time, per diem, co-ops, properly trained interns, and temporary personnel. Compliance with this SPI is a condition of employment. Additional requirements may be added to this SPI to meet specific client site requirements. In such a case, the addition must be approved by the Principal in Charge, and the addition will not remove the individual(s) involved from compliance with this SPI.

RESPONSIBILITY: The Directors of Health and Safety and Human Resource are responsible for all facets of this program, and have full authority to make necessary decisions to ensure success of the program. The Director of Health and Safety will develop written detailed instructions covering each of the basic elements in this program, and is the sole person authorized to amend these instructions.

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ATTACHMENTS

Attachment A: Substance Abuse SPI Acknowledgement Form

Attachment B: Course of Recommended Treatment Agreement

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ACRONYMS AND ABBREVIATIONS

BAT	Breath Alcohol Technician
BrAC	Breath Alcohol Concentration
Directors	Directors of Health and Safety
EAP	Employee Assistance Program
GC/MS	Gas Chromatograph/Mass Spectrometry
MRO	Medical Review Officer
SPI	Standard Practice Instruction
TPA	Third Party Administrator

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1. RAMBOLL POLICY STATEMENT

Ramboll expects every employee to work unimpaired by alcohol or drugs. The Company particularly is concerned about employees who may operate potentially dangerous equipment or motor vehicles while under the influence of alcohol or drugs. These employees pose a significant risk to their own safety and the safety of others.

Ramboll strictly prohibits the following conduct:

- The unauthorized use, possession, manufacture, distribution, dispensation, or sale of illegal drugs or of alcohol on Company premises, in Company-supplied vehicles, or in any location while engaged in Company business. Unauthorized possession includes possession on an employee's person, as well as storage in a locker, desk, Company or personal vehicle, or any other repository on Company premises or while on Company business.

- Performing any job duty under the influence of drugs or alcohol on Company premises, including the parking lots, in Company-supplied vehicles, or in any location while on Company business. An employee will be considered "under the influence" of alcohol or drugs if he or she exhibits recognizable symptoms of alcohol or drug abuse, including, but not limited to, slurred or inappropriate speech, dazed appearance, uneven gait, altered attention span, or other symptoms without an adequate explanation.

- The possession, use, manufacture, distribution, dispensation, or sale of alcohol or drugs off Company premises that may adversely affect the individual's work performance, his or her own or others' safety at work, or the Company's reputation in the community.

2. GENERAL REQUIREMENTS

The following requirements are applicable to all Ramboll employees:

- Any employee who is convicted under any criminal drug statute for a violation occurring in the workplace, or in any other location while on Company business, or in circumstances which will adversely affect the Company's reputation in the community, must notify the Company of the conviction within five days of the conviction. If an employee who has been convicted as described above is directly involved in the performance of work pursuant to a federal government contract or grant, the Company will immediately notify the government as required by law.

- Employees may possess and take medication prescribed for them by a licensed physician in accordance with the prescription. If the medication is to be brought on the job site, it must be in its original container and labelled with the employees name and must be used only as prescribed. Employees who are using prescription or over-the-counter medications are responsible to assure the medication(s) being taken do not have an impact on the employee's ability to perform their job duties in a safe and effective manner.

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- If an employee experiences side effect or is unsure of the possible effect, they should consult their physician prior to coming to work. If the employee is experiencing side effects that could have an adverse impact on safety or performance they must report it to HR or site manager prior to coming to work. If the employee is not experiencing such effects but the medication warnings indicate possible effects and after consultation with their physician, there is a reason to believe that there may be a risk to safety or performance, then they must report this to HR.
- If the employee does not report taking medications with adverse side effects and is later observed to be impaired on the job, under the policy this will be treated the same as illegal drugs discovered during a drug test.

- Violation of the Company's alcohol and drug abuse policy will result in severe disciplinary action, up to and including discharge, at the sole discretion of management. In the event of a conviction for a drug-related offense occurring in the workplace as described above, disciplinary action will be taken within 30 days of notification of the conviction. The Company may, at its sole discretion, consider alcohol or drug abuse rehabilitation, testing, or counseling as a part of the discipline imposed as a result of a policy violation.

- At an Ramboll-sponsored social event where alcohol is served, any employee who has driven and has any concerns about driving home safely after the function, should take a taxi, secure a ride from someone else clearly capable of driving safely, or arrange for transportation by a family member or friend. Staff should suggest an alternative means of transportation to anyone who erroneously believes that he or she is capable of driving. Employees who drove to the function and who elect to return home by taxi will be reimbursed for doing so by presenting a receipt from the taxi driver to the Office Administrator.

Questions regarding the availability of alcohol and drug abuse rehabilitation or counseling services pursuant to the Company's employee benefits program should be directed to the Director of Human Resources.

3. SPECIFIC REQUIREMENTS

This Standard Practice Instruction (SPI) is designed to meet the unique needs of employees designated as an "Operation" employee and those that are working at sites where alcohol and/or drug testing is required as a contract condition. This may include employees classified as Site, and/or Facility employees including full-time, part-time, per diem, co-ops, properly trained interns, and temporary personnel. Compliance with this SPI is a condition of employment. Additional requirements may be added to this SPI to meet specific client site requirements. In such a case, the addition must be approved by the Principal in Charge and the addition will not remove the individual(s) involved from compliance with this SPI.

4. TESTING FOR DRUGS AND ALCOHOL

4.1 Use of Third Party Provider

4.1.1 Program Management

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An experienced and qualified Third Party Administrator (TPA) will be utilized to manage the program. The TPA will be responsible for providing collection, testing, and the Medical Review Officer (MRO). All TPA personnel, including the collection site and clinical testing laboratory personnel shall maintain confidentiality of drug test results and medical information except as authorized by a test subjects consent or law. Collection site and clinical testing laboratory personnel shall use forensic procedures to ensure specimen integrity and shall document appropriate chain-of-custody procedures. All procedures will follow regulatory protocols where legally permissible (e.g., 49 CFR Part 40, DHHS Guidelines or equivalent).

4.1.2 Specimen Collection and Alcohol Testing

Specimen collection and alcohol test arrangements will be made for each active site. These will be managed by the TPA. All collections and transportation thereof will be conducted in accordance with applicable regulatory guidelines and be in accordance with this program (e.g., 49 CFR Part 40, DHHS Guidelines or equivalent).

4.1.3 Medical Review Officer (MRO)

The MRO will be provided by the TPA.

4.1.4 Random Sample Management

All covered personnel will be required to participate. The TPA or a client specified TPA shall be utilized to administer random sample management. In some cases, a client may require a pre-entry test, and in this case personnel will be required to participate and provide a pre-entry sample for testing.

4.2 Use of Certified Laboratory

4.2.1 Drugs

Testing for drugs required under this policy shall be performed by a laboratory retained by the TPA that is certified by a recognized regulatory body to conduct such tests. The protocol shall require a confirmation test on all samples that produce a positive test result on an initial screen. The laboratory shall report all results to the MRO.

4.2.2 Alcohol

Testing for alcohol required under this policy shall be performed by a qualified testing facility retained by the TPA. The protocol for alcohol testing shall be performed by a laboratory retained by the TPA that is certified by a recognized regulatory body to conduct such tests. Results from the tests will be forwarded to the TPA.

4.3 Applicants for Employment

4.3.1 The Company shall conduct drug and alcohol testing once a job offer has been extended to an applicant for a position that requires drug and/or alcohol testing. The job offer will be contingent on successfully passing the drug and alcohol test. Applicants who refuse to

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undergo drug and alcohol testing, or who otherwise interfere or tamper with the testing process, will be denied employment.

4.3.2 Offers of employment are contingent upon a negative test result. It there is a positive result on the initial screen will not be withdrawn until the confirmatory test has been administered and verified by the Medical Review Officer. Split samples and retesting is not available to applicants.

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4.4 Current Employees

The Company may require any current employee to undergo testing for drugs and/or alcohol under the following circumstances.

4.4.1 "Random" - When an employee is notified by the company representative that the TPA has selected them for testing. This testing will be on an unannounced basis and will require testing for drugs and alcohol.

4.4.2 "Reasonable suspicion" - When the Company has reason to suspect, based upon observed employee behavior or circumstances in which the company reasonably believes that the employee may be under the influence of drugs or alcohol. For the purpose of requiring a drug or alcohol test, "reasonable suspicion" exists if facts and circumstances warrant a rational inference that a person is using and/or is mentally or physically impaired due to being under the influence of alcohol or drugs. Reasonable suspicion will be based upon the following but not limited to:

4.4.2.1 observable phenomena, such as direct observation of use and/or the physical symptoms of impairment resulting from using or being under the influence of alcohol or drugs during working hours, while on Company business, while on Company premises, or while in Company vehicles, in violation of this Policy; or

4.4.2.2 information provided by an identifiable and credible source, as to such impairment or use referred to in (a) above; or

4.4.2.3 circumstances which reasonably suggest that such testing is appropriate, including but not limited to:

4.4.2.3.1 unexplained significant deterioration in individual job performance; repeated abusive behavior, insubordination, etc;

4.4.2.3.2 excessive absenteeism, including tardiness;

4.4.2.3.3 employee admissions regarding current drug abuse or present impairment by alcohol as referred to in (a) above; or

4.4.2.3.4 unexplained absences from normal work areas when there is reason to suspect activity in violation of this Policy.

4.4.3 "Post-accident"

When the employee is involved, by action or omission, or has contributed to an accident, incident, potentially recordable injury, or property damage, knowingly or unknowingly, the employee will be required to be tested for drugs and alcohol. If the incident is deemed by the manager and/or principal to be minor in nature and there is no reason to suspect drug or alcohol involvement, the manager and/or principal may waive this requirement.

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4.4.4 "By agreement"

As a condition of any agreement between the Company and the employee.

4.5 Positive Drug or Alcohol Results

4.5.1 Drug: Positive is defined as:

Drug	Initial Screen (nanograms/milliliter)	GC/MS Confirmation Limits (nanograms/milliliter)
Marijuana metabolites (THCA)2	50 ng/mL[3]	15 ng/mL
Cocaine metabolite (Benzoylecgonine)	150 ng/mL[3]	100 ng/mL
Codeine/Morphine	2,000 ng/mL	2,000 ng/mL
Hydrocodone/Oxymorphone	300 ng/mL	100 ng/mL
Oxycodone/Oxymorphone	100 ng/mL	100 ng/mL
6-Acetylmorphine	10 ng/mL	10 ng/mL
Phencyclidine	25 ng/mL	25 ng/mL
Amphetamine/Methamphetamine	500 ng/mL	250 ng/mL
MDMA/MDA	500 ng/mL	250 ng/mL

4.5.2 Alcohol: Positive is defined as having a Breath Alcohol Concentration (BrAC) of 0.02 or greater.

4.5.3 Ramboll Operations reserves the right to alter these limits in the future including but not limited to meeting specific client requirements that are more stringent.

4.6 Right of Refusal; Consequences

Any employee or job applicant has the right to refuse to submit to a drug and/or alcohol test; the consequences of refusal are as follows:

4.6.1 If an employee refuses to submit to a test or fails to cooperate in the testing process as required under this SPI, the employee will be subject to discipline up to and including termination.

4.6.2 If an applicant refuses to submit to a test or fails to cooperate in the testing process, the job offer will be withdrawn.

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5. TESTING PROCEDURES – ALL TYPES OF TESTS

5.1 Employee and Applicants

5.1.1 Employees and applicants subject to a drug or alcohol test must report to the Company's designated collection/test facility at the time assigned (no longer than 2 hours after notification).

5.1.2 Upon arriving at the collection/test facility, employees and applicants must identify themselves and fully cooperate in the process. Photo identification maybe required by the facility.

5.1.3 All employees and applicants must sign a written consent before any test may be administered. Refusal to sign a lawful consent will be treated as a refusal to submit to a drug and/or alcohol test.

5.1.4 The identity of employees and applicants who have tested positive for drugs or alcohol will be disclosed to only those persons the company deems have a need to know such information in order to administer or otherwise effectuate this Instruction or under the circumstances permitted by applicable statute and regulation.

5.2 Drug Testing

5.2.1 Urine samples will be collected by the collection facility. The collection facility personnel are responsible for ensuring that substituted or adulterated samples are not submitted. Should an employee submit insufficient specimen for the required tests, the employee must be examined by a medical professional, at the employee's expense to identify a medical reason. The MRO in consultation with the medial professional, will order the medical exam, and have the final authority in a determination if this is a refusal to submit.

5.2.2 Urine samples for employees (not applicants) will be collected using a "split-sample" method, which means the sample is split and saved in two containers to facilitate re-testing. In this SPI, the sample used for the screen and first confirmatory test is referred to as the "original sample"; the sample sent to a second laboratory for re-testing is referred to as the "split sample".

All collections and transportation thereof will be conducted in accordance with applicable regulatory guidelines and be in accordance with this program (e.g., 49 CFR Part 40, DHHS Guidelines or equivalent).

5.2.3 Urine samples which test positive for the presence of drugs on the initial screen will be subject to a confirmation test. Initial and confirmation test report results must indicate the test method used. All confirmatory tests shall use a gas chromatograph/mass spectrometry (GC/MS) methodology.

5.2.4 Employees and applicants whose confirmation test results are positive will be notified by the Company's Medical Review Officer ("MRO") within three (3) working days of receiving the

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laboratory report, and invited to provide any information which supports an alternate medical explanation for the positive test result.

5.2.4.1 The MRO contact with an employee or applicant will be confidential.

5.2.4.2 If the MRO is unable to reach an employee or applicant, the Ramboll contact will attempt to notify him/her.

5.2.4.3 Attempts to reach an applicant or employee will be documented by the MRO and Ramboll as applicable.

5.2.5 The MRO will cancel a positive test result when the employee or applicant provides adequate medical information acceptable to the MRO. If an employee or applicant either declines to provide information or fails to contact the MRO within five (5) calendar days after being notified by the Operations designee, the MRO will report the test as "verified positive." If Ramboll determines that the employee or applicant is unavailable to contact for a valid reason such as but not limited to a vacation, the five calendar days can be extended until the employee is available to respond.

5.2.6 The MRO will notify the Ramboll contact, applicants and employees of any verified positive drug test and will provide the Ramboll contact with a copy of the test results. Employees will also be notified of the drug identified. Upon written request, the MRO or the Ramboll contact will provide an applicant or employee with a copy of the test results.

5.2.7 An employee (not applicant) has the right to a re-test of the split sample, at his/her own expense, by another certified laboratory, provided the employee informs the Company, in writing, within three (3) working days of receiving notice of the verified positive test.

5.2.8 All samples which test positive, whether an original sample or the split sample, will be retained per the TPA procedures.

5.3 Alcohol Testing

5.3.1 Testing for alcohol required under this policy will be performed by a qualified testing facility retained by the TPA. The protocol for alcohol testing will follow applicable recognized guidelines. All necessary equipment, personnel, and materials for conducting the alcohol testing shall be provided at the testing site (US DOT Guidelines or equivalent).

5.3.2 If the result of the screening test is 0.02 BrAC or greater, then the Breath Alcohol Technician (BAT) shall perform a confirmation test.

5.3.3 In the event the screening and confirmation test results are not identical, the confirmation test result shall be deemed to be the final result on which any disciplinary action by the company may be taken.

5.3.4 The BAT or MRO shall transmit all alcohol testing results to the Ramboll contact in a confidential manner. The BAT or MRO shall ensure that immediate transmission of test results to the company is conducted in order for the company to prevent the employee from performing further work, if applicable.

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6. TESTING PROCEDURES – POST-ACCIDENT

6.1 An employee involved in an accident or incident subject to a post-accident drug and/or alcohol test is responsible for notifying his/her manager as soon as possible to arrange for the required tests.

6.2 Urine samples for drug tests should be taken as soon as possible following the accident per section V.

6.3 If the employee is seriously injured and requires immediate, ongoing medical treatment that prevents the employee from submitting to a post-accident drug and/or alcohol test, the employee is required to provide any authorizations necessary for the Company to obtain hospital reports and other documents or records that would indicate whether or not the employee was under the influence of any illegal drug or any legal drug or alcohol whose use is prohibited by the policy.

6.4 The following actions will be treated as a refusal to submit to a drug and/or alcohol test:

6.4.1 A failure, without adequate justification, to notify a supervisor in a timely manner to arrange for collection of a urine sample and/or alcohol test or

6.4.2 A refusal by an injured employee unable to submit to the drug and/or alcohol test because of necessary medical treatment to provide the required authorizations for hospital reports and any other relevant medical record.

6.5 The Company reserves the right to suspend an employee, with or without pay, pending the results of a post-accident test. If the suspension is without pay and the test result is negative, the employee will be paid straight-time pay for the days missed.

7. TESTING PROCEDURES – REASONABLE SUSPICION

7.1 Operations Supervisors, Managers and Principals will be familiar with actions, behavior and appearance factors which indicate that an employee is under the influence of drugs and/or alcohol.

7.2 If a Operations Supervisors, Managers and Principals suspects that an employee is under the influence of drugs or alcohol, she/he should attempt to locate another Manager or Principal to either observe the employee or discuss the situation. If another Manager or Principal is not available, do not delay stopping the individual from performing any activity that might risk his/her safety or the safety of others. If a determination is made to require a drug and/or alcohol test, the person(s) observing the employee's conduct and behavior forming the basis for that determination are responsible for documenting the observed behavior and notifying the Managing Principal in a timely fashion.

7.3 If an employee suspects a co-worker is under the influence of drugs or alcohol, she/he should attempt to locate the site supervisor for further guidance. If the site supervisor is unavailable contact the Director of PBU or the local HR representative.

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7.4 An employee suspected of being under the influence of drugs and/or alcohol will be removed immediately from her/his job duties. The employee's Manager will arrange for transportation of the employee to the designated collection/test facility. The Manager will notify the testing facility to expect the employee.

7.5 The Company reserves the right to suspend an employee, with or without pay, pending the results of a reasonable suspicion test. If the suspension is without pay and the test result is negative, the employee will be paid straight-time pay for the days missed.

8. TESTING PROCEDURES – RANDOM TESTING

8.1 Employees with a training classification of Operations will be in the random testing program. Employees will be selected for testing by the TPA using a valid random number table, random number generator program, or other random selection process selected by the TPA. The TPA will notify the Ramboll contact who will work with the employee's supervisor or manager to notify the employee that has been selected for a random test.

8.2 Once notified, the employee will immediately proceed to the designated collection facility. Employee must undergo testing within two hours of being notified.

8.3 Employees not at work or not available in their assigned office at the time of selection, i.e., travel, remote assignment, leave of absence, vacation, sick days or other reason will remain in the random selection pool as long as they remain in the training classification of Operations. The following procedures apply to those employees not available for testing when the Ramboll contact is notified:

8.3.1 Employees not available in their assigned office, on vacation, sick day or other short-term absence may be notified of their selection upon their return to work at their assigned office or site.

8.3.2 Employees on leave-of-absence who are scheduled to return to work within thirty (30) days of the date of their selection may be notified of their selection upon their return.

8.3.3 Employees on leave-of-absence who are not expected to return to work within thirty (30) days may have their names skipped. The Company's records of its random drug testing program may reflect that the employee was selected but on layoff or leave.

9. TRAINING

All employees affected by this policy will be required to participate in substance abuse training provided by Ramboll. This training will be provided in video format to Supervisors and employees upon induction in the substance abuse program and to supervisors annually. Training will be provided:

9.1 Before the employee is first assigned duties that require induction in the substance abuse program.

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9.2 Before there is a change in assigned duties.

9.3 Whenever there is a change in operations that present a hazard for which an employee has not previously been trained.

9.4 Whenever Ramboll has reason to believe that there are deviations from established substance abuse program required by this instruction or inadequacies in the employee's knowledge or use of these procedures.

10. DISCIPLINE

10.1 An employee in violation of this SPI (including receiving unacceptable drug test results) will be immediately removed from duties at an operations site and will be subject to disciplinary action up to and including discharge.

10.2 The employee's Manager and/or Principal will review the infraction and determine the level of disciplinary action to be taken. The actions can include but is not limited to reassignment, suspension, reference to a course of recommended treatment or discharge. Given the seriousness of an infraction in this SPI, the disciplinary action taken up to and including discharge is at the discretion of the Manager and Principal.

10.3 Should an employee be referenced to a course of recommended treatment, this leniency requires that the employee agree to the following:

10.3.1 That the employee signs the course of recommended treatment agreement, violations of which will result in disciplinary action up to and including immediate discharge at the sole discretion of management.

10.3.2 That the course of recommended treatment agreement provides that the employee is required to, and the employee does:

10.3.2.1 Agree to a course of treatment as recommended by approved health care providers and agreed upon by management. The treatment course and doctor visits will be paid for by the employee.

10.3.2.2 Sign an authorization permitting the health care provider and the employee's Manager and/or Principal to receive and share information received from any counselor or health care provider as allowed by HIPAA privacy laws

10.3.2.3 Successfully complete the course of recommended treatment to the satisfaction of both the healthcare provider and the Company.

10.3.2.4 Upon release by the healthcare provider, submit to return-to-work drug and alcohol screens conducted by the TPA. A positive test will result in disciplinary action up to and including discharge as determined by the Manager and Principal.

10.3.2.5 Discontinue the use of illegal drugs and alcohol.

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10.3.2.6 Submit to frequent unannounced drug and alcohol testing during the hours of work for a period of 24 months following the initial positive drug or alcohol screen. Any positive test will result in immediate termination.

10.4 The procedures applicable to the course of recommended treatment are as follows:

10.4.1 The employee signs the course of recommended treatment agreement. If the employee does not consent to sign the agreement, the assessed disciplinary action may be revised to immediate discharge at the discretion of the Manager and Principal.

10.4.2 The employee is placed on a three-day unpaid leave, during which he/she must undergo evaluation by an approved health care provider for treatment recommendation. The employee will cover the cost of the doctor visit and cost of treatment.

10.4.3 If the health care provider's initial recommendation is that the employee is not fit to return to work, the employee will be placed on an unpaid leave of absence and may apply for short term (or State) disability. If the employee does not qualify for short term disability, he/she will remain on an unpaid leave and may not return to work until released by a health care professional (following the successful completion of the health care-recommended program, or until the Company otherwise determines that the employee is fit to return).

10.4.3.1 The employee is fit to return when the employee is able to perform the essential functions of their position with our without reasonable accommodation.

10.4.4 If the health care provider's initial recommendation is that the employee is fit to return to work and the Company agrees, the employee shall return to work. The Company has no obligation to retain an employee on active status during a period of treatment, however, and can require that the employee remain on unpaid leave during the treatment period. Whether or not actively at work, the employee at all times remains subject to the course of recommended treatment agreement.

10.5 The Company at all times retains the ability to take disciplinary action against the employee for violation of any Company policies, procedures or rules (whether or not caused by alcohol or drug use), and to enforce performance standards.

10.5.1 Any employee who incurs a second positive test for illegal drugs or alcohol at any point in his/her Company employment will be immediately subject to disciplinary action up to and including discharge at the discretion of the Manager and Principal.

10.5.2 Any employee who is under the influence of any legal drug whose use is prohibited by this Policy and the use of that drug was not reported to the Company's TPA is subject to discipline up to and including termination.

10.5.3 Any employee who refuses to submit to a drug or alcohol test required in accordance with this Instruction will be immediately suspended without pay and subject to further disciplinary action, up to and including termination.

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10.5.4 The Policy does not, in any way, affect the right of the Company to take disciplinary action against an employee, where appropriate, for violation of other general Company policies, procedures and/or rules.

11. APPLICATION OF FEDERAL, STATE AND LOCAL REGULATIONS

Given the restrictions on drug testing under the State of California law, none of the testing provisions of this policy are applicable until further notice to any Company employees in California who are not covered by applicable transportation regulations.

12. EMPLOYEES HANDLING US GOVERNMENT CONTRACTS

Under US Federal Law, employees working on government contracts are required, as a condition of Company sales to or grants from the US Federal Government, to notify the Company of any criminal drug statute conviction for a violation occurring in the workplace no later than 5 days after such conviction. Further, the law requires the Company to notify employees handling government contracts that violation of the Company's substance abuse Policy may lead to disciplinary action up to and including termination of employment.

13. DEFINITIONS

13.1 **"Legal Drugs"** for the purpose of this policy are those drugs which have been prescribed by a doctor and those over-the-counter drugs which have been legally obtained and are being used for the purpose for which they are prescribed or manufactured.

13.2 **"Illegal Drugs"** for the purpose of this policy means any drug (a) which is not legally obtainable or (b) which is legally obtainable but has not been legally obtained, including prescribed drugs not being used for prescribed purposes or in the prescribed amounts and / or (c) possession of drug paraphernalia.

13.3 **"Under the Influence"** (a) with regard to drugs means having concentrations of a drug detectable by scientific test at or above the concentrations set forth by this policy, (b) with regard to alcohol, means having concentrations detectable by scientific test at or above the concentrations set forth by this policy.

13.5 **"Operations"** Personnel that have the training classification of Operations Work and/or in the Ramboll practice area involving site operations.

12.6 **"Ramboll Contact"** The person designated by Ramboll to communicate with the TPA and when necessary, Ramboll employees, to implement the Practice Information.

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14. REVISION SUMMARY

Version	Author	Description of Change	Date
V7	M. Lozada	Minor Change – grammar edit to page i. Moderate Change – added "(including receiving unacceptable drug test results)" to Section 9.1 (page 10).	08/26/2013
V8	K. Heitman S. Schwartz	Update testing requirements, limits. Added training section. Updated prescription drug acknowledgment.	8/22/2017

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ATTACHMENT A
SUBSTANCE ABUSE SPI ACKNOWLEDGEMENT FORM

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ACKNOWLEDGEMENT

I have received a copy of the Substance Abuse Standard Practice Instruction and have carefully and thoroughly read it. I understand that it is my obligation as a condition of employment to abide by all of its terms.

_____ _____

Signature Date

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ATTACHMENT B
COURSE OF RECOMMENDED TREATMENT AGREEMENT

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COURSE OF RECOMMENDED TREATMENT AGREEMENT

I, _____, understand that my (reinstatement and) continued employment (are) is contingent upon compliance with all of the following terms of this agreement.

☐ I will be evaluated for chemical dependency by a health care provider and company approved treatment program at employee expense.

☐ I authorize the company to receive all relevant information (HIPAA Compliant) regarding my progress in my rehabilitation program.

☐ I will be subject to frequent and unannounced testing (follow-up monitoring) for up to two years.

☐ I recognize, accept, and agree that any future violation of this Practice Instruction by me will result in disciplinary action up to and including termination of my employment as determined by my Manager and Principal.

☐ I am responsible for meeting the same standards of performance and conduct that are set for other employees.

I understand that failure to comply, in whole or in part, with all of the terms and conditions of this agreement will result in further disciplinary action, up to and including termination of employment with the Company.

_____ _____

Employee Signature Date

_____ _____

Company Representative Date

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APPENDIX D
Control Mechanisms

The following Control Methods should be implemented for Hazards that were identified as part of the Tasks that will be conducted as part of this Project.

B1: Chemical

Ramboll personnel shall familiarize themselves with the appropriate H&S responses for exposure to known onsite chemicals prior to beginning work at the site. Site-specific chemicals are not limited to known chemicals of concern present in environmental media. During the preparation of the site-specific HASP, Ramboll personnel shall also consider historical chemical use resulting in potential chemicals of concern, as well as any current chemical use (e.g. drums, cylinders, containers) or chemicals brought onsite to complete project work (e.g. laboratory chemicals, sample preservatives). Personnel shall include relevant SDSs in the site-specific HASP and review Attachment A Hazardous Material Properties prior to work involving hazardous materials.

Ramboll personnel, contractors, subcontractors and visitors shall wear appropriate PPE while performing site activities based on the expected constituents of concern (COCs) and additional site hazards. At a minimum, equipment shall include safety glasses, steel-toed boots and hard hats (when overhead work is being performed or when overhead hazards exist). Additional PPE requirements, addressing the site-specific hazards and chemicals of concern, will be outlined in the site-specific HASP.

Air monitoring may be performed to ensure onsite exposure levels are maintained below regulatory requirements. Air monitoring equipment, monitoring plan and controls shall be specified in the site-specific HASP.

Containers of unknown origin and/or unknown contents should not be opened by Ramboll personnel without approval from the Corporate H&S Director. For projects in which containers are present with unknown contents, consult the site/facility representative for additional information and, if appropriate, consider retaining a qualified waste management company for testing and identification.

For additional information, refer to Standard Practice Instruction 6–Hazard Communication. Consult with your local HSC for any personal air monitoring requirements.

B2: Dust/Particulates/Fumes

Working in the vicinity of operating equipment (e.g. drilling rigs, heavy machinery, excavating equipment, power tools) poses unique safety situations including generation of dusts, particulate and fumes.

When the surface is disturbed soil, dust and other particulates (e.g. concrete dust) can be released to the air. Severe weather conditions can also generate or contribute to hazardous dust and particulate conditions. This presents a hazard to the breathing zone of Ramboll employees, subcontractors, facility personnel and other bystanders. It can also present an offsite hazard if transport of the generated dust and/or particulates off the subject property is possible. The level of risk associated with dust and particulate exposure is generally tied to the level of contamination in the soil, however, soil to dust/particulate transfer is not easily predictable and typically requires onsite real time monitoring to establish baseline exposure values.

Depending upon the work to be done by Ramboll personnel, a preliminary site field survey may need to be performed prior to involvement in drilling and/or heavy equipment operations. In the pre-planning stage, the site geology, ground cover and scope of work (i.e. methods of investigation) should be discussed with the PM, PIC and any subcontractors. If operating equipment will be utilized and dust/particulate generation is a potential hazard, subcontractors should be directed (in the subcontract) to be prepared to control this hazard with water spray, or other method (e.g. tenting). The site specific HASP should include clear directives to monitor breathing the zone and/or site perimeter conditions using approved monitoring devices including, but not limited to personal air monitoring (PAM), dust meters, or perimeter monitoring with data logging equipment.

For additional information, refer to B18–Heavy Machinery, SPI 11–Trenching and Excavation Awareness and SPI 37–Rigging and Material Lifting. Consult with your local HSC for any additional requirements.

Both fuel operated equipment and volatile chemicals can present a fume hazard to Ramboll employees. Typically, when work is conducted outside, staff can anticipate that standard scopes of work and typically encountered constituents of concern will not present a fume hazard when best practices such as standing up wind are established and followed. However, there are scenarios in which Ramboll employees must be prepared to implement additional controls to address hazardous fumes. Certain work circumstances, specifically interior work conducted with gasoline-powered motors warrants evaluation for proper ventilation and monitoring to ensure sufficient oxygen and to avoid the buildup of harmful fumes (e.g. carbon monoxide, specific constituents of concern).

Prior to start of work, the scope of work and site-specific factors must be discussed with the PM, PIC and/or local HSC to ensure that the site-specific HASP includes appropriate controls to address the potential site-specific hazards. Regardless of the site-specific constituents of concern, oxygen must be maintained at a percentage ranging between 19.5% and 23.5% of the total ambient air. Ramboll personnel shall monitor the work area for oxygen deficiency hazards using monitoring devices that have been appropriately calibrated and are recommended for this specific use, as applicable. If direct air monitoring readings suggest an oxygen deficiency and/or the build-up of harmful substances, attempt to employ a passive corrective action such as moving the position of Ramboll personnel upwind of the hazardous area or equipment exhaust. If warranted, additional corrective engineering controls may include moving or removing the equipment, venting exhaust to the exterior of the building (typically if interior work is to be conducted, contractors need to be notified in advance that venting will be required), increasing work zone ventilation by opening overhead doors, utilizing fans or the facility ventilation system and/or upgrading PPE. If engineering controls do not adequately address the hazard, leave the area and contact the PM, PIC and/or HSC. Work will not continue until the hazardous fumes are properly addressed and safe work conditions are verified.

The presence of petroleum and solvent contaminated material presents a potential fire hazard. Smoking and use of open flame will be prohibited and the use of non-sparking tools and equipment will be required, if conditions warrant. Where the potential of fire exists, Ramboll will provide portable fire extinguishers and employees must be trained on proper use. All fire extinguishers shall be maintained as follows:

- Fully charged and in operable condition;
- Clean and free of defects;
- Readily accessible at all times; and
- Be visually inspected each month and undergo a maintenance check each year.

Fire prevention and protection measures include elimination of ignition sources, where feasible, identification of combustion sources and atmospheres (e.g. LEL will be monitored) and early detection and rapid response to fire/explosion situations. In addition to standard operating procedures, the following safe work practices will be implemented:

- Site activities will comply with National Electric Code and explosion proof criteria.
- Smoking will not be permitted (or only in designated areas, if such areas are available). On sites where subcontractors are under the direction of Ramboll and fire/explosion hazards will be present, the subcontract shall state that smoking will not be permitted onsite and the Ramboll site supervisor shall enforce this requirement.
- Appropriate air monitoring will be conducted, when necessary.
- Welding, open flame or spark-producing operations will not be allowed onsite.
- Solvents with a flash point of less than or equal to 100°F will not be used for cleaning purposes.
- Fire extinguishers shall be kept in all work vehicles.

All fires and visible smoke that are detected at the site will be dealt with immediately by the individual recognizing the fire and/or smoke. In the event of visible smoke, fire or explosion, the following emergency response procedures will be implemented:

- Immediately cease operations; and
- In all emergency fire situations, contact emergency services.

For small fires, personnel may attempt to extinguish the fire, if safe to do so and they have been trained. One fire extinguisher ONLY may be used to fight the fire. After one fire extinguisher is depleted, personnel must evacuate the area. For larger fires, perform immediate site evacuation.

For more information, please refer to SPI 3–Emergency Action Plan. Consult with your local HSC for any additional requirements.

B3: Job Zone Control

Implementation of Ramboll scopes of work require that field personnel have a clear and organized plan prior to the start of work to control the chemical hazards of the job, ensure all contaminated materials (environmental media and otherwise) are contained and personnel, PPE and/or equipment are appropriately decontaminated. Job zone control will vary depending on the level contamination and complexity of the project and site and may include but not limited to:

- A site map;
- Site preparation for project activities (e.g. making roads, establishing traffic patterns);
- Establish work zones (i.e. Exclusion Zone, Contamination Reduction Zone and Support Zone);
- Use of the buddy system;
- Decontamination procedures;
- Site security (e.g. fences, locks, hired security);
- Communication plan; and
- Safe work practices (e.g. good hygiene, avoid contact with contaminated media).

If the site investigation/remediation is being done at hazardous waste site, the PPE requirements will be forwarded as noted in the site-specific HASP. Kneeling, lying in, or sitting on contaminated ground or materials must be avoided or a protective barrier must be used. Avoid or minimize handling of contaminated materials. Clean water will be kept available for decontamination, washing and dust control. When water is required for decontamination, the necessity of containerizing and properly handling this water must also be evaluated. Consideration must also be given to decontamination of equipment such as drilling rigs, augers and heavy equipment used for excavation/trenching. Subcontractors may need to include items such as decontamination pads and wash water containerization in the cost estimation stage; advance planning for job zone control is imperative.

The job zone control plan must be clearly outlined in the site-specific HASP and discussed in advance of start of work with all Ramboll project personnel, associated subcontractors and site contacts, as appropriate. Consult with your local HSC for any additional requirements.

B4: Heat

Heat stress can be a significant hazard, especially for workers wearing protective clothing. Depending on the ambient conditions and the work being performed, heat stress can occur very rapidly, within as little as 15 minutes. Site personnel will be instructed in the identification of a heat stress victim, the first-aid treatment procedures for the victim and in the prevention of heat stress incidents.

Workers will be encouraged to immediately report any heat-related problems that they experience or observe in fellow workers. Any worker exhibiting signs of heat stress and exhaustion should be made to rest in a cool location and drink plenty of water. Emergency help by a medical professional is required immediately for anyone exhibiting symptoms of heat stroke, such as red, dry skin, confusion, delirium, or unconsciousness. Heat stroke is a life threatening condition that must be treated immediately by competent medical authority.

The following American Conference of Governmental and Industrial Hygienists (ACGIH) screening criteria table shows heat stress exposure in degrees Celsius for an 8 hour work day, five days per week with conventional breaks will be used in determining safe exposure for acclimatized (adapted to site-specific environmental conditions) and unacclimatized (not adapted to site-specific environmental conditions) employees. Please note that at elevated temperatures, the ability to safely complete heavy or very heavy work is very limited and frequent rest breaks are required. The project schedule and budget should account for additional staff and/or a longer timeline to completion.

ALLOCATION OF WORK IN A WORK/REST CYCLE	ACCLIMATIZED				ACTION LIMIT (UNACCLIMATIZED)			
	LIGHT	MODERATE	HEAVY	VERY HEAVY	LIGHT	MODERATE	HEAVY	VERY HEAVY
75-100%	31.0 (87.8°F)	28.0 (82.4°F)	--	--	28.0 (82.4°F)	25.0 (77°F)	--	--
50-75%	31.0 (87.8°F)	29.0 (84.2°F)	27.5 (81.5°F)	--	28.5 (83.3°F)	26.0 (78.8°F)	24.0 (75.2°F)	--
25-50%	32.0 (89.6°F)	30.0 (86°F)	29.0 (84.2°F)	28.0 (82.4°F)	29.5 (85.1°F)	27.0 (80.6°F)	25.5 (77.9°F)	24.5 (76.1°F)
0-25%	32.5 (90.5°F)	31.5 (88.7°F)	30.5 (86.9°F)	30.0 (86°F)	30.0 (86°F)	29.0 (84.2°F)	28.0 (82.4°F)	27.0 (80.6°F)

Heat Stress Prevention

Whenever possible, or within the control of Ramboll, engineering controls should be utilized to protect workers from heat related hazards. For example, isolation from the heat source, ventilation such as open windows, fans or other methods of creating air flow and heat shielding such as awnings or umbrellas.

Appropriate work practices can also lessen the chances of heat related hazards as follows:

- Water intake should be about equal to the amount of sweat produced (i.e. drinking 5-7 ounces of water every 15-20 minutes). Electrolyte fluids may also be necessary.
- Whenever possible, gradual exposure to heat (i.e. acclimatization) is preferred to allow the body's internal temperature to actuate to the working conditions.
- Whenever possible, adjust the work schedule to reduce risk of heat stress. For example, postpone nonessential or heavier work to the cooler part of the day and perform work in the shade if portable.
- Rotate personnel to reduce the amount of time spent working in direct sun and heat. Work at sites where heat stress is a significant hazard should not be completed by Ramboll personnel working alone.
- Increase the number and/or duration of rest breaks and whenever possible, rest break areas should be in a cool area as close to the work area as is feasible.

Wear appropriate PPE when necessary, such as thermally conditioned clothing, self-contained air conditioning in a backpack and plastic jackets/vests with pockets that can be filled with dry ice or ice. However, based on the type of work being done, where work is being performed or other required PPE, these options may be prohibited or make the use of this PPE impossible or impractical.

For more information, please refer to SPI 30–Heat Stress. For additional information on Heat Stress first aid, refer to Appendix M First Aid Guidance. Consult with your local HSC for any additional requirements.

B5: Cold

The four environmental conditions that cause cold-related stress are low temperatures, high/cool winds (wind chill), dampness and cold water. One, or any combination of these factors, can cause cold-related hazards. Cold stress, including frostbite and hypothermia, can result in severe health effects.

A dangerous situation of rapid heat loss may arise for any individual exposed to high winds and cold temperatures. Major risk factors for cold-related stresses include:

- Wearing inadequate or wet clothing thus increasing the effects of cold on the body.
- Taking certain drugs or medications such as alcohol, nicotine, caffeine and medication thus inhibiting the body's response to the cold and/or impairing judgment.
- Having a cold or certain diseases, such as diabetes, heart, vascular and thyroid problems and thereby increasing susceptibility to the winter elements.
- Lower body-fat composition or other physiological differences. Statistics show that men experience far greater death rates due to cold exposure than women, potentially attributable to participation in risk-taking activities, lower body-fat composition and/or other physiological differences.
- Becoming exhausted or immobilized, especially due to injury or entrapment, thus speeding up the effects of cold weather.
- Advanced age. The elderly are more vulnerable to the effects of harsh winter weather.

The following table provides the resulting equivalent chill temperature to exposed skin as a consequence of increasing wind speeds at decreasing actual temperatures. Ramboll personnel shall be aware of predicted weather conditions before beginning site work and stay apprised of changes.

TABLE 2. Cooling Power or Wind on Exposed Flesh Expressed as Equivalent Temperature (under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
	Equivalent Chill Temperature (°F)											
calm	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
5	48	37	27	16	6	−5	−15	−26	−36	−47	−57	−68
10	40	28	16	4	−9	−24	−33	−46	−58	−70	−83	−95
15	36	22	9	−5	−18	−32	−45	−58	−72	−85	−99	−112
20	32	18	4	−10	−25	−39	−53	−67	−82	−96	−110	−121
25	30	16	0	−15	−29	−44	−59	−74	−88	−104	−118	−133
30	28	13	−2	−18	−33	−48	−63	−79	−94	−109	−125	−140
35	27	11	−4	−20	−35	−51	−67	−82	−98	−113	−129	−145
40	26	10	−6	−21	−37	−53	−69	−85	−100	−116	−132	−148
(Wind speeds greater than 40 mph have little additional effect.)	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security				INCREASING DANGER Danger from freezing of exposed flesh within one minute.				GREAT DANGER Flesh may freeze within 30 seconds.			
	Trenchfoot and immersion foot may occur at any point on this chart.											

*Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Equivalent chilll temperature requiring dry clothing to maintain core body tempearture above 36°C (96.8°F) per cold stress TLV

For more information, please refer to SPI 29–Cold Stress. For additional information on Cold Stress first aid refer to Appendix M First Aid Guidance. Consult with your local HSC for any additional requirements.

B6: Severe Weather

Monitor the potential for severe weather in the days following the project. Severe weather conditions include but are not limited to high winds, electrical storms and heavy rain, the highest hazard being lightning. When lightning is spotted, site personnel should seek shelter immediately and use the following steps to avoid injury:

- Note the flash-boom ratio: count the time from the flash to the bang—for each 5 seconds between, the lightning is 1 mile away {activate lightning safety plan at count of 30 or 6 miles [9.6 kilometers (km)] away} and don't resume activities for 30 minutes—it's called the 30-30 rule).
- If the storm is more than 6 miles (9.6 km) away (greater than 30 seconds between lightning and thunder), the site supervisor should monitor the storm and be prepared to cease work if the storm becomes closer than the safe distance of 6 miles (9.6 km). Since storms can travel at varying speeds and the amount of time it takes to cease and secure operations will also vary, prudent judgment should be exercised when storms are in the vicinity and/or developing (e.g. darkening skies, increasing wind speeds, etc.).
- Regardless of travel distance to the storm, based on the flash-boom ratio, workers should not stay in exposed areas (on a roof, in an aerial lift, on a steel truss, on an ungrounded steel structure, in a golf cart, un-sided building, etc.) after lightning has been witnessed. All personnel must move to a safe, preferably interior, location.
- Workers should wait 30 minutes from the last sight of lightning or sound of thunder before returning to work.
- Those required to travel from one building to another during the 30 minute wait time should do so only by enclosed vehicle.
- Once the 30 minute wait time period has elapsed and no additional lightning or thunder has been seen or heard, individuals may resume normal work.

Here are some guidelines in preventing this electrifying hazard:

- Always monitor weather conditions, especially when going outdoors. Be prepared to shut down the job if thunderstorms are forecast.
- Keep an eye on the weather throughout the day. Stay tuned to the radio for updates on the weather.
- If lightning threatens, seek shelter indoors.

If a storm is up and you are caught outdoors, seek the appropriate shelter. Here are examples of safe shelter sites:

- Substantial buildings;
- Low ground — seek cover in clumps of bushes;
- Fully enclosed metal vehicles with the windows rolled up; and
- Trees of uniform height.

The following are unsafe areas to seek shelter in:

- Electric/power poles;
- Electrical equipment;
- Heavy and road machinery;
- Solitary trees;
- High ground and caves;
- Water;
- Open fields;
- All outdoor metal objects, like gates and fences;
- High mast light poles; and
- Metal bleachers.

If you feel your hair standing on end and/or hear "crackling noises," you are in lightning's electric field and it is close.

If lightning is extremely close to you and you are caught outside without shelter, immediately remove baseball cap and other metal objects and place them away from you. Put your feet together, duck your head and crouch down low in baseball catcher's stance with hands on knees.

Be cautious in following a thunderstorm as the lightning may not be over.

If a co-worker gets struck by lightning, administer first aid immediately. Remember that it is safe to touch them as they do not carry an electric charge. Seek medical assistance immediately.

For more information about severe weather systems not described herein, please refer to SPI 3-Emergency Action Plan. Consult with your local HSC for any additional requirements.

B7: Safe Walking Surfaces and Work Areas

Hazards from floor and wall openings, careless movements, protruding objects, debris, spills, placement of materials on paths or foot traffic areas, present a problem with regards to slips, trips, falls and injury. When possible, prior to site work, evaluate site ground conditions and identify areas where an increased risk of slips, trip or falls may exist. If conditions warrant, consider distinguishing a safe work path or establishing road/walk-ways on longer term projects.

Ramboll personnel shall minimize the risk of slips, trips and falls by establishing general good housekeeping in work areas at all times including, but not limited to keeping the work area clear of excess equipment and cleaning up wet surfaces as soon as possible. In addition, the floor of every workroom shall be maintained in a clean and, as much as possible, a dry condition. Employees should avoid walking on wet and/or cluttered surfaces and be conscious of the fact the wet surfaces could be slippery and have the potential to cause injury. Spilled materials should be cleaned up immediately.

Personnel should stay alert at all times and, if tired or distracted, take this into account when working at the site. To minimize the possibility of injury:

- Wear sturdy, steel-toed work boots with good tread.
- Do not run.
- Slide feet when walking on slick/wet surfaces.

- Do not walk up or down steep embankments/hills, if possible. If not possible, walk at an angle when going up/down embankments/hills.
- Do not carry items that block your vision.
- Use handrails/grips when available and maintain 3-point contact whenever possible.
- Do not jump down from equipment. Look down before you step down.
- Report any floor openings that are not clearly marked and/or guarded.
- Keep paths and work areas clear of tools, equipment, boxes, cords, etc. Tape or secure cords, wires, etc. to minimize trip/fall hazard.
- If a protruding object cannot be moved, make sure the object can be easily seen or guard/pad the object, if possible.
- Use ancillary lighting, such as flashlights and headband lights, when necessary.

Sufficient lighting should be provided in all areas at all times. Employees should notify the responsible person of conditions where there is an absence of sufficient natural and/or permanent artificial light.

Emergency exit doors will be kept free of obstacles at all times. Any employee finding an emergency door blocked should immediately report the condition and correct it if possible. Exit lights and signs will also be maintained in proper condition at all times and immediately reported if deficient.

For more information about physical hazards, please refer to SPI 26–Slips, Trips and Falls. Consult with your local HSC for any additional requirements.

B8: Noise

Hearing protection will be worn by all personnel working within the vicinity of equipment where noise is sufficient to interfere with general conversation at a normal speaking volume, when noise levels exceed 85 A-weighted decibels (dBA) and/or when the manufacturers' requirements indicate that hearing protection is mandatory. Personal hearing protection, such as earplugs or earmuffs, may be used to reduce the amount of noise exposure while the above control measures are being evaluated or if such controls fail to reduce the exposure levels to below the PELs.

Hearing protective devices (HPDs) may be used to reduce the amount of noise exposure while control measures are being evaluated or if controls fail to reduce the exposure levels to below 85 dBA. The use of HPDs is mandatory for Ramboll employees whose 8 hour TWA noise exposure exceeds 85 dBA. Other employees may also voluntarily wear HPDs, as long as their use does not interfere with the safe performance of on the job duties.

HPDs can prevent significant hearing loss, but only if they are used properly and the correct device is chosen. This can be difficult when personnel work in a different environment for each project. When evaluating the need for hearing protection, consider the sources of noise that will be present on the project, your proximity to those sources and the duration of your exposure. If the exact source(s) of noise are known, you can consult the manufacturer (or internet) for an accurate dBA. Conversely, example sound levels can be researched on the internet for common types of machinery and ALWAYS use conservative professional judgment.

Each type of HPD has a noise reduction rating (NRR), found on its packaging, which is the measure, in dB, of how well a hearing protector reduces noise. The higher the number, the greater the noise reduction.

Ramboll uses the following method to assess the hearing protector's adequacy:

- Obtain the employee's noise exposure A-weighted TWA, when possible, or use an estimate.
- Subtract 7 dB from the NRR and subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.
- For example, if an earplug has an NRR of 26 and the 8 hour TWA is 100 dBA, the exposure would be 100-(26-7) = 81 dBA. Thus, this type of earplug, if worn properly, should provide adequate protection.

Also, when dual protectors are used, the combined NRR provides approximately 5 dB more protection than the higher rated of the two products. For example, using ear plugs (NRR of 29 dB) with earmuffs (NRR 27 dB) would provide a NRR of 34 dB.

(Earplugs NNR 29) + 5 = 34 dB (the combined NRR).

There are three types of HPDs:

- Ear plugs, the most popular HPD, which are inserted into the ear canal to provide a tight seal against the canal walls to keep out excess noise;
- Ear bands, which rest outside the ear canal and provide a seal to keep out excess noise; and
- Earmuffs, which enclose the entire ear inside rigid cups and the inside of the muff cup is lined with acoustic foam.

Multiple types of earplugs and earmuffs should be provided to employees and the appropriate pair selected to control the noise hazards they may experience in the field.

Hearing protection should be worn when working within 25 feet of operating heavy equipment (drilling rigs, earth working equipment, etc.) as working around this type of equipment can result in exposure to hazardous levels of noise (levels greater than 90 dBA).

For more information about acoustical hazards, please refer to SPI 8–Occupational Noise Exposure. Consult with your local HSC for any additional requirements.

B9: Unexploded Ordinances

Some sites (e.g. mines, firing ranges, former military-owned/operated sites, ordinance manufacturing facilities, etc.) may have old explosives, blasting caps, or other types of unexploded ordinances stored on site (e.g. in mines, in structures surrounding the mine or buried on site). Individuals must take immediate action in the event of finding and/or suspecting that explosives may be present. These actions include, but are not limited to, not touching or disturbing suspected explosives or making loud noises in their immediate vicinity. Slowly retreat from the area and immediately report to the PIC/PM, local HSC and Corporate Health and Safety Director so that ordinance experts can be contacted.

B10: Closed/Abandoned Mines

Project work conducted on former mining sites presents a higher level of risk to Ramboll personnel. The underground mine and associated buildings and equipment may not have been maintained over the years. The structural soundness of the mine, buildings and equipment may be compromised and could collapse. Mining sites are often in remote and dangerous areas. Mining operations are often specifically controlled by an administration or group designated by the country-specific location of the site (i.e. Mine Safety and Health Administration in the US) and have specific health and safety regulations they are accountable to meet. Additional training is typically required before Ramboll personnel are permitted to work at a mine site.

Personnel are to avoid all contact with mines, mine structures and building supports without prior HS authorization. Personnel are not to venture into mines or perform work in any areas should they appear structurally unstable. These conditions are to be immediately reported to the PC, Project HSC and Corporate Health and Safety Director.

B11: Operational Facility

Working in an operational facility requires that Ramboll establish a safe work perimeter and cordon work area to the extent that it is possible and appropriate. Creating this safe work area will protect Ramboll personnel and its subcontractors from traffic and hazards created in the operating environment and, in turn, protect facility employees or other observers, pedestrians, vehicles, adjacent property owners, etc. from hazards created by Ramboll activities. Prior to start of work, Ramboll personnel shall discuss this safe work area with the operational facility representative(s) in coordination with any Ramboll subcontractors. Consideration for potential hazards including forklift traffic, pedestrian traffic, overhead and/or underground hazards, dust and/or fume generation, at a minimum, shall be discussed. If traffic control is required beyond cones, signage and temporary fencing, etc. and the facility cannot provide in-house traffic control, Ramboll shall consider contracting with a traffic control contractor and/or conducting work during off-hours.

Working in an operational facility requires that Ramboll establish a safe work perimeter and cordon work area to the extent that it is possible and appropriate. Creating this safe work area will protect Ramboll personnel and its subcontractors from traffic and hazards created in the operating environment and, in turn, protect facility employees or other bystanders from hazards created by Ramboll activities. Prior to start of work, Ramboll personnel shall discuss this safe work area with the operational facility representative(s) in coordination with any Ramboll subcontractors. Considerations including forklift traffic, pedestrian traffic, overhead and/or underground hazards, dust and/or fume generation, at a minimum, shall be discussed. Consider the use of cones, signage and temporary fencing, etc. If conditions warrant and the facility cannot provide in-house traffic control, Ramboll shall consider contracting with a traffic control contractor. Depending on the operations conducted by the facility and the investigation required by Ramboll, it may be necessary to consider modifying work hours to early morning, overnight, weekend, or some other time where facility operations can be modified.

For additional information, refer to B18–Heavy Machinery, SPI 11–Trenching and Excavation Awareness, SPI 27 Subsurface and Overhead Clearance, SPI 33–Tool and Equipment Safety and SPI 37–Rigging and Material Lifting. Consult with your local HSC for any additional requirements.

B12: Radiation

The two broad categories of radiation–non-ionizing and ionizing–are distinguished by the frequency, low and high, respectively. Non-ionizing radiation is commonly encountered, is low frequency and is typically benign (e.g. radio waves, microwaves, infrared radiation). Non-ionizing radiation also encompasses lasers and the visible light spectrum. In general, neither hazard evaluation nor controls are typically needed when conducting work where non-ionizing radiation is present. However, in a commercial/industrial occupational setting, non-ionizing radiation can present significant hazards without proper controls. Each work site presents unique hazards and as such should be evaluated for any necessary controls. At a minimum, PPE shall include appropriate eye and skin protection.

Ionizing radiation includes the higher frequency radiation classes including ultraviolet, x-ray and gamma rays. Chronic or acute exposure to ionizing radiation can cause injury under certain circumstances and hazard evaluation is required. While there is no level of ionizing radiation that is considered "safe", health professionals generally agree on limiting a person's exposure beyond background radiation to about 100 millirem (mrem) per year from all sources. Exceptions are occupational, medical or accidental exposures. Medical X-rays generally deliver less than 10 mrem.

Work on projects involving ionizing radiation exposure requires approval from the HS department, additional radiation training and the development or participation in an exposure monitoring program. Contact the HS Director for additional information.

B13: Confined Spaces

With the exception of Ramboll's wastewater treatment operations, Ramboll does not have confined spaces on its premises. However, sites that are visited by Ramboll or its subcontractors could possibly have confined spaces and, as such, must obtain and review confined-space information from the host facility.

In general, Ramboll employees are not permitted to enter a confined space or perform work in a confined space that would create a hazard and make it a permit-required confined space. If Ramboll personnel are asked by a client to enter a confined space, Ramboll management must be informed and be contacted for prior authorization.

To be a "confined space," all of the following must be met:

- The space is large enough and configured such that a person can bodily enter and perform assigned work;
- The space has limited or restricted means for entry or exit; and
- The space is not designed for continuous occupancy.

Permit-required confined spaces. To be a "permit-required confined space", the space must first meet all of the definitions given above and present one or more of the following conditions:

- Contains or has a potential to contain a hazardous atmosphere;
- Contains a material that could engulf an entrant (person entering the space);
- Is configured such that an entrant could be trapped or asphyxiated by inwardly converging walls or floors; or

- Contains any other recognized serious safety or health hazard.

Ramboll's health and safety policy prohibits unauthorized entry of site and facility employees into confined spaces.

Prior to entering a confined space, Ramboll employees (or its subcontractor's employees) need additional training. Without Confined Space training, entry into confined spaces is prohibited. In addition, entry authorization will only be given after Ramboll management has reviewed the nature of the confined space, the hazards present and the measures needed to ensure safety. Under these circumstances, Ramboll will work with the host facility to determine training requirements, sampling requirements, written program requirements and equipment needed to safely enter the confined space. Ramboll shall develop a standardized training format to meet the requirement for a safe confined space entry, as applicable.

Ramboll personnel should prevent unknowing entry into confined spaces through heightened awareness when assessing new or unfamiliar facilities and job tasks. Some common structures personnel may encounter in the field that *may* trigger confined space entry requirements include crawl spaces, ditches, trenches/excavations, underground equipment rooms or vaults and other industrial equipment spaces. Early identification of potential confined space issues allows the project team and the HS department to assess the hazards and implement the appropriate controls prior to the start of work activities. If you are unsure if a space at your worksite triggers confined space requirements, contact your PM, HSC and the HS department for addition assistance.

For more information, please refer to SPI 10–Confined Space Awareness. Consult with your local HSC for any additional requirements.

B14: Live Electrical Equipment

Electricity may pose a particular hazard to site workers due to the need to supply power to operate a newly installed system (e.g. remediation system) or the ongoing operations at the job site (e.g. electrically powered pumps/sampling devices, electrically generated lighting)). If wiring or other electrical work is needed in order to complete a Ramboll project scope of work, a qualified, licensed electrician must perform it.

In advance of starting work, it is important to understand the environment where work will be performed to ensure that work can be conducted safely. Depending on the environment, electrical equipment may need to be labeled as inherently safe and/or grounded in a specific manner. Consult with facility personnel for any site-specific directives.

General electrical safety requirements include:

- All electrical wiring and equipment must be a type listed by Underwriters Laboratories (UL) Factory Mutual (FM) Engineering Corporation or other recognized testing or listing agency.
- All portable generators or other portable internal combustion type devices used on site will be grounded. All grounds will be validated twice daily with a multimeter to confirm a resistance of less than 10 ohms.
- All installations must comply with the National Electrical Safety Code (NESC), the National Electrical Code (NEC) or USCG regulations.

- Portable and semi-portable tools and equipment must be grounded by a multiconductor cord having an identified grounding conductor and a multicontact polarized plug-in receptacle.
- Tools protected by an approved system of double insulation, or its equivalent, need not be grounded. Double-insulated tools must be distinctly marked and listed by UL or FM.
- Live parts of wiring or equipment must be guarded to prevent persons or objects from touching them.
- Electric wire or flexible cord passing through work areas must be covered or elevated to protect it from damage by foot traffic, vehicles, sharp corners, projections or pinching.
- All circuits must be protected from overload.
- Temporary power lines, switchboxes, receptacle boxes, metal cabinets and enclosures around equipment must be marked to indicate the maximum operating voltage.
- Plugs and receptacles must be kept out of water unless constructed for submersion.
- All extension cord outlets must be equipped with ground fault circuit interrupters (GFCIs), if possible.
- Attachment plugs or other connectors must be equipped with a cord grip and be constructed to endure rough treatment.
- Extension cords or cables must be inspected prior to each use and replaced if worn or damaged.
- Cords and cables must not be fastened with staples, hung from nails or suspended by bare wire.
- Flexible cords must be used only in continuous lengths without splice, with the exception of molded or vulcanized splices made by a qualified electrician.

In the event that a live electrical hazard presents the potential for fire, Ramboll will provide portable fire extinguishers and employees shall be trained on proper use. All fire extinguishers shall be maintained as follows:

- Fully charged and in operable condition;
- Clean and free of defects;
- Readily accessible at all times; and
- Be visually inspected each month and undergo a maintenance check each year.

Fire prevention and protection measures include elimination of ignition sources, where feasible, identification of combustion sources and atmospheres and early detection and rapid response to fire/explosion situations. In addition to standard operating procedures, the following safe work practices will be implemented:

- Site activities will comply with National Electric Code and explosion proof criteria.
- Smoking will not be permitted (or only in designated areas, if available). On sites where subcontractors are under the direction of Ramboll and fire/explosion hazards will be present, the subcontract shall state that smoking will not be permitted onsite and the Ramboll site supervisor shall enforce this requirement.
- Appropriate air monitoring will be conducted, when necessary.

- Welding, open flame or spark-producing operations will not be allowed onsite.
- Solvents with a flash point of less than or equal to 100 degrees Fahrenheit will not be used for cleaning purposes.
- Fire extinguishers shall be kept in all work vehicles

All fires and visible smoke that are detected at the site will be dealt with immediately by the individual recognizing the fire and/or smoke. In the event of visible smoke, fire or explosion, the following emergency response procedures will be implemented:

- Immediately cease operations; and
- In all emergency fire situations, contact emergency services.

For small fires, personnel may attempt to extinguish the fire, if safe to do so and they have been trained. One fire extinguisher ONLY may be used to fight the fire. After one fire extinguisher is depleted, personnel must evacuate the area. For larger fires, perform immediate site evacuation.

For more information, please refer to SPI 3–Emergency Action Plan and SPI 9–Electrical Safety. Consult with your local HSC for any additional requirements.

B15: Overhead Hazards

Work in the vicinity of operating equipment (e.g. drill rigs, heavy machinery, excavating equipment, etc.), in the vicinity of structural features such as scaffolding, cranes/rigging, low overhead clearance and in unstable environments with falling debris presents overhead safety hazards. Ramboll personnel shall evaluate the presence of overhead hazards prior to the start of work and ensure that appropriate controls are put in place to protect site personnel including, but not limited to PPE (i.e. hard hats). As circumstances may change after work begins, Ramboll personnel should be aware that site controls to address overhead hazards may need to change as well.

When conducting work around a scaffold, controls are required in addition to wearing hardhats. Personnel shall be provided with additional protection from falling hand tools, debris and other small objects through the installation of toeboards, screens or guardrail systems, or through the erection of debris nets, catch platforms, or canopy structures that contain or deflect the falling objects. When the falling objects are too large, heavy or massive to be contained or deflected by any of the above-listed measures, the employer shall place such potential falling objects away from the edge of the surface from which they could fall and shall secure those materials as necessary to prevent their falling.

When Ramboll is conducting work at an operational site and/or with the assistance of a subcontractor, these precautions and safety mechanisms must be discussed and established prior to the start of work and documented in the site-specific HASP.

B16: Work Near Railroads

In the event that work activities are required adjacent (within 25 feet) to a railroad track, the rail company must be contacted prior to the start of work and access provided. Access may require additional discussion, planning, fees and personnel. The health and safety procedures must be coordinated with the rail company.

If work activities are planned in the vicinity of a rail line (greater than 25 feet), the following procedures will be implemented:

- The hazards of working near railroad lines will be included in job briefings prior to commencing work and when the activity changes;
- Mounting, dismounting, or crossing over moving locomotives or cars is prohibited;
- Employees will be alert for the movement of cars, locomotives, or equipment at any time, in either direction, on any track and will remain at least 25 feet (8 m) from the end of standing cars, equipment, or locomotives, except when proper protection is provided (e.g. a flagman is present or the track is taken out of service by the proper authority, prior to starting any work on or about the tracks); and
- Employees will not take refuge under any car, equipment, or locomotive.

Please refer to SPI 33–Tool and Equipment Safety for additional information. Consult with your local HSC for any additional requirements.

B17: Traffic Management

If Ramboll personnel are required to conduct work within an active public roadway, the appropriate entity–local, state, federal–responsible for the roadway must be contacted. Specialized permits may be required in addition to retention of specialized traffic management contractors. Various degrees of barrier protection may be required based on site-specific traffic conditions.

In addition to and in the absence of local traffic management requirements, Ramboll personnel will take the appropriate steps to protect the worksite from interference with traffic/pedestrians and vice versa. The following measures for safe coexistence of traffic and employees shall be considered:

- Alternative walkways where possible.
- Use of an air horn to alert drivers or other workers.
- Maintain good housekeeping and clean the areas as work is completes.
- Use the buddy system while performing work.
- Use a spotter for backing, tight maneuvers and equipment/tank/bin drop-offs.
- Use traffic control devices, field vehicles and barricades.
- Park all vehicles (with wheels in a safe direction away from fieldwork) to block traffic with a flashing yellow light. Also, park so that access to the vehicle is away from oncoming traffic while working.
- When parking a vehicle and equipment, utilize a 'first move forward' driving practice.
- Work in an upright position, facing traffic when possible.
- Make eye contact with vehicle drivers so that they can recognize your presence.
- Minimize work time in traffic through scheduling.
- Establish a stop work hand signal.

If controls have been reviewed and upgraded but the situation with speeding vehicles is still unsatisfactory, request additional assistance from the local police department.

Please refer to SPI 33–Tool and Equipment Safety for additional information. Consult with your local HSC for any additional requirements.

B18: Heavy Machinery/Drilling Rigs

Working in the vicinity of operating equipment (e.g. drill rigs, heavy machinery, excavating equipment, power tools, pumps, etc.) poses unique safety situations such as high pressure hazards from hoses and pipes, overhead hazards and material releases. Also, other hazards may be present such as falls from elevation, electrical contact and improper machine guarding. Ramboll personnel shall only operate equipment they are trained to operate and that is equipped with appropriate protection devices. For equipment operated by subcontractors, Ramboll personnel shall familiarize themselves with the equipment being utilized and shall, at a minimum, know how to stop or turn off the equipment in the event of an emergency. Ramboll personnel do not operate drilling or other heavy equipment, however, it is every employee's responsibility to recognize safe, appropriate use and be familiar with all potential and/or existing hazards related to the use of operating equipment. In the event of unsafe work practices by facility personnel, subcontractors and/or other Ramboll personnel, all Ramboll personnel have stop work authority for any unsafe operations.

Certain scopes of work conducted during Ramboll projects, require the use of heavy equipment (e.g. excavators, loaders, cranes, etc.) that must be subcontracted with a qualified subcontractor. Ramboll personnel should, under no circumstances, operate or ride on heavy equipment. Site personnel will don high visibility vests and maintain a safe distance of at least 20 feet (6.1 m) from all heavy equipment in operation. If the equipment has a mast or an arm characteristic of a drill rig, crane, or excavator, a safe distance is approximately one and a half times the height of the equipment. If activities warrant closer proximities to operating equipment personnel will discuss this need and safe procedures for approach with the equipment operator in advance of the start of work. Prior to approach, personal shall make eye contact with the operator and ensure that the equipment is powered down, or at a minimum, in a resting position. A second Ramboll employee will stand watch to keep him/her out of the path of equipment while performing the required activity. Further, personnel shall keep a minimum distance of 3 feet from an open drill hole, excavation, mud pit or any other opening. Ramboll personnel will not place tools, meters, etc. in a position that could create a fall, trip or slip hazard. As much as is possible, employees will work with the appropriate site personnel to ensure the area in the vicinity of the operating equipment is clean, orderly and free of slip, trip and fall hazards. The following procedures should be followed when heavy equipment is in use:

- Use common sense. Do no assume that the equipment operator is keeping track of your whereabouts. Never walk directly in back of, or to the side of, heavy equipment without advance discussion and agreed upon procedures, the operator's knowledge, eye contact and acknowledgement.
- All heavy equipment must be shut down during refueling.
- Maintain visual contact of moving equipment at all times.
- Establish hand signal communication prior to the start of work in circumstances when verbal communication is difficult. This mode of communication should be discussed at the start of each work day during the health and safety tailgate meeting.

- All heavy equipment shall have backup alarms of some type.
- Use chains, hoist, straps and any other equipment to safely aid in moving heavy materials.
- Be sure that no underground or overhead power lines, sewer lines, gas lines, or telephone lines, will present a hazard in the work area. Specifically note overhead hazards in the area where equipment will need to mobilize across the site from the site entrance to the work area.
- Restrict all non-essential people from of the work area. If observation by non-essential third parties (e.g. the client, facility personnel, stakeholders) is necessary, determine a safe zone outside the active work area and cordon the area in some manner.
- Prohibit loose-fitting clothing or loose long hair around moving machinery.
- Instruct equipment operators to report any abnormalities such as equipment failures, unusual odors, etc.
- Store tools in clean, secure areas so that they will not be damaged, lost or stolen.
- When an equipment operator must negotiate in tight quarters, request that the subcontractor provide a second person to ensure adequate clearance. Ramboll personnel shall not provide specific direction as to how to operate equipment–it is the responsibility of the subcontractor.
- All heavy equipment must be properly leveled and supported prior to use.
- When heavy equipment is utilized inside a building, precautions must be taken to ensure that there is appropriate ventilation and exhaust is vented to the outside.
- Heavy equipment and trucks will be operated in specific site control zones and marked traffic lanes.
- Materials, tools, or other objects will not be thrown, tossed or dropped. Always hand off or lower items as needed.

Employee Restrictions and Responsibilities

Under no circumstances will a Ramboll employee operate a heavy machinery, a portion thereof, or any other piece of contractor or facility equipment.

In addition, Ramboll personnel will not:

- Direct equipment operator to a work location, provide specific guidance to subcontractor with respect to the operation of the equipment, assist in the movement of equipment or participate in the movement or breaking down of any portion of the equipment;
- Climb on the equipment;
- Watch a subcontractor arc-weld;
- Smoke while at the work site;
- Refuel an engine while it is still running or hot, siphon gasoline or park near equipment exhaust; or
- Wear loose fitting clothing or PPE near operating equipment.

B19: Trenching/Excavation

An excavation is any manmade cut, cavity, trench, or depression in the ground surface, formed by earth removal. A trench is narrow excavation (in relation to its length) made below the surface of the ground. The following safe operating guidelines apply to open trenches or excavations exceeding 4 feet (1.3 m) in depth or of any depth if unstable soil conditions exist.

Excavations and trenches present a heightened risk on Ramboll projects. In addition to the heavy equipment hazards discussed in B18, trenches and excavation create hazards associated with confined spaces, dangerous gas build up, unstable soil conditions, water retention, etc. For these reasons, excavation and trenching work shall only be performed by competent contractors training in the health and safety requirement associated with this type of work, in accordance with corporate standards and local/region regulations. When excavation/trenching work in managed by Ramboll personnel under a direct subcontractor, additional health and safety planning should be performed in conjunction with the subcontractor to ensure all HS requirements are satisfied.

Regardless of the management of the excavation or trenching work, Ramboll personnel working on projects where this type of work is being performed shall have an awareness level of training on the topic and ensure best practices are followed, including but not limited to:

- Excavated materials will be stored and retained at least 2 feet (0.6 m) from the edge of the excavation. This procedure must be observed even when excavation/trench entry will not occur. The location for staging soil shall be determined by Ramboll personnel, the subcontractor and facility personnel, if applicable, in advance of the start of work.
- Trees, boulders and other surface encumbrances that create a hazard will be removed or made safe before the start of work.
- Special precautions will be taken in sloping or shoring the sides of excavations adjacent to a previously backfilled excavation.
- Except in hard rock, excavations below the level of the base of the footing of any foundation or retaining wall will not be permitted, unless the wall is underpinned and all other precautions have been taken to ensure the stability of the adjacent walls. Please consult directly with the project PM, PIC, local HSC and the Global Director of Health and Safety when planned excavations potentially threaten the integrity of any structures.
- Excavations will be inspected at least daily, or more often as conditions warrant, by a competent person (i.e. the subcontractor in coordinator with the Ramboll site supervisor) to ensure that changes in temperature, precipitation, shallow groundwater, overburden, nearby building weight, vibrations, or nearby equipment operation has not caused weakening of sides, faces and flows. Without proper training in confined space entry, Ramboll personnel shall not enter any excavation greater than 4 feet (1.3 m) in depth (or less if soil is deemed unstable by a competent person). In the event that a Ramboll employee is properly trained in confined space entry and has project-specific approval from the Corporate H&S Director prior to entry, the atmosphere of the excavation must be tested to ensure that an oxygen deficient or hazardous atmosphere does not exist. If, at any time, the concentration of any airborne contaminant exceeds one-half its PEL, or other applicable occupational exposure limit (OEL), the airborne oxygen concentration is less than 19.5%, or explosivity exceeds 10% of the LEL, personnel shall not be permitted to enter the excavation. Engineering controls or other hazard controls (i.e. upgraded PPE) shall be instituted to eliminate or control the hazard.

- Field personnel shall not enter any excavation, greater than 4 feet in depth, without specific direction, for any reason. If personnel fall into the excavation and require rescue, properly trained emergency personnel shall be contacted for support.
- Ramboll personnel shall not operate trenching or excavation equipment. However, prior to start of work, the subcontractors shall direct Ramboll staff to the emergency stop for all equipment.

Ramboll personnel directing subcontractors conducting trenching/excavation activities shall request, at the subcontracting stage, if possible, the following safe work practices:

- When mobile equipment is used or allowed adjacent to excavations, stop logs, or barricades will be installed. The grade will always be away from the excavation. Construction of such features shall be the responsibility of the subcontractor.
- A means of egress (ladder, ramps, stairways, etc.) shall be accessible at any location inside the excavation without requiring more than 25 feet (8.3 m) of lateral travel distance.
- Dust conditions during excavation will be kept to a minimum. Wetting agents shall be used when appropriate.
- Diversion ditches, dikes, or other suitable means will be used to prevent water from entering an excavation and for drainage of the excavation. Construction of such features shall be the responsibility of the subcontractor.
- All excavations will be marked and protected at all times to ensure site personnel, visitors, or unauthorized personnel do not enter without permission or fall into the trench.
- Personnel will work in pairs when working around an excavation of 2 feet (0.6 m) or more.

In the event of unsafe work practices by facility personnel, subcontractors and/or other Ramboll personnel, all Ramboll personnel have stop work authority for any unsafe operations. For more information, please refer to SPI 11–Trenching and Excavation Awareness. Consult with your local HSC for any additional requirements.

B20: Vehicle Use

Work areas and site conditions must be considered when designating and selecting a vehicle for use (i.e. rental or company-owned). The vehicle shall be maintained in safe working order as required by the manufacturer. This would include a routine preventive maintenance schedule for servicing and checking of safety-related equipment. Special consideration should be taken when weather conditions reduce the safety and visibility while driving. Appropriate measures should be taken while driving during inclement weather including snow, icy and/or wet conditions; high winds; hail, heavy rains; debris or other impairments to safe driving caused by natural weather.

Special-use vehicles [e.g. all-terrain vehicles (ATVs), snowmobiles, etc.] are vehicles with a light engine or electric motor, other than construction equipment and are not intended and/or allowed for highway use. These vehicles may not have seat belts and do not meet substantial roll over protection standards (ROPS).

When operating vehicles, the following general practices will be followed:

- All vehicles will be operated in accordance with the manufacturer's requirements and specifications.
- Drivers should use prudent judgment and proceed cautiously when driving on non-paved roads. If using a rental car, ensure that the rental agreement allows driving on non-paved roads.
- Drivers will adhere to all site, local and state traffic laws including, but not limited to use of a hands free device when speaking on a mobile phone. **TEXTING WHILE DRIVING ANY VEHICLE IS STRICTLY PROHIBITED.**
- Operators of special-use vehicles shall be trained by a competent person–senior Ramboll personnel or otherwise. At a minimum, the training will be hands-on and the operator shall demonstrate basic skills prior to the conclusion of the training exercise. All individuals are required meet all training aspects before vehicle operation. This training shall be documented with the local HSC prior to the start of work.
- Vehicles shall remain on flat surfaces at all times and shall not be operated on slopes steeper than a 30% grade.
- Daily inspections of vehicles for safety and maintenance will be required (i.e. fluid leaks/levels, tire pressure, tire surfaces, lights, fuel levels, brakes, etc.).
- Speed limits shall be maintained relative to legal requirements, safe operating speeds for the vehicle and in compliance with any facility-specific directives.
- Make sure the engine is turned off before dismounting the vehicle.
- Avoid driving over any extreme obstacles (i.e. wood/logs, fences, boulders, etc.).
- Operation is limited to the daylight hours, if possible.
- Do not carry passengers.
- Slow down before coming to a stop.
- Shut engine down prior to refueling.
- Each driver will have a valid driver’s license.

For more information, please refer to SPI 40–Driving Safety. Consult with your local HSC for any additional requirements.

B21: Water On/Near Water

Certain scopes of work conducted during Ramboll projects, require work on, over, or near water. All personnel and visitors must wear a USCG-approved PFD, or location-specific equivalent, when near water (i.e. within 4 feet/1.22 m), over water, wading in water or on any vessel, where the danger of drowning exists. This PFD must be properly secured to the wearer, free of all defects including rips, tears, stress and fading and be kept clean and free of excessive dirt and oil. Several factors are relevant to determining whether a danger of drowning exists. These include the type of water body (i.e. a pool, a river and a canal), depth, presence, or absence of a current, height above the water surface, the use of fall protection when working above a water body and other site-specific/work-

specific factors. Prior to the start of work, the contemplated scope of work shall be discussed with the PM, PIC and local HSC to determine appropriate controls.

Depending on the factors present, there are some circumstances where a drowning hazard could exist where workers are near or over water that is relatively shallow (i.e. less than 2 feet/0.6 m) in depth. For example, where workers are not using fall protection and are 10 feet above a river, a worker may fall and be knocked unconscious. Without the use of a life jacket or buoyant work vest, a worker in such a scenario could drown.

A life ring equipped with 90 feet of solid braid polycarbonate line, or equivalent must be close to the working area and accessible for use. This includes activities on board all vessels.

USCG boating safety guidelines or equivalent should be adhered to when operating a boat during sampling activities. Boats must be equipped with the required running lights for night-time and/or, country-specific poor visibility conditions. Boats must be equipped with an anchor and alternate means of locomotion (e.g. extra motor, floatable oars).

All water work shall be performed by at least a two person team. Both people shall be equipped with the proper safety gear and capable of readily summoning emergency rescue if needed. Ramboll personnel are prohibited from working in or near water by themselves.

At least one lifesaving rescue vessel (e.g. a skiff) shall be immediately available at locations where employees are working over, in, on or adjacent to water where the danger of drowning exists. The need to have a rescue vessel "immediately available" for use is dependent upon a number of factors, including but not limited to:

- The number of work locations operating;
- The distance to each of those locations;
- Water temperature;
- Currents; and
- Other hazards such as, but not limited to, rapids, dams and water intakes.

In general, if the water is so shallow that rescuers could simply run into the water body without endangering themselves and/or others or the work was being conducted very close to shore (e.g. the length of the skiff from shore would be greater than the working distance from shore and/or the skiff would foul on the bottom anyway), a skiff would not be required.

All work aboard a vessel shall be performed by at least a two-person team. If work is performed at times when water temperatures are less than 38°F (3-4°C), it is recommended, but not mandatory, that sampling personnel wear float coats. The vessel should be operated only by designated, experienced staff.

For additional information, please refer to SPI 31–Water Safety. Consult with your local HSC for any additional requirements.

B22: Working from Heights [Less than 4 feet (1.2 m)]

Fall protection is not required for work conducted at heights less than 4 feet above ground level. However, when the potential for work at varying heights exists, or the potential that implementation of the scope of work may increase the height at which work is being conducted (e.g. excavation/

trenching), hazards associated with work at heights should be considered. Further, a mechanism for monitoring and documenting the potential changing conditions and a contingency plan for controlling potential hazards should be included in the site-specific HASP.

In the event that unanticipated conditions resulting in work at heights greater than 4 feet (1.2 m) are encountered during implementation of the scope of work, site work should be stopped immediately and the Ramboll site supervisor shall contact the project PM, PIC and/or local HSC.

Work up to 4 feet (1.2 m) in height presents an increased risk of slips, trips and falls and an increased severity of injury. Working off the back of a pickup or sport utility vehicle is a common low height situation encountered in the field. When ascending and descending a truck bed, dock or other raised structure implement best work practices like two-person teams and safe, deliberate movements.

For additional information, please refer to SPI 10–Fall Protection and SPI 26-Scaffolding. Consult with your local HSC for any additional requirements.

B23: Working from Heights [Greater than 4 feet (1.2 m)]

Increased risk is presented when Ramboll personnel work from heights greater than 4 feet (1.2 m) and an increase awareness and frequent assessment of changing work conditions is expected. Work from height greater than 6 feet (1.8 m) requires additional fall protection requirements, potentially fall prevention devices and PPE and additional H&S training. Since the height of the work required for many projects may vary (e.g. work near and around excavations), Ramboll personnel must evaluate the need to fall protection controls when work is conducted at heights greater than 4 feet (1.2 m).

The best fall protection control is to eliminate the hazard through the use of engineering controls or modification of the scope of work. However, at times hazards are identified during the course of project work or develop as a result of changing site conditions. If dangerous or unexpected work conditions are identified, site work should be stopped immediately and the Ramboll site supervisor shall contact the project PM, PIC and/or local HSC and the appropriate controls shall be implemented before work begins again.

In general, due to the tasks included in the scope of work, the hazards associated with working at heights can be anticipated in advance and depending on the objectives of the work, cannot be avoided. Hazard controls shall be documented in the site-specific HASP. At a minimum, the HASP shall include the hazards and risks associated with working at heights and control methods and will detail the required steps for protecting employees from fall hazards. Fall protection includes but is not limited to personal fall arrest systems consisting of a full body harness, a lifeline and an attachment point. HS department notification and additional training is required for job tasks that involve fall protection equipment (i.e. body harness and lifeline, etc.).

Ramboll will provide training to ensure that the purpose, function and proper use of fall protection is understood by employees and that the knowledge and skills required for the safe application and usage is acquired by employees. Training will be conducted prior to job assignment and will include, as a minimum the types of fall protection equipment appropriate for use; recognition of applicable fall hazards associated with the work location and the work to be completed; and load determination and balancing requirements. All other employees whose work operations are or may be in an area where fall protection devices may be utilized, will be instructed to an awareness level concerning hazards associated with fall protection operations.

For additional information, please refer to SPI 10–Fall Protection and SPI 26-Scaffolding. Consult with your local HSC for any additional requirements.

B24: Overhead/Underground Utilities

Various forms of underground and overhead utility lines, pipes (carrying water, wastewater, gas, electricity and/or communication lines), or other hazards may be encountered during work activities. Every effort shall be made to locate and mark underground utilities, pipes and other hazards prior to the start of intrusive work. Intrusive work includes any work activity where the work surface is penetrated at a depth greater than 6 inches (15.2 centimeters). At a minimum, Ramboll will conduct a historical site review to develop a plot plan with the most up to date utility information, contact the appropriate One Call service (where available), contract a private utility locating service [where available (REQUIRED IN THE US)] and clear the critical zone around any intrusive location to 5 feet (1.3 m) in every direction. The measures described herein are required for interior work as well, including, but not limited to sub-slab soil gas probe installation. It is imperative, prior to any utility locating activities conducted by Ramboll personnel and/or a subcontractor, that the geology, surface covering (e.g. asphalt, concrete) and other potential interfering factors such as reinforced flooring, the presence of metal in the subsurface are identified and understood. This information must be transmitted to the private locating service in advance of start of work and preferably during the contracting phase so that appropriate locating equipment is selected.

As line voltage increases, your safe working distance will also increase. If overhead lines are present, call the utility company and find out what voltage is on the lines so the safe working distance can be calculated, or stay at least 28 feet (9 m) from cables supported on wooden poles and 50 feet (15 m) from cables supported on metal poles. Work involving machinery with high extensions (drill rigs, backhoes, etc.) will remain at least 10 feet (3.3 m) from overhead power lines or further depending on the voltage of the line.

Should any operations cause equipment to come into contact with utility lines, the appropriate authority will be notified immediately and an Incident Report consistent with SPI 19–Incident Reporting will be completed. Work will be suspended until the appropriate actions for the particular situation can be taken.

Please reference Section 6 of the site-specific HASP and SPI 27–Subsurface Clearance for additional information. Consult with your local HSC for any additional requirements.

B25: Electrically Powered Equipment and Tools

Many Ramboll scopes of work require that Ramboll personnel and/or its subcontractors utilize electrically powered equipment and tools. In order to use this equipment safely, ensure that all electrical equipment is properly grounded prior to use. Avoid standing in water when operating electrical equipment. Ground fault outlets or adapters shall be used for any electrical equipment, if possible. Apparatus, tools, equipment and machinery will not be repaired while in operation; LOTO procedures will be implemented when necessary (see B28–LOTO).

Tools can be hazardous when improperly used since these types of tools utilize energy in the form of electricity, liquid fuel, hydraulics, pneumatics and/or powder-actuated. The following precautions will be taken by personnel to prevent injury:

- Power tools will always be operated within their design limitations and only by employees who have been appropriately trained in the use, operation and proper handling of such tools.
- Guards are not to be removed or rendered inoperative.
- Eye protection, gloves and steel-toed safety footwear are required during operation. Refer to the equipment manuals for guidance and include this information in the site-specific HASP.
- Store tools in an appropriate dry location when not in use.
- Work only in well illuminated locations.
- If power tools will be used to penetrate a ground, parking, floor surface or other surface, Ramboll personnel must first evaluate the presence of underground utilities or obstructions.
- Tools will not be carried by the cord or hose and cords or hoses will not be yanked to disconnect from the power receptacle.
- Cords and hoses will be kept away from heat, oils and sharp edges or any other source that could result in damage.
- Tools will be disconnected when not in use, before servicing and when changing accessories such as blades, bits and cutters.
- Observers will be kept at a safe distance at all times from the work area.
- Tools will be maintained in a clean manner and properly maintained in accordance with the manufacturer's guidelines. Pre-use inspection of hand and portable power tools should occur.
- Ensure that the work area is kept clean to maintain proper footing and good balance.
- Ensure that proper apparel is worn. Loose clothing, ties, or jewelry can become caught in moving parts.
- Tools that are damaged will be removed from service immediately and tagged "Do Not Use" until proper repair or disposal.

Please refer to SPI 9–Electrical Safety, SPI 33–Tool and Equipment Safety and SPI 34–Equipment Grounding. Consult with your local HSC for any additional requirements.

B26: Cutting Devices and Tools

Cutting devices are a type of hand tool that may frequently be encountered on Ramboll projects. The devices range from household scissors to box cutters and other sharp, exposed blades used to cut materials. Cutting devices should only be used by Ramboll personnel when it is an inherent part of their job task, like cutting open packing tape on a box that has been shipped to you for your project. For further example, cutting soil sample liners is a job task generally appointed to our drilling subcontractors and should not be performed by Ramboll personnel. If the use of a cutting device is required for a certain task, the safest device available that meets the needs of the job should be used. safety cutting devices, like the "Klever Kutter" should be the first choice, when they are appropriate for the job. This device is designed to naturally shield the blade from the user. Some other guidance to consider:

- Always cut away from the body.
- Evaluate the need for work gloves or cut-resistant gloves during the planning stages of the project. Different types of gloves provide varying levels of protection that should be

considered during the risk assessment. The materials used to make the gloves and the tensile strength of the weave determine exactly how much pressure can be applied before the fabric fails and cuts through. Usually the more protective gloves have less dexterity (or ease of movement) for the user, increasing other hazards in the process. A risk assessment should consider all these factors when evaluating PPE.

Please refer to SPI 33–Tool and Equipment Safety for further information. Consult with your local HSC for any additional requirements.

B27: Lifting Operations

Ramboll will ensure that all potential hazards regarding rigging and material lifting in our job sites are properly evaluated; however, Ramboll does not intend to provide employees with the knowledge/skill/ training to erect and/or dismantle rigging and/or material lifting equipment. The site-specific HASP should include provide documentation of the factors involved when rigging and material equipment is used by our direct subcontractors. In general, all scaffolds, rigging and material lifting equipment must be erected and dismantled by a qualified and competent third-party contractor.

For lifting operations, even those conducted by a contractor, Ramboll personnel shall be aware of proper procedures and observe the following precautions:

- Store materials and equipment in designated areas to avoid creating additional hazards (e.g. block exits and/or unstable storage). Properly demarcate areas where materials and/or equipment may be placed, loaded or unloaded by adequate guarding and posting.
- Safely arrange materials and equipment to prevent tipping, falling, collapsing, rolling (i.e. properly stack, secure and/or stabilize items by interlocking, strapping or securing by an effective method to protect persons and property from potential injury and/or damage).
- Ensure that storage areas are kept free from accumulation of materials that constitute hazards from tripping, fire, explosion, or pest harborage. Vegetation control must be exercised when necessary.
- Manual lifting and handling of material must be done by methods that ensure the safety of both the employee, the material and the structure. Tag lines may be used to stabilize loads unless their use creates an unsafe condition.
- Personnel are prohibited from walking and/or working under loads that are about to be lifted and/or are suspended.
- Wear required personnel protective equipment as applicable, including, but not limited to a hard hat to protect against overhead hazards. See B15–Overhead Hazards for additional control information.

Please refer to SPI 37–Rigging and Material Lifting for further information. Consult with your local HSC for any additional requirements.

B28: LOTO

LOTO applies to the control of energy during servicing and/or maintenance of machines and equipment. In general, Ramboll personnel will not be authorized to perform LOTO job tasks unless additional training has been provided and employees are considered competent in that task. Where

applicable, Ramboll will establish a program and utilize procedures for affixing appropriate LOTO devices to energy isolating devices and to otherwise disable machines or equipment to prevent unexpected energization, start-up or release of stored energy in order to prevent injury to employees. Any LOTO procedure will be clearly identified and will be incorporated into the site-specific HASP. Ramboll will ensure that all equipment and machinery meeting the criteria for LOTO that are part of the work activities are evaluated and that information and training programs and LOTO procedures are implemented.

LOTO requirements do not apply to minor tool changes and adjustments and other minor servicing activities, which take place during normal production operations if they are routine, repetitive and integral to the use of the equipment for production. This exception is appropriate provided that the work is performed using alternative measures which provide effective protection in accordance with the site-specific HASP and equipment manual recommended procedures.

Please refer to SPI 20–Control of Hazardous Energy Sources (Lockout/Tagout) for further information. Consult with your local HSC for any additional requirements.

B29: Material Handling/Ergonomics

Lifting, carrying and lowering objects represent a potential physical hazard to Ramboll personnel. Therefore, it is every employee's responsibility to realistically evaluate the object to determine if the weight and size exceeds the employee's ability to lift, lower or carry it. To eliminate or minimize the risk of lifting hazards, utilize proper techniques, such as keeping the back straight and legs bent. Objects should always be lifted, lowered and carried as close to the body as possible. If the equipment cannot be lifted in this manner, it is too heavy to lift alone. Call other personnel or use a mechanical device for aid in lifting. Mechanical aids, like hand trucks and carts, or the buddy system should be used to move heavy objects, objects with poor handgrips, or large bulky objects. Some other things to consider:

- Evaluate the object for the presence of any physical hazards such as pinch points, sharp or jagged edges, burrs or rough and slippery surfaces;
- The route in which the object will be moved should be free from obstructions, which could cause difficulty in moving the object;
- Asses other hazards such as stairs before you move the object and consider smaller loads with multiple trips as a safe alternative;
- If an object is stored at a level higher than five feet, or on the floor, an appropriate mechanical device may be necessary to move the object;
- Recognized lifting hazards should be designed out of the work process whenever possible;
- Seek help when handling loads that are too bulky to grasp or lift, when employees cannot see around or over a load, or when they cannot safely handle a load for any other reason; and
- Consider the use of PPE, such as gloves and forearm protection, when appropriate.

Proper lifting and lowering techniques should be followed even if the object or material to be lifted is of lighter weight. Keep the objects as close to the body as possible and:

- Establish a firm footing with feet at approximately shoulder width and one foot slightly ahead of the other. This posture will aid in keeping good balance and will establish a stable lifting base.
- Always bend at the knees, not at the waist when lifting or lowering an object.
- Obtain a good secure grip on the object.
- When beginning to lift, tighten your stomach muscles and use your legs to lift the object, as leg muscles are generally stronger than back muscles.
- Lift slowly and smoothly.
- If you need to turn as you lift, do not twist at the waist, but instead pivot with the feet. When lowering the object, reverse the procedure.
- When possible, conduct lifting activities over a period of time with adequate rest breaks. If material handling must take place over a short period of time, use mechanical means and/or the buddy system.

When it is necessary to move heavy and/or bulky objects, a non-powered hand truck should be used whenever possible. Some things to consider are:

- Keep the center of gravity of the load as low as possible and place heavy objects below lighter ones.
- Place loads where the weight of the load will be carried by the axle, not the handles and where it will not slip, shift of fall during movement.
- Load only to height to allow a clear view ahead. Only walk backwards with a hand truck in specific instances such as when going up an incline.
- When going down an incline the hand truck should be in front of the operator and when going up an incline, it should be downhill from the operator.
- Move the hand truck at a safe speed.

Please refer to SPI 44–Occupational Ergonomics for additional information. Consult with your local HSC for any additional requirements.

B30: SIMOPS

SIMOPS are one or more activities or work taking place at the same time, with the potential to affect one another. The operations must be occurring within significant proximity to each other that they create new or additional hazards. The Designated Site Supervisor will be responsible for determining when SIMOPS are present on a Ramboll work site and coordinating safe work for all activities.

SIMOPS shall be identified on the site-specific HASP and appropriate mitigation/hazard controls shall be identified and implemented to eliminate or minimize risks through the hierarchy of controls:

- Eliminating SIMOPS via scheduling or permitting;
- Substituting work processes with less hazardous processes;
- Separating SIMOPS by distance, barricade, signage, isolation or engineering controls; and/or

- Implementing other controls such as training, communication, PPE and Stop Work authority.

Planning, scheduling, communication and cooperation are essential for safe and effective SIMOPS on ENVIRON work sites and should be documented in the site-specific HASP/RA. A communication plan should be established between each work group to include coordination meetings prior to projects where multiple operations are scheduled and the appropriate response if an unexpected event occurs.

B31: BBP

In general, Ramboll must determine which employee(s) have a potential occupational exposure to BBPs and establish an exposure control plan. Ramboll currently does not have employees that have a continuous potential for occupational exposures to bloodborne pathogens; however, during the implementation of Ramboll scopes of work, there is potential for injury and the potential for personnel to respond and all employees approved to conduct field work are required to complete first aid or country-equivalent training. Procedures in which a potential for occupational exposure may occur without regard to the use of PPE include, but are not limited to, basic first aid treatment and CPR.

The best method for ensuring the health of the employees at risk is to understand and follow the concept of Universal Precautions. This concept refers to the assumption that all blood and bodily fluids are contaminated with pathogens. Universal Precautions shall be observed by all Ramboll personnel. Universal precautions shall be observed to prevent contact with blood or other potentially infectious materials. Under circumstances in which differentiation between body fluid types is difficult or impossible, all body fluids shall be considered potentially infectious materials.

Engineering and work practice controls shall be used to eliminate or minimize employee exposure. Where occupational exposure remains after institution of these controls, PPE shall also be used. Hand washing is a primary work practice control. If this is not available or feasible, then alternative methods, such as antiseptic hand cleaners, in conjunction with clean cloths or paper towels, or antiseptic towels will be provided. When these alternative methods are used, employees shall wash their hands (or other affected areas) with soap and running water as soon as feasible thereafter. Ramboll will provide hand washing facilities or alternative methods which will be readily accessible to employees. Additional considerations include the following:

- Eating, drinking, smoking, etc. are prohibited in first-aid and restroom areas where there is reasonable likelihood of occupational exposure.
- Employees should don appropriate personal protective equipment prior to performing any first aid to ensure that they will not contact blood. Each office will maintain the appropriate personal protective equipment with the first aid supplies. This equipment should include impervious gloves and mouth shields. Gloves worn should be compatible with cleaning and disinfection solutions used.

In any circumstance where there is a potential exposure to bloodborne pathogens by a Ramboll employee or its subcontractors, an Incident Report must be filed in a timely manner in accordance with SPI 19–Incident Reporting.

Please refer to SPI 4–Medical and First Aid Program and SPI 20–Bloodborne Pathogens for additional information. Consult with your local HSC for any additional requirements.

B32: Plants and Animals

Care will be taken by all site workers to avoid poisonous plants, animals and/or stinging or biting insects such as ticks, mosquitos, spiders, bees, wasps, hornets and yellow jackets. Workers allergic to any particular plant, animal exposure, or insect sting or bite should notify the local HSC and all site personnel (including facility and subcontractor personnel) prior to start of work. If stung, bitten, or otherwise exposed to an allergen, the affected person shall utilize emergency medicine, if prescribed by their doctor and seek emergency support when appropriate.

The first step in controlling the risks presented by certain plants and animals is thorough field preparations, including but not limited to the following:

- Research local species that are present or active in your area;
- Identify important information to aid in identification and plan for appropriate control mechanisms;
- Document hazards in your field-specific project plan [i.e. HASP or remedial action (RA)] and communicate with field personnel;
- Follow the hierarchy of controls to reduce risks, which we will discuss later in this lesson; and
- Identify first aid treatments and emergency protocols.

Animals and insects that pose a threat to human safety vary greatly by region and local environment. Furthermore, the level of threat they pose varies greatly by species and situation. Some animals only pose nuisance threats while others can be life threatening. Of those animals that can be harmful to humans, few will outright attack unless they feel threatened or are protecting their young. Therefore, it is very important to evaluate each situation where animals can be encountered individually to assess the risk.

The hazards posed by poisonous plants are different because plants are stationary. Once properly identified, harmful species can typically be removed or cornered off so personnel do not come into contact with them. But be cautious! If poisonous plants are identified in one area of the site, it's likely they may be in others as well.

Before you travel to a site to perform field work, perform your due diligence by identifying the plants and animals that may pose a threat in that particular area. This information can be conducted through internet research but be sure to consider only reputable sources and cross-reference important information. Field guides from various sources, including Peterson and Oxford, provide valuable information on a wide variety of plant and animal hazards. Some guides are specific to a certain geographical location. These guides are a great resource for local staff; share them when possible! Finally, many local regional agencies supply information on dangerous plants and animals in their area.

Even though you may be familiar with the plants and animals in your area, you might not be as familiar with things in another region of your country, another country, or even another continent! So, when traveling to different areas for your projects it is prudent to consult with:

- Site contact (client, maintenance staff, etc.);
- Ramboll personnel who have previously been onsite;
- Ramboll personnel who are local to the region;

- Local and regional wildlife agencies; and
- Reputable field guides.

Document important species-specific information to the site HASP/RA or other site-specific plan. Keeping track of this information will help everyone on the project to identify and control plant and animal hazards. It will also be useful as a quick guide in the event of a field encounter. Further, this information should be used during daily H&S meetings to keep personnel aware and informed of site risks. Consider providing the following:

- Names of species;
- Photographs of the animals/plants discussed;
- Indicators of animal/plant presence;
- Measures of what to do if animals/plants are encountered;
- Controls and safe work practices, which will be discussed next; and
- First aid measures.

Please refer to SPI 28–Plants and Animals for additional information. For species-specific information and first aid procedures, including information on tick removal and first aid, refer to Appendix M First Aid Guidance. In the event that first aid is required for any encounter with a poisonous plant, insect, or animal, an incident report, consistent with SPI 19–Incident Reporting, must be completed. Consult with your local HSC for any additional requirements.

B33: Job Safety

If it is deemed that a work site is in an area where Ramboll personnel and/or the job site may be at risk from potential criminal acts, wild animals, etc. the risks will be evaluated and implementation of site-specific preventative measures will be taken to minimize the risk. Consideration shall also be given to security for equipment left onsite. For example, if Ramboll installed a remediation system on an isolated client site, it is prudent, at a minimum, to plan for site and equipment security with fencing and locking devices on any valves.

Informational resources such as the client, local law enforcement officials, Park or Wildlife Service and Animal Control could be utilized to assess the risk and to ensure the safest possible work environment. For example, local law enforcement can be made present or make frequent patrols in the area while work is being done, outside security can be hired and work can occur only during certain times of the day. It is also possible that after initial risk evaluation, the PM, PIC, local HSC and/or the Corporate H&S Director may determine that work may not proceed at all.

B34: Personal Safety

If it is deemed that a work site is in an area where an employee's personal safety may be at risk from working in an isolated area, working early/late, or in areas of limited cell phone service, the risks will be evaluated and implementation of site-specific preventative measures will be taken to minimize the risk. Informational resources such as the client and local law enforcement officials, could be utilized to assess the risk and to ensure the safest possible work environment. For example, when working early/late, or in areas of limited cell phone service, local law enforcement can be made present or make frequent patrols in the area while work is being done or check in with onsite client representatives may be arranged. It is also possible that after initial risk evaluation, the PM, PIC, local HSC and/or the Corporate H&S Director may determine that work may not proceed at all. Some

general guidelines are provided here, but each situation is different and actions must be taken based on the specifics of each.

In areas of risk, employees will communicate via cell phones or 2-way radios and will check-in at predetermined times throughout each workday. The communication schedule and the responsible parties shall be clearly documented in the site-specific HASP. See SPI 42-Working Alone for additional information.

B35: Working Alone

Further personal safety risk evaluation is warranted when working alone. Ramboll considers employees to be working alone when they cannot be seen or heard by another worker and/or where assistance is not readily available in the event of an injury, illness or emergency. Whenever possible, employees will not work alone in isolated areas or under extreme conditions. If conducting high risk activities, such as confined space entry, electrical system work or work involving the use of respirators, work may not be performed alone. If the isolated area work involves hiking/walking into areas that are unmarked, or if there is potential to become directionally disoriented (e.g. no trails, unmarked trails, forested or highly vegetated areas), employees will be trained on the use of a compass and trail/topography maps. If necessary, Ramboll personnel will complete wilderness safety training. The employee will work with the Park/Wildlife service in advance to determine what emergency planning is necessary to prepare to complete the proposed scope of work including scenarios such as unexpected weather, animal attack and search/rescue.

Communicating through cell phones or 2-way radios will be utilized whenever possible. Employees will check-in at predetermined times throughout each workday and if the risk rating increases, employees will check-in more frequently. If employees do not call in to the PM, or designated representative, the employee will be contacted. If contacting the employee is unsuccessful, the appropriate authorities will be notified. In addition, the planned start and estimated finish times for each workday will be communicated by the site supervisor to the PM, or designated representative and employees will check in at the beginning and end of the work day. If employees will be moving from isolated area to isolated area, there will be established beginning and ending locations, planned start and estimated finish times and planned routes that will be followed throughout the day. Employees will not deviate from this schedule without first contacting the appropriate personnel. It may also be necessary to notify the client, law enforcement, or Park/Wildlife officials of these schedules.

The communication schedule and the responsible parties shall be clearly documented in the site-specific HASP.

Please refer to SPI 42–Working Alone for additional information. Consult with your local HSC for any additional requirements.

B36: Seasonal Hunting and Dangerous Wildlife

When planning to complete a scope of work in an isolated and/or wooded area, seasonal hunting hazards should be considered. Contact the client, local law enforcement and/or park/wildlife officials to evaluate this risk. During recreational hunting seasons, field personnel will wear appropriate clothing, such as fluorescent orange high visibility vests, to enhance visibility to potential hunters and not blend in with the landscape. Field personnel should also use whistles, air horns and/or other means to make their presence known to hunters and wildlife alike. The schedule of the hunting season, if applicable,

will be included as an addendum to the site-specific HASP in order to inform personnel of the type of game (e.g. deer, pheasant, duck, etc.) that is being hunted and the type of weapon being used (e.g. bow and arrow, shot gun, single shot rifle, etc.). Be aware that even if "No Trespassing" and/or "No Hunting Allowed" signs are posted, trespassers and/or hunting may still be on-going in the work area. At no point should field personnel or contractors confront trespassers.

Local authorities should be contacted about any hunting season that may be in session and if it is possible that hunters may be present in the area in which Ramboll personnel will be working. If so, employees will wear brightly colored hardhats/hats and reflective vests, will not work before dawn. Work will end 30 minutes before dusk.

If you see wild animals while driving, stay in your vehicle. Never get out for a photo or a closer look. Keep windows up and do not try to keep the animal from crossing a road with your vehicle. If you see a wild animal while on foot, never approach the animal. If the animal has not seen you, go back the way you came. Do NOT turn your back and run which could evoke their natural predator instinct. Instead, keep facing the animal and back away at a steady pace. If you are near a car or building, get inside. In addition, in areas of higher risk (i.e. contacted officials have indicated that wild animals are a nuisance), employees may want to consider carrying "pepper spray".

If, while on the project site and despite any precautions set forth, if an employee feels that their personal safety is at risk, they shall cease work, leave the work area and immediately report their concerns to the project PM, PIC and local HSC so that appropriate steps can be taken.

Please refer to SPI 28–Plants and Animals for additional information. Consult with your local HSC for any additional requirements.

APPENDIX E
Standard Practice Instructions 42 – Working Alone

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STANDARD PRACTICE INSTRUCTION 42

WORKING ALONE

RAMBOLL

STANDARD PRACTICE INSTRUCTION 42

IMPLEMENTATION DATE: June 2015

REVISION DATE: June 2018

SUBJECT: Working Alone

BASIS: The risk of injury or harm for people who work alone may be increased because of difficulties contacting emergency services when they are required. Emergency situations may arise because of the sudden onset of a medical condition; accidental work-related injury or disease; attack by an animal; exposure to the elements; or by becoming stranded without food or water. The consequences could be potentially very serious and/or fatal. This Standard Practice Instruction (SPI) explains the occupational safety and health regulations that apply to people who work alone.

GENERAL: Ramboll will ensure that work practices and environmental conditions that impact the work environment are evaluated to ensure that proper safety precautions work practice controls are identified and instituted. This SPI is intended to address the issues of working alone by evaluating and identifying the hazards where work is proposed to be performed; communicating information concerning these hazards; and establishing appropriate procedures and protective measures for our employees to use and follow.

RESPONSIBILITY: The Directors of Health and Safety (the "Directors") are solely responsible for all facets of this program and has full authority to make necessary decisions to ensure success of the program. The Directors are the sole persons authorized to amend these instructions and are authorized to halt any operation of the company where there is danger of serious personal injury. In addition, Ramboll has expressly authorized the Program Manager (PM) and/or Health and Safety Coordinator (HSC) to halt any operation where there is danger of serious personal injury.

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ACRONYMS AND ABBREVIATIONS

HASP	Health and Safety Plan
HS	Health and Safety
HSC	Health and Safety Coordinator
JSA	Job Safety Analysis
PIC	Principal-in-Charge
PM	Project Manager
PPE	Personal protective equipment
SPI	Standard Practice Instruction

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1. WRITTEN PROGRAM

Ramboll will review and evaluate this Standard Practice Instruction (SPI) on a triennial basis, or when changes occur to that prompt revision of this document, or when facility operational changes occur that require a revision of this document. Effective implementation of this program requires support from all levels of management within this company. This written program will be communicated to all personnel that are affected by it. It encompasses the total workplace, regardless of number of workers employed or the number of work shifts. It is designed to establish clear goals, and objectives.

2. INTRODUCTION

The term 'isolated' is defined in many ways but basically means apart, detached or separate as to be alone. The term isolated is often used to describe a physical location, but this training focuses on work that isolates Ramboll employees from others, or work that is truly performed "alone". This module will address the risk of working alone, when the worker cannot be seen or heard by another person, and solo work, when there is a singular Ramboll person at the job site.

It is infrequent, but Ramboll performs some job tasks that require lone work. In some situations these tasks only require short periods of lone work, when a single member separates from a team to perform a specific task. In less frequent situations, the employee may be on their own for the entirety of the work shift or job. The hazards and risk level of lone work will differ for every job and must be assessed on a task-by-task basis.

3. WORKING ALONE

Ramboll employees are considered "working alone" when the worker cannot be seen or heard by another worker, where assistance is not readily available in the event of an injury, illness or emergency.

Some examples of jobs that require Ramboll employees to work alone include but are not limited to:

- Ecological surveys
- Groundwater sampling
- Operators at WWTPs
- Site visits or security checks

Keep in mind that even if multiple Ramboll employees are working together as a team on-site for a project, some tasks may require a single employee to work alone. For example, groundwater monitoring events are often staffed by a team that splits apart to perform sampling at various well locations. Preferably sampling can occur in teams of at least two, but sometimes personnel perform this out of sight and/or hearing of their team members.

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Being the sole Ramboll professional on a job site is a more frequent occurrence than working alone (i.e., field work is often performed by subcontractors while a single Ramboll employee is managing the activities). Ramboll personnel also may travel large distances via air, rail and/or road to visit commercial and industrial facilities on their own. These situations present some of the same hazards and risks as lone work, as well as some differences.

Working alone presents increased risk for injury or harm because the lone worker may have difficultly contacting emergency services when they are required. In some cases, the lone worker may be incapable of contacting emergency services/help or aiding themselves due to the circumstances of the incident/injury. They could be pinned in a vehicle or knocked unconscious! In other cases, their means of communication may be rendered useless, either due to the incident, equipment malfunction or lack of cellular/mobile phone service.

Many emergency situations may arise that present a greater risk to a lone worker: the sudden onset of a medical condition, accidental work-related injury, attack by an animal or person, exposure to the elements, or by becoming stranded without food or water. When working alone, the lone worker cannot contact others in the area to provide assistance or first aid in these situations.

4. PROHIBITED "WORKING ALONE" ACTIVITIES

Ramboll personnel should not work alone if work involves high-risk activities including but not limited to:

- When wearing any type of respiratory protection device;
- When performing any type of confined space entry or working in or near any area that is defined as "immediately dangerous to life and/or health";
- When working on any type of electrical system;
- Where the danger of drowning exists and/or the project involves the use of a water craft ;
- While performing any activities where the use of fall protection is required;
- Performing reconnaissance or site characterization at uncontrolled hazardous waste sites;
- Where site activities involve excavation and/or trenching; and
- In situations where employees may have reason to believe that an unfriendly or hostile encounter could occur; and
- At any location listed in a site-specific Health and Safety Plan where working alone is prohibited.

5. HAZARDS ANALYSIS

Each Ramboll job that requires lone work should assess the hazards and risks specific to that job. This process should involve the employee who will be performing the lone work, as well

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as the project team and HS department, as required. Some questions to ask when assessing the risk of lone work include:

- What length of time will the person be working alone?
- What time of day will lone work occur?
- What form(s) of communication are available?
- Where is the location of the work?
- What is the nature of work?
- Any unusual hazards at the work location (e.g., wildlife issues, site security)?

For additional factors to consider when assessing the hazards and risk of lone work, see Attachment A: Factors to Consider when Working Alone.

Once the hazards and risks are identified, control methods should be discussed and implemented to appropriately control those risks. The hierarchy of control should be applied to reduce the risks presented by lone work. The first level of controls, elimination or substitution should always be applied first. Does the work have to be performed alone? Can a team of 2 people be sent instead? Substitution is also a preferred control method, when it can be applied. If the lone work involves monitoring the area for security purposes, could an electronic system be installed instead? Or if the work involves monitoring system performance, could a remote computer program be used for the same access? Solutions will obviously be very dependent on the specifics of the project.

Further down the hierarchy are engineering controls. Engineering controls focus on changes in the design to the job or tool as a method of eliminating or reducing hazards. For most jobs and tools, engineering controls will be applied to the other job hazards, regardless if the task is being performed solo or as a team. However, the implementation and performance of these controls is even more important in lone working situations. Ensure that engineering controls, like exhaust systems or machine guards, are appropriate for the hazard and in good working conditions prior to work starting.

In some lone work situations, electronically monitoring the position of the lone worker (or work vehicle) using a GPS device from a remote location may be a feasible engineering control, dependent on project-specific risk. However, this should not be the only control method applied!

Administrative controls are often used in combination with engineering controls and are commonly referred to as safe work practices. The two most effective safe work practices for controlling lone worker risks are 1. An effective communication system and 2. A procedure for regular contact. These will be discussed in detail in the next lesson of this module.

PPE is at the bottom of the hierarchy for effectiveness in controlling hazards and should always be used in conjunction with other controls. Personnel working alone should consider wearing or carrying high visibility PPE that can be used to signal for help in case of emergency. Lone workers should also carry a well-stocked first aid kit enhanced with any project specific first aid needs they may encounter during their lone work.

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6. CONTROL METHODS

Safe work practices should be implemented for each lone worker that includes both an reliable means of communication and an effective contact schedule. The key to meeting this requirement is considering what constitutes effective for the specific hazards and risks identified in each particular lone work situation.

6.1 Reliable Means of Communication

A reliable means of communication may include a telephone, mobile/cellular, and/or satellite phone, a two-way radio, personal alarm, or computer based system. This effective means of communication should provide a lone worker with a reliable method for signalling assistance.

When evaluating these options, consider the location and environment in which the lone worker will be traveling, as well as the hazards and risks the work presents. If the area is unfamiliar, reach out to local resources, like regional authorities (Fish and Wildlife Services, etc.), local Ramboll personnel or client contacts to inquire about cell phone service, environmental hazards, and other safety and security issues. It is best to start these inquiries well in advance of the lone work starting, often referred to as front end loading.

The communication system most commonly used is a cellular ("cell") or mobile phone. These are so prevalent in our society today that nearly every employee has one and in many cases they can be an effective means of communication. However, in physically remote or isolated areas, cell phone coverage may not be reliable or geographical features may impede on service. If doubt exists, contact the cellular provider to confirm coverage areas. Further, a mobile or cell phone is not of much use if it is turned off, disable by local authorities or if it has a dead battery. Carefully consider the work plan for issues like these if a cell or mobile phone is used as the sole source of communication for a lone worker.

A multitude of "SOS" apps have been developed for smartphones. Most allow the user to signal for help by pressing a single emergency button. When the emergency button is pressed, a notification with your GPS location is sent out to a pre-set list of contacts. One app reviewed, EmergenSee takes the SOS idea a step further, for an annual fee the user can also connect to EmergenSee's professional monitoring partner who will coordinate emergency services for the user if the application is engaged. While these apps provide added security in some situations, they would not be very helpful if the user was render unconscious or if their phone was destroyed in an accident.

Two-way radios, or "walkie talkies", have varying degrees of complexity and capabilities dependent on a number of factors such as frequency, power and distance from or between broadcasters. If radios will be used for the lone worker's communication system, ensure an adequate supply of batteries is available. When possible, test the range of the radio prior to conducting lone work tasks with a buddy.

Satellite communication systems can be used in more geographically remote locations where cell phones or two-way radios are not effective. Satellite phones are largely available for rent via many online sources, and phones can be shipped to the user with a set amount of minutes and duration of use. Some particularly remote work sites that have occasional

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visitors, like mines, may have their own satellite phone system for visitors/subcontractors to rent/use. Contact the site point-of-contact to address this and other remote security issues in advance of work starting.

Personal security systems provide a means of emergency communication for those working alone. These systems, commonly referred to as personal alarms or alerts, are electronically enabled to pinpoint the users exact location. The user carries a transmitter or transcriber that is connected to a central receiver. Some personal security systems include a non-movement sensor that automatically activates an alarm if the user has not moved within a certain amount of time.

Emergency location beacons are typically used where life-threatening emergencies may occur in remote area, work that Ramboll does not typically partake in. Nonetheless, if the security of the situation calls for such, than it should be used in combination with another means of communication and only used in the event of an emergency.

Emergency location beacons are not dependent on local base stations or affected by damage to aerials, vehicle power supplies or damage like other forms of communication. The beacon is simply an alerting device used to pinpoint location by honing in on the transmission. It is not possible to transmit any other data or voice message. These types of devices are frequently used on vessels and aircrafts, but other types for personal use are referred to as Personal Locator Beacons (PLB).

6.2 Effective Contact System

An effective means of communication should be used in unison with an effective contact system. The contact system should establish a point of contact or 'buddy', defined intervals of time between check in's (a schedule), and the procedures to follow in case the worker cannot be contacted (an action plan). Basically, who the lone worker will call, when the calls will occur and what to do if they miss a scheduled contact. A trigger word should also be identified for use if the lone worker cannot speak openly and is in danger.

The point of contact, or "buddy", and a designated alternative should be assigned to the lone worker for scheduled check in's. The buddy should be available during all check in times and record the results of check in's.

The amount of time between each scheduled check in should be commiserate with the hazards and levels of risk identified for each job that requires lone work. When personnel are traveling in well populated areas over well-constructed roads and plan to return to home base the same day and work tasks are assessed as low risk, then a telephone call on arrival and departure may be sufficient.

When employees are traveling to remote areas with high environmental or safety/security risks, more frequent check in's would be necessary. It is up to the lone worker, in conjunction with the project management team and HS to develop a schedule to effectively control the risks of that project.

There are several ways to capture/record a lone worker's scheduled contacts. The system used in your office/region should be agreed to in advance and familiar to employees prior to

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working alone. Attachment B is an example Lone Worker Contact Schedule. This exact form may be used, or your office/region may develop (or already have something developed) something similar that meets the requirements for working alone. If cellular/mobile service is available, the lone worker may simply call or text their 'buddy' who can then record the contacts on their form. Alternatively, an email could be sent to the 'buddy' and similarly recorded on the form. There are also some smart phone apps that provide digital check-ins. The Guardian MPS app, for example, allows users to log in and out of daily tasks, storing activity details, GPS location fixes and the expected duration of the activity. Whatever the system, it should be agree to in advance by the lone worker and project staff.

An action plan should be established that defines the steps to be taken in the event that the lone worker does not make a scheduled contact and cannot be reached. The action plan should be appropriate to the hazards of the work, reflecting the level of risk encountered by the lone worker on the project.

If at any time the lone worker feels they are at a heightened risk, they should leave the work site as soon as possible, only stopping to collect equipment/supplies if they feel it is safe to do so.

7. SOLO WORK

Lone work may be an infrequent occurrence for most Ramboll personnel, but solo work is definitely not. Ramboll personnel are commonly the only Ramboll person on site managing a job in its many forms. This may involve managing subcontractors performing hands-on remediation work, performing audits or inspection of client properties, or traveling for long distances across the country by air, rail and road. The hazards and risks faced by solo workers have some important similarities and differences that should be evaluated for each project.

When a solitary Ramboll employee is on site with contractors, the increased risk of attending to an injury by yourself is generally decreased since others are scheduled to be on site with Ramboll. However, this is not always from the beginning to the end of the job. On occasion, Ramboll may arrive on site prior to subcontractors to prepare for the day, or we may stay later to pack samples, ship containers and complete chains of custody. Take these scenarios into consideration when preparing the site health and safety plan and consider check-ins with project management at the beginning and end of shift.

Audits and inspection of client properties related to Due Diligence, Environmental Health and Safety, and Industrial Hygiene work may result in varying levels of solo and possibly lone work. Ramboll may travel to client facilities and meet with a representative that accompanies us throughout our visit. In other cases, we may be left to investigate a site on our own. Sometimes these are active facilities with lots of workers and other times they are empty and abandoned. Typically, Ramboll does not know the potential solo and lone work hazards we may encounter on these types of jobs, so it is important to contact the client ahead of time to determine the situation.

When solo Ramboll personnel are scheduled to meet an unknown client/site representative our risk alerts should be in overdrive because they are particularly vulnerable in these types

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of situations. Many working alone regulations stem from the 1986 disappearance of a young girl in Scotland, Suzy Lamplugh.

> "At 12.40pm on 28th July, Suzy had left her office, Sturgis and Sons, 654 Fulham Road, taking her house and car keys and a purse with £15 and credit cards, but leaving her handbag behind. Ten minutes later she was seen waiting outside an empty property, 37 Shorrald's Road which had only been on the market for one week. At 1.00pm she was joined by a man (presumably the "Mr Kipper" she had written in her diary) who was dressed "immaculately – as if he's used to it" and minutes later they were seen walking away from the house. At 6.45pm her manager reported Suzy's disappearance to the police."

Suzy was never found. This incident highlights the dangers of meeting unknown personnel while working solo on a job site. By contacting the client ahead of time to vet the situation we can gain some insight to what can be expected when we arrive solo on site. Who will be meeting the Ramboll personnel? Will they be a uniformed employee with proper identification? Will they accompany the Ramboll employee for the duration of their stay or will we be walking the site solo? This is also a good instance where an SOS smart phone applicable would be recommended. Unlock your phone and open the SOS app prior to exiting your vehicle and walking onto site, this way if the situation is not as expected or likely dangerous, the employee can engage the SOS to notify their preset contact list.

Traveling solo is a frequent occurrence for many Ramboll personnel and varies greatly in method (road, rail, air), duration and location. Ramboll has well established safe travel policies provided on Ernie. Refer to Ramboll's Business Travel Security Program for more information on this topic.

In general, the Travel Approval Process flowchart on Ernie describes the considerations that must be made prior to traveling outside your home country. If your destination is listed as a high or extreme medical or travel risk on a Travel Warning list (supplied by either Ramboll, your home country or Ramboll's third party international travel consultancy International SOS), than approval must be obtained from your division president prior to booking your trip. Further, an International Travel HASP will need to be developed which addresses:

- Transportation
- Security
- Accommodations, and
- Communications.

Finally, approval of the International Travel HASP by the Risk Management Team is required at least 10 days prior to travel and before committing to travel. Please see the Travel Approval Process on Ernie for additional information.

When traveling solo, the highest level of personal awareness is required, particularly when traveling through and/or to an unfamiliar area. Keep your personal belongings with you whenever possible, and only release them to certified personnel, like airport

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workers/baggage handlers. Be highly aware of your personal surroundings and suspicious people or activities. If you see something, report it to the proper authorities. Never accept assistance or a ride from someone you are not familiar with. If ground transportation is needed, schedule it in advance through a recommended vendor or use the appropriate airport/train depot designation for cabs/taxis. When driving through unfamiliar areas, ensure the vehicle is equipment with a first aid and/or safety kit in case an issue is encountered. Never stop to assist others on the roadside when traveling solo; instead report the incident to the local authorities.

Once adequate information has been gathered and the hazards and risks have been properly assessed, the project team should determine an appropriate check in policy for that project. This may involve a courtesy call or check in when travel or project work has been completed, or more frequent contact based on project conditions. Some regions and offices have developed additional lone and solo work policies, please contact your local HSC for more information on the procedures that apply to you!

8. REVISION SUMMARY

Versions	Author	Level of Change	Description of Change	Date
1.0	Kristen Heitman	Major	Change from draft to official procedure. Define working alone and working as solo Ramboll personnel and requirements.	4/15/2015

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ATTACHMENT A
FACTORS TO CONSIDER WHEN WORKING ALONE

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Factors to consider when identifying the hazards and assessing the risk of injury for personnel who work alone. Adapted from the Government of Western Australia Department of Commerce Guidance Note Working Alone 2009.

Factors to consider:

The length of time the person may be working alone

- How long will the person need to be alone to finish the job?
- What is a reasonable time for the person to be alone?
- It is reasonable for the person to work alone?

The time of day when the person is working alone

- Is there increased risk at certain times of day?

Communication

- What forms of communication does the person have access to?
- Is voice communication essential for the safety of the person?
- Will the communication system work properly in all situations?

Location of the work

- Is the work in a remote location?
- What is the form of transport? Is the vehicle fitted with emergency supplies?
- What is likely to happen if there is a vehicle breakdown?
- Is first aid equipment available for immediate treatment?
- Is first aid equipment vehicle based, or can the lone worker bring it with them?

Nature of the work

- Is there adequate information and instruction for the person to work alone safely?
- What tools, equipment may be used?
- Are tools, equipment maintained and safe to use?
- Is fatigue likely to increase risk?
- Is there an increased risk of violence or aggression when workers are alone?
- Can environmental factors affect the safety of the worker?
- Is there risk of attack from animals?
- Has all protective equipment and clothing been obtained?
- Are there procedures for regular contact?

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Competencies of the lone worker

- Anything in the lone worker's background that is likely to increase their risk if they work alone?
- Anything that would interfere with the person's ability to contact emergency services?
- Is the person physically capable of completing all work activity alone?
- Any pre-existing medical condition that may increase risk?
- What is the person's level of work experience and training?

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ATTACHMENT B
EXAMPLE LONE WORKER CONTACT SCHEDULE

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LONE WORKER CONTACT SCHEDULE

Ramboll employees are considered working alone when the worker cannot be seen or heard by another worker, where assistance in not readily available in the event of an injury, illness or emergency.

	Name	Telephone #	Buddy (Check one box)	Alternate (Check one box)
Lone Worker				
Principle in Charge / Project Director			☐	☐
Project Manager			☐	☐
HSC			☐	☐
Other:			☐	☐

CHECK IN SCHEDULE

	Time	Date	Check	Time	Date	Check	Time	Date	Check
Beginning of shift			☐			☐			☐
			☐			☐			☐
			☐			☐			☐
			☐			☐			☐
			☐			☐			☐
End of shift			☐			☐			☐

Personal Emergency Contact	Phone #

ACTION PLAN

In the event that the lone worker misses a scheduled contact the Action Plan will go into effect. Once contact has been established with the lone worker, the Action Plan will be abandoned and the contact schedule will be reviewed and resumed. (Modify this action plan to your project specific needs.)

1. Repeat attempts to contact the lone worker.
2. If 2 hours have passed since the last scheduled contact, notify the PM and/or PIC.
3. Notify lone workers personal/family emergency contact.
4. Contact emergency services and request assistance.

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APPENDIX F
Standard Practice Instructions 31 – Water Safety

Prepared By:
Ramboll Environ US Corporation
333 W. Wacker Drive, Suite 2700
Chicago, Illinois

Implementation Date
June 2015

Revision Date
June 2017

Version Number
2015 Version 9

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STANDARD PRACTICE INSTRUCTION 31

WATER SAFETY

RAMBOLL ENVIRON

STANDARD PRACTICE INSTRUCTION 31

IMPLEMENTATION DATE: June 2015

REVISION DATE: June 2017

SUBJECT: Water Safety

BASIS: Unsafe water practices result in death, injuries and property damage each year. Recognizing, evaluating and controlling water safety hazards and risks can reduce the likelihood of these negative results. Many environmental and mechanical factors in the work place influence the safety of the worker in and around water, including chemicals in the form of liquids, dusts, fumes, mists, vapors, and gases; physical agents such as motors, noise, vibration; biological agents such as insects and aquatic wildlife; environmental factors such as extremes in temperature, adverse weather conditions, decreased visibility, or tidal or wave conditions; and ergonomic factors including repetitive motion, and fatigue. The objective is to reduce the risk of hazards associated with water quality monitoring, sampling, vessel operation and maintenance, and dredge material placement monitoring and investigation.

GENERAL: Throughout all aspects of work conducted by Ramboll Environ US Corporation (Ramboll Environ), the prevention of accidents and the compliance with legislative requirements are taken as a minimum standard upon which to base a sound, proactive health and safety management approach. The approach outlined in this Standard Practice Instruction (SPI) is designed to ensure the health, safety and welfare of Ramboll Environ staff, contractors and others potentially affected by Ramboll Environ's work. The aim is to manage risk to the lowest practicable level, ensuring compliance with the relevant applicable legislation and Ramboll Environ Policy.

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ACRONYMS AND ABBREVIATIONS

HASP	Health and Safety Plan
PFD	Personal floatation device
Ramboll Environ	Ramboll Environ US Corporation, formerly ENVIRON International Corporation (ENVIRON)
SCGL	Stairways, catwalks, guardrails, & ladders
SPI	Standard Practice Instruction
USCG	United States Coast Guard

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1. WRITTEN PROGRAM

Ramboll Environ will review and evaluate this SPI on a triennial basis, or when changes occur that prompt revision of this document, or when facility operational changes occur that require a revision of this document. Effective implementation of this program requires support from all levels of management within Ramboll Environ. This written program will be communicated to all personnel that are affected by it. It encompasses wherever Ramboll Environ is actively working, regardless of the number of workers employed or the number of worker shifts. It is designed to establish clear goals and objectives.

For the purposes of this SPI, the term "working near water" will collectively mean any environment where an employee is NEAR (i.e., equal to or less than four feet (1.22 meters)) to a water body, whether tidal or non-tidal, and where there is any potential for an employee to enter the water, either voluntarily or not. This would also include situations where the applicable task involves working IN, ON, or OVER water.

2. GENERAL SAFETY PRACTICES

Overall, a Health and Safety Plan (HASP)/Risk Assessment helps to identify potential and actual hazards and risks workers may be exposed to as they perform their work. In addition, it also identifies what control measures should be taken to protect against those hazards and risks, as well as how to respond to emergencies that may unexpected happen. As such, projects involving tasks that are near, in, on, or over bodies of water must assess the risk and implement control measures and practices as outlined in this SPI as a minimum requirement. All identified hazards, risks and control mechanisms will be communicated to affected employees as part of the HASP review process and are required to sign the project specific HASP BEFORE work can begin.

REH personnel are **prohibited** from participating in underwater work, such as scuba or snorkeling work. If a project requires underwater work to be considered by a direct subcontractor, please contact the HS Department for addition safety requirements and controls.

3. GENERAL PRACTICES AND HOUSEKEEPING

- Water work must be performed during daylight hours.
- Good housekeeping (e.g., minimal clutter) must be maintained at all times in all project work areas. All cords and lines should be properly stowed when not in use.
- Common paths of travel should be established and kept free from the accumulation of materials and obstructions.
- Provide slip resistant surfaces, rails, ropes and other devices to be used to execute project tasks. Refer to SPI 26 entitled "Slips, Trips, and Falls" for additional requirements concerning this topic.
- Specific areas should be designated for the proper storage of materials. Tools, equipment, materials and supplies shall be stored in an orderly manner.

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- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area. Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills should be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.
- Wear appropriate personal protective equipment (gloves, boots, and clothing) to eliminate direct contact with sediment. This would be in addition to any personal floatation devices.
- All permits must be posted or otherwise made available at the project site and/or on board the vessel as applicable.
- All documents pertaining to health & safety and/or procedural requirements must be made available in the language that is understood by all workers. For projects with multi-national workers, this means that the same document must be available in the first language of the worker.

4. GENERAL HAZARDS AND CONTROL MEASURES

4.1 Biohazards. All personnel should be aware of biohazards associated with each site and may include but not limited to poisonous plants, insects, animals, or exposure to blood-borne pathogens or mold. Long sleeves will help protect against insect bites and exposure to poisonous plants. If desired and if pesticides are not a potential contaminant of concern at the site, insect repellant may be applied to clothing in accordance with the manufacturer's directions. Site personnel should avoid contact with animals whenever possible.

4.2 Hearing Damage. While aboard any vessel, personnel may be subjected to noise in access of 85dBA. In these situations personnel shall wear appropriate hearing protection. Refer to SPI 8 entitled "Occupational Noise Exposure Program" for additional requirements concerning this topic.

4.3 Thermal Hazards. All personnel should be aware of thermal hazards associated with each site and take the appropriate measures to protect themselves.

During period of hot weather, personnel shall be aware of the symptoms and appropriate response actions for heat exhaustion and heat stroke. Several Factors contribute to heat stress in the work environment, including high temperature and humidity; direct sun or heat; limited air movement; physical exertion; poor physical condition; some medications; inadequate tolerance for hot workplaces; and insufficient water intake.

The screening criteria for heat stress exposure in degrees Celsius (and shown in degrees Fahrenheit (F)) for an 8 hour work day, 5 days per week with conventional breaks will be used in determining safe exposure for acclimatized and un acclimatized employees as follows:

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Actual Temperature (C)								
Allocation of Work in a Work/Rest Cycle	**Acclimatized**				**Action Limit (Un acclimatized)**			
	Light	**Moderate**	**Heavy**	**Very Heavy**	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75-100%	31.0 (87.8F)	28.0 (82.4F)	--	--	28.0 (82.4F)	25.0 (77F)	--	--
50-75%	31.0 (87.8F)	29.0 (84.2F)	27.5 (81.5F)	--	28.5 (83.3F)	26.0 (78.8F)	24.0 (75.2F)	--
25-50%	32.0 (89.6F)	30.0 (86F)	29.0 (84.2F)	28.0 (82.4F)	29.5 (85.1F)	27.0 (80.6F)	25.5 (77.9)	24.5 (76.1F)
0-25%	32.5 (90.5F)	31.5 (88.7F)	30.5 (86.9F)	30.0 (86F)	30.0 (86F)	29.0 (84.2F)	28.0 (82.4F)	27.0 (80.6F)

Refer to SPI 30 entitled "Heat Stress" for additional requirements concerning this topic.

For cold stress, the four environmental conditions that cause cold-related stress are low temperatures, high/cool winds, dampness and cold water and cold surfaces. Wind chill is a combination of temperature and wind velocity, and is a crucial factor to evaluate when working outside so that proper precautions can be taken (e.g., breaks, suitable clothing, and/or the stopping of non-essential work).

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Cooling Power on Exposed Flesh Expressed as an Equivalent Temperature Under Calm Conditions

Estimated Wind Speed (mph)	Actual Temperature Reading (F.)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Chill Temperature (F.)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-145
35	27	11	4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect.)	LITTLE DANGER In <hr with dry skin. Maximum danger of false sense of security				INCREASING DANGER Danger from freezing of exposed flesh within 1 minute			GREAT DANGER Flesh may freeze within 30 seconds				
Trench foot and immersion foot may occur at any point on this chart.												

*Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA. Source: ACGIH, Threshold Limit Values for Chemical Substances in the Work Environment for 1984-1985.

The cooling power of wind (°C)

Estimated wind speed (in km/h)	Actual temperature reading (°C)												
	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
	Equivalent chill temperature (°C)												
Calm	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
8	9	3	-2	-7	-12	-18	-23	-28	-33	-38	-44	-49	-54
16	4	-2	-7	-14	-20	-27	-33	-38	-45	-50	-57	-63	-69
24	2	-5	-11	-18	-25	-32	-38	-45	-52	-58	-65	-72	-78
32	0	-7	-14	-21	-28	-35	-42	-50	-56	-64	-71	-78	-84
40	-1	-8	-16	-24	-31	-38	-46	-53	-60	-67	-76	-82	-90
48	-2	-10	-17	-25	-33	-40	-48	-55	-63	-70	-78	-86	-94
56	-3	-11	-18	-26	-34	-42	-50	-58	-65	-73	-81	-89	-96
64	-3	-11	-19	-27	-35	-43	-59	-59	-66	-74	-82	-90	-98
(Wind speeds greater than 64 km/h have little additional effect.)	LITTLE DANGER In < 1 hr with dry skin. Maximum danger of false sense of security.				INCREASING DANGER Danger from freezing of exposed flesh within one minute.			GREAT DANGER Flesh may freeze within 30 seconds.					
	Trenchfoot and immersion foot may occur at any point on this chart.												

Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36°C (96.8° F) per cold stress TLV.

At air temperatures of 35.6F (2C) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided with a change of clothing and treated for hypothermia. During periods of cold weather, field personnel shall acquaint themselves with the symptoms of cold stress, frostbite and hypothermia as well as SPI 29 entitled "Cold Stress" for additional requirements concerning this topic.

4.4 Eye and Head Injury. Appropriate eye protection should be worn at all times to help guard against eye injury resulting from foreign objects striking the eye and harmful solar radiation. A hard-hat shall be worn while working around heavy equipment and overhead hazards.

4.5 Submerged and Unmarked Objects. Personnel shall be aware of the possible existence of submerged and/or unmarked objects while accessing the site, during vessel operation, and while sampling.

4.6 Slip, Trip, Fall Hazards. Proper house-keeping procedures shall be maintained to prevent slip, trips, and falls. Electrical cords and lines should be properly stowed when not in use. Personnel should be made aware of any hazards that may lead to slips, trips, and falls. Handrails should be used whenever available to prevent slips, trips and falls. Stairways, catwalks, guardrails and ladders (SCGL) may be encountered on dredges, scows, support vessels, berths, wharfs, docks, and at up-land and beach nourishment sites. Personnel shall wear a United States Coast Guard (USCG), or country specific equivalent, -approved personal floatation device (PFD) whenever using a stairway, catwalk or ladder that extends or spans, over or near water. Personnel should avoid using both hands to carry objects while on stairways; if unavoidable, use extra caution. Refer to SPI 35 entitled "Ladder and Stairway Safety" for additional requirements concerning this topic.

The following requirements apply to SCGL:

4.6.1 SCGL shall be maintained free of slippery conditions and dangerous projections such as protruding nails.

4.6.2 When doors or gates open directly onto a stairway, catwalk, or ladder a landing shall be provided that extends at least 20 inches (58 cm) beyond the swing of the door.

4.6.3 At least one handrail or guardrail shall be installed on all stairways, catwalks, ladders, elevated platforms and decks to provide personnel with handhold for support.

4.6.4 Handrails shall be between 30 and 37 inches (76.2-94 cm) from the surface of the tread and have a minimum clearance of 3 inches (7.6 cm) between the handrail and any wall or other object. When the top rail of a stair rail also serves as a handrail, the top rail shall be between 36 and 37 inches (76.2-94 cm) from the surface of the tread. Midrails, screens, mesh, intermediate vertical members, or equivalent intermediate structural members shall be installed between the top rail and treads.

4.6.5 When on a vessel, guardrails shall be installed along each unprotected side or edge of a landing or deck to prevent personnel from falling. Guardrails shall consist of top rails, mid rails, and posts, and shall have a vertical height of 42 inches (106.7 cm) +/- 3 inches (7.6 cm) from the upper surface of the top rail to the floor, platform, runway, or ramp level. Standard guardrail systems shall be provided with toe boards on all open sides/ends at

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locations where persons are required or permitted to pass or work under the elevated platform or where needed to prevent persons and material from falling from the elevated platform.

4.6.6 Handrails and guardrails shall be capable of withstanding a 200 pound force applied in any downward or outward direction, be surfaced to prevent laceration injuries or cloth snagging, and be constructed so the rail ends do not create a projection hazard.

4.7 Back Injury. Proper lifting techniques such as keeping the back straight and the legs bent shall be utilized when lifting equipment. If the equipment cannot be lifted in this manner, it is too heavy to lift alone. Call other personnel, or use a mechanical device for lifting. When in transit on any vessel, personnel shall stand in a stable position and keep legs bent to absorb the motion of the vessel caused by heavy seas or chop.

4.8 Vessel/Vehicle Traffic. Personnel shall be aware of other vessels and other vehicles operating in the area and take appropriate actions to avoid collision and damage.

4.9 Weather Hazards can present a considerable challenge to conducting field activities in a safe manner. Site personnel shall be aware of any severe weather event and take appropriate safe actions. Sampling vessel operations should monitor weather conditions closely and may choose to discontinue sampling activities if severe weather conditions compromise site safety. Severe weather events may include: fog, high winds, high seas, heavy current, lightning, extreme heat or cold, flooding, snow, and ice. Sampling during adverse weather conditions (e.g., excessive heat or cold, storm events with precipitation, lightning, high winds) and where environmental hazards (e.g., poison ivy, biting insects, unstable slopes, falling tree limbs) are present requires additional level of preparation, precaution and awareness.

4.10 Severe weather conditions include high winds, electrical storms, and heavy rain.

- When lightning is spotted site personnel should use the following steps to avoid injury from lightning:
- Note the flash-boom ratio by counting the seconds after the lightning was seen until the thunder was heard. By counting the seconds between seeing lightning and hearing thunder and dividing by 5, you can estimate your distance from the storm (in miles or kilometers). If the storm is 6 miles (9.66 km) away or less (30 seconds between when lightning was seen and thunder was heard), stop work and take shelter.
- If the storm is more than 6 miles (9.66 km) away (greater than 30 seconds between lightning and thunder), monitor the storm and be prepared to cease work if the storm approaches an unsafe distance. Since storms can travel at varying speeds and the amount of time at takes to cease and secure operations will also vary, prudent judgment should be exercised when storms are in the vicinity of the working area and/or developing (e.g., darkening skies, increasing wind speeds, etc.).
- Workers should not stay in exposed areas (e.g., on, in, or near water) after lightning has been witnessed. All personnel must move to a safe location.

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- Workers should wait 30 minutes from the last sight of lightning or sound of thunder before returning to work. The last noted time of lightning or thunder shall be recorded in the field notebook.
- Once the 30 minute wait time period has elapsed and no additional lightning or thunder has been seen or heard, individuals may resume normal work.

4.8.1 Additional Environmental Hazards. Considerations should include but not be limited to the following:

- Wear clothing that is appropriate for protection from the elements and also appropriate for protection from biological, chemical or physical hazards associated with the field activities to be conducted.
- Consider the appropriateness of using sunscreen or bug repellents in light of the potential for introducing contaminants from these substances into the samples. Often suitable clothing can provide adequate protection.

5. WATER AND VESSEL SAFETY

5.1 General Water Safety

5.1.1 All personnel and visitors when immediately near water (i.e., within 4 feet/1.22 meters), over water, wading in water or on any vessel, **where the danger of drowning exists,** must wear a Type III, Type V work vest, or better USCG-approved, or country specific equivalent, International Orange PFD equipped with a USCG-approved, or country specific equivalent, automatically activated light (not required during daylight hours). However, several factors are relevant to determining whether a danger of drowning exists. These include the type of water body (i.e., a pool, a river, a canal), depth, presence or absence of a current, height above the water surface, and the use of fall protection when working above a water body.

Depending on the factors present, there are some circumstances where a drowning hazard could exist where workers are near or over water that is relatively shallow (i.e., less than 2 feet (0.6 meters) in depth). For example, where workers are not using fall protection and are 10 feet (1.05 meters) above a river, a worker may fall and be knocked unconscious. Without the use of a life jacket or buoyant work vest, a worker in such a scenario could drown.

This PFD must be properly secured to the wearer. The PFD must be inspected for defects and free of all defects (e.g., rips, tears, stress) which could alter the strength or buoyancy prior to, and after, each use. In addition, the PFD will be kept clean and free of excessive dirt and oil.

5.1.2 A life ring equipped with 90 feet (27.4 meters) of solid braid polycarbonate line, or equivalent must be close to the working area and accessible for use. This includes activities on board all vessels.

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For land projects adjacent to water bodies, ring buoys shall be spaced no further than 200 feet (67 meters) apart in close proximity and parallel to the water body. The number of ring buoys will depend on the overall length of the work occurring adjacent to the water body but at a minimum, three ring buoys will be used. The middle ring buoy will be placed center lined of the proposed work site, with the 2 end ring buoys 200 feet (67 meters) from the center ring buoy, one up stream and one downstream. Additional ring buoys will be installed at a distance no greater than 200 feet (67 meters) from the next adjacent downstream ring buoy.

5.1.3. USCG boating safety guidelines, or country specific equivalent, should be adhered to when operating a boat during sampling activities.

- Boasts must be equipped with the required running lights for night time or poor visibility conditions.
- Boats must be equipped with an anchor and alternate means of locomotion (e.g., extra motor, floatable oars).
- The boat must be equipped with suitable signaling devices, such as an air horn and signal light.

5.1.4 Prudent judgment must be exercised when determining if it is safe to conduct work in open water. One factor that needs to be considered is wind speed. The Beaufort wind force scale is an empirical measure for describing wind speed mainly based on observed sea conditions in the open ocean and not along shore. In general, winds of force 6 or 7 result in the issuance of a small craft advisory, with force 8 or 9 winds bringing about a gale warning, force 10 or 11 a storm warning ("a tropical storm warning" being issued instead of the latter two if the winds relate to a tropical cyclone), and force 12 a hurricane force wind warning (or hurricane warning if related to a tropical cyclone). A set of red warning flags (daylight) and red warning lights (night time) is displayed at shore establishments which coincide with the various levels of warning. Open water work should not be conducted when wind forces are above 5 on the Beaufort scale as noted below:

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Beaufort wind force scale

Specifications and equivalent speeds									
Beaufort wind scale	Mean Wind Speed		Limits of wind speed		Wind descriptive terms	Probable wave height in metres*	Probable maximum wave height in metres*	Seastate	Sea descriptive terms
	Knots	m/s	Knots	m/s					
0	0	0	<1	0–0.2	Calm	-	-	**0**	Calm (glassy)
1	2	0.8	1–3	0.3–1.5	Light air	0.1	0.1	**1**	Calm (rippled)
2	5	2.4	4–6	1.6–3.3	Light breeze	0.2	0.3	**2**	Smooth (wavelets)
3	9	4.3	7–10	3.4–5.4	Gentle breeze	0.6	1.0	**3**	Slight
4	13	6.7	11–16	5.5–7.9	Moderate breeze	1.0	1.5	**3–4**	Slight–Moderate
5	19	9.3	17–21	8.0–10.7	Fresh breeze	2.0	2.5	**4**	Moderate
6	24	12.3	22–27	10.8–13.8	Strong breeze	3.0	4.0	**5**	Rough
7	30	15.5	28–33	13.9–17.1	Near gale	4.0	5.5	**5–6**	Rough–Very rough
8	37	18.9	34–40	17.2–20.7	Gale	5.5	7.5	**6–7**	Very rough–High
9	44	22.6	41–47	20.8–24.4	Severe gale	7.0	10.0	**7**	High
10	52	26.4	48–55	24.5–28.4	Storm	9.0	12.5	**8**	Very High
11	60	30.5	56–63	28.5–32.6	Violent storm	11.5	16.0	**8**	Very High
12	-	-	64+	32.7+	Hurricane	14+	-	**9**	Phenomenal

* 1. These values refer to well-developed wind waves of the open sea.
2. The lag effect between the wind getting up and the sea increasing should be borne in mind.

5.1.5 Water safety training will be provided to employees working immediately near water (i.e., within 4 feet/1.22 meter), over water, wading in water or on any vessel, **where the danger of drowning exists.** At a minimum, training will include how to properly wear, inspect, and store a PFD; cold water immersion, general boating safety, as well as the effects of hypothermia as outlined in the chart below.

Hypothermia Chart

IF THE WATER TEMPERATURE F (C) IS:	EXHAUSTION OR UNCONSCIOUSNESS	EXPECTED TIME OF SURVIVAL IS:
32.5 (0.28)	Under 15 Minutes	Under 15 - 45 Minutes
32.5 - 40.0 (0.28-4.4)	15 - 30 Minutes	30 - 90 Minutes
40.0 - 50.0 (4.4-20)	30 - 60 Minutes	1 - 3 Hours
50.0 - 60.0 (10-15.5)	1 -2 Hours	1 - 6 Hours

Hypothermia Chart

IF THE WATER TEMPERATURE F (C) IS:	EXHAUSTION OR UNCONSCIOUSNESS	EXPECTED TIME OF SURVIVAL IS:
60.0 - 70.0 (15.5-21)	2 - 7 Hours	2 - 40 Hours
70.0 - 80.0 (21-26.6)	3 - 12 Hours	3 Hours - Indefinitely
OVER 80.0 (<26.6)	Indefinitely	Indefinitely

The use of an Immersion Suit or other buoyant thermal protective device will greatly enhance survival time. Chart is for general reference only.

5.2 Working Near Water

5.2.1 A Type III, Type V work vest, or better USCG-approved, or country specific equivalent, International Orange PFD equipped with a USCG-approved, or country specific equivalent, automatically activated light (not required during daylight hours), and reflective tape shall be properly worn (zipped, tied, latched, etc., in closed fashion) at all times when working within 4 feet or 1.22 meters from a water source, **where the danger of drowning exists**.

5.2.1.1 All near water work shall be performed by at least a two-person team. Deviations to this provision will require acknowledgment and sign-off from the Principal in Charge in accordance with SPI 42 entitled "Working Alone".

5.3 Working In Water

There are many situations when an employee may be required to work in water, whether performing work outside of a designated vessel, or performing ground work in wet or marshy areas. These situations present the same hazards and risks deep water, and the same safety precautions shall apply.

5.3.1 **Where the danger of drowning exists**, a Type III, Type V work vest, or better USCG-approved, or country specific equivalent, International Orange PFD equipped with a USCG-approved, or country specific equivalent, automatically activated light (not required during daylight hours), and reflective tape shall be properly worn (zipped, tied, latched, etc., in closed fashion) at all times when working in water.

5.3.2 All water work shall be performed by at least a two-person team. Both people shall be equipped with the proper safety gear and capable of readily summoning emergency rescue if needed. Ramboll Environ personnel are prohibited from working in or near water by themselves.

5.4 Rescue Vessels

5.4.1 At least one lifesaving rescue vessel (e.g., a skiff) shall be immediately available at locations where employees are working over, in, on or adjacent to water where the danger of

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drowning exists. The need to have a rescue vessel "immediately available" for use is dependent upon a number of factors, including but not limited to:

- The number of work locations operating;
- The distance to each of those locations;
- Water temperature;
- Currents, and;
- Other hazards such as, but not limited to, rapids, dams, and water intakes.

In general, if the water is so shallow that rescuers could simply run into the water body without endangering themselves and/or others or the work was being conducted very close to shore (e.g., the length of the skiff from shore would be greater than the working distance from shore and/or the skiff would foul on the bottom anyway), a skiff would not be required.

5.4.2 In the event that a skiff is required or used, the following criteria must be implemented:

1. The skiff must be in the water or capable of being quickly launched by one person.
2. There must be at least one person present and specifically designated to respond to water emergencies and operate the skiff at all times.
3. When the operator is on break, another operator must be designated to provide the requisite coverage while employees are working or operations cease (i.e., employees return to dry land).
4. The designated operator must either man the skiff at all times or remain in the immediate area such that the operator can quickly reach the skiff and get underway.
5. The skiff operator may be assigned other tasks provided the tasks do not interfere with the operator's ability to monitor water activities, quickly reach the skiff, and get underway.
6. The communication system, such as a walkie-talkie, must be used to inform the skiff operator of an emergency and to inform the operator where the skiff is needed.
7. The skiff must be equipped with both an operational motor and oars.
8. The skiff operator must be certified in first aid.

Having a skiff, or lifesaving vessel, immediately available for rescue activities should be determined by the Project Manager based on a hazard analysis of the job requirements, site characteristics and any other pertinent information.

5.5 Working Aboard a Vessel

5.5.1 All work aboard a vessel shall be performed by at least a two-person team. If work is performed at times when water temperatures are less than 38°F (3-4C), it is recommended, but not mandatory, that sampling personnel wear float coats. The vessel should be operated only by designated, experienced staff.

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5.5.2 USCG boating safety guidelines, or country specific equivalent, should be adhered to when operating a vessel during sampling activities.

5.5.3 USCG approved PFDs, or country specific equivalent, must be worn by all staff when aboard a vessel.

5.5.4 Vessels must be equipped with the required running lights for night-time and poor visibility conditions.

5.5.5 The vessel must be equipped with an anchor and alternate means of locomotion (e.g., oars).

5.5.6 The vessel must be equipped with suitable signaling devices, such as an air horn and signal light. All vessels are required to have functioning navigational lights for any required dusk or night work, and any work required when conditions such as fog impair visibility.

5.5.7 Weather and water conditions must be monitored to determine if it is safe to be out on a water body.

5.5.8 If the work involves reaching, stretching, etc., from the vessel, the worker shall be equipped with a harness and lifeline or the use of a PFD. The lifeline shall be attached to the vessel.

5.5.9 Footwear shall have sufficient traction to reduce the risk of slipping.

The remaining paragraphs of this section are intended to apply to the operation of Class A and Class 1-2 boats.

- Class A – a vessel less than 16 feet long (4.9 meters). Class A has the greatest number of vessels. They can all be car topped or trailered. Due to their lightness and small size, many can become unstable if weight in them is excessive or carelessly loaded. Too much weight makes these boats sluggish, reduces their freeboard (the height of their sides above water) and can swamp (flood) them.
- Class 1 – a motorized vessel from 16 feet (4.9 meters) to less than 26 feet (7.9 meters) in length. Though heavier and more powerful than Class A vessels, most are still trailer able.
- Class 2 – a motorized vessel from 26 feet (7.9 meters) to less than 40 feet (12.2 meters) in length. Heavier, and more stable than Class 1 vessels, some are trailer able.

5.6 Boarding Small Vessels. Be sure that the boat is properly secured with at least two mooring lines, fore and aft. With one hand on the vessel, quickly lower yourself straight down into the center of the vessel. An appropriate PFD should be worn. If others are boarding, have them step as close as possible to the center line of the boat while you hold the boat in place along the pier, dredge or adjacent support vessel. Avoid carrying anything as you board. Step down into the boat and have someone assist you with loading items by hand, one by one.

5.7 Loading of Vessels. Amount and location of weight (persons and gear: the movable ballast) is critical for capsize protection. In a small utility vessel, keep weight toward the center of mass. If you see waves approaching, take them on the bow preferably at a 45 degree angle.

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Overloading a small boat inhibits its ability to rise to oncoming waves. Less freeboard means less clearance above the water's surface to prevent swamping. All crafts must be operated within the boat manufacturers' weight limit.

5.8 Vessel Safety Equipment. Vessel safety equipment for Class A and Class 1-2 vessels.

5.8.1 Persons on the vessel should wear a USCG approved, or country specific equivalent, type III personal floatation vest at all times. In addition, a throw able Type IV devices will be readily available for use.

5.8.2 At least one B-1 Type (class A and class I), and two B-1 Type (class 2) USCG approved, or country specific equivalent, hand held portable fire extinguishers will be on the vessel, readily available for use.

5.8.3 Visual Distress Signal Flares and battery operated lights will be in good working order and readily available on the boat.

5.8.4 A sound-producing distress signal, bell, whistle, or horn, will be in good working order and readily available on the boat.

5.8.5 A first aid kit will be available on the boat.

5.8.6 All boat fuel will be contained in engine manufacturer's approved containers that supply fuel to the engine via neoprene fuel lines. No fuel transfers between containers are to be conducted aboard the boat.

5.8.7 A secondary means of propulsion will be available on the vessel (second engines, oars or paddle).

5.8.8 A boat hook, anchors, and proper mooring lines will be available on the vessel.

5.9 Safe Vessel Operations

5.9.1 The vessel will only be operated by experienced personnel. At a minimum, all operators must have a licensed USCG captain, or country specific equivalent, depending on vessel size.

5.9.2 The vessel will be operated in a safe manner and all state and federal waterway regulations will be obeyed. A safety meeting will be conducted that reviews the project tasks, hazards/controls mechanisms, communication devices, signals, and other safety issues prior to the commencement of the project. This meeting will be documented in the HASP by all participants.

5.9.3 No smoking or alcoholic beverages are permitted on the vessel.

5.9.4 No recreational equipment will be allowed on the vessel unless specifically authorized as part of the work-related equipment.

5.10 Vessel Accidents. Coast Guard regulations, as well as state regulations, require accident reports if significant injuries or property damage occurs. It is normally best to stay with the

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boat in case of an accident and use signal flares or a distress horn to summon help. Hypothermia is a significant risk for those involved in boating accidents due to the rapid conduction of body heat by cold water.

5.11 Man Overboard Procedures

- Mark the vessels position using the Man Overboard option on the GPS if available.
- If within eye contact, never take your eye off the person overboard.
- Shout **"man overboard port/starboard side"**.
- Point at the person continually.
- Achieve physical contact with the person for extraction from the water: reach (extend an arm, pole, etc.), throw (life ring, PFD, cooler, etc.), go (considering wind, current, seas, depth, and space, maneuver and position the boat favorably and as quickly and as safely as possible).
- Monitor the person for hypothermia.

5.12 Communication. At a minimum, there must be a means of communication or other appropriate provisions must be made for access to emergency/medical assistance. This may be in the form of cell phones, CB radios, and/or two-way radios1. Sampling vessels operating on larger, open bodies of water shall be equipped with at least one VHF and UHF radio.

5.12.1 VHF-marine radio:

- Ch. 16 – used for hailing and emergencies: May Day, May Day, May Day (immediate danger, loss of life eminent), Pan-Pan (urgent situation involving people). Sampling vessel must monitor Ch. 16 at all times.
- Ch. 22 – United States Coast Guard Broadcasting: Security - information on navigational updates, weather, general safety.
- Ch. 13 – Bridge to Bridge (commercial navigation), navigational purposes.
- Ch. 09 – Hailing.
- Ch. 26 – Marine Operator.

5.12.2 UHF radio:

- Ch. 1 (453.425 MHz) – Inter-vessel communication. Sampling vessel must monitor UHF Ch. 1 at all times when acting in support of water operations.

5.13 Environmental Permits. A copy of all applicable permits will be stored and maintained on the sampling vessel at all times.

5.14 Chartering a Boat.

[1] Two-way radios are only appropriate if other staff members are present on land and within range)

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Registration requirements for vessels vary by area, check with your local authority for guidelines specific to the area of intended boating. However, in general, registration often includes a Vessel Registration issued by the local regulatory agency with Vessel Documentation, as applicable. Registration numbers typically must be painted or permanently attached to each side of the forward half of the vessel and documentation of the vessel marked on the hull.

Inspection requirements for vessels vary by area, check with the local authority for specific inspection guidelines. For example, small passenger vessels under 100 gross tons operating on navigable waterways of the US are inspected for safety by the USCG and a copy of this inspection should be available for review and proof of inspection posted onboard.

Insurance requirements for chartered boats vary based on the classification of the vessel and intended use, and are typically maintained by the owner of the chartered boat. "Bareboat" charters, when the charterer supplies their own captain, require a different type of insurance coverage. In most cases the company that provides the bareboat requires the charterer to sign a hold harmless agreement that states the charterer and guests will not sue owner for injuries aboard during the charter. Inquiries should be made to the owner(s) of all chartered boats as to insurance requirements.

The Captain ensures that the ship complies with local and various international laws. The Captain is ultimately responsible for aspects of operation such as safe navigation of the ship, its orderliness and seaworthiness, safe handling of all cargo, management of all personnel, and maintaining the ship's certificates and documentation.

One of the Captain's duties is to ensure compliance with the vessel's security plan (as required by the International Maritime Organization), as applicable. The plan, customized to meet the needs of each individual ship, spells out duties including conducting searches and inspections, maintaining restricted spaces, and responding to threats from terrorists, hijackers, pirates, and stowaways.

Requirements for boating licenses and certifications vary by location, and due diligence shall be performed to ensure that the captain has the appropriate credentials and experience to operate the vessel. These may include:

- United States Coast Guard Charter Boat Captain License (OUPV or Master depending on vessel and crew number)
- American Sailing Association License
- Other Location-Specific Boating Safety courses or classes
- A hands-on Sail Test Challenge
- Demonstrated experience on a vessel of similar or greater size and power

The crew aboard any vessel must agree and understand the responsibilities of the Captain.

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6. DEFINITIONS

Bank. Means all land abutting the edge of any river, canal or enclosed water such as a pond or lake.

Bow. The forward part of the boat.

Float Coat. A type of PFD that combines the warmth of a coat with the buoyancy of a life-vest. They offer added insulation and protection from cold winds and water.

Floodwater. Means any area of water that in normal circumstances does not exist and incorporates any water that is formed as a result of heavy rainfall and/or overflow water from any normal source of water, e.g. rivers, canals, etc.

Ice. Refers to any water whilst in a frozen state, note that salt water freezes at a lower temperature than fresh water.

Marina. A docking facility, or landing in a harbor next to a pier, where ships are loaded, unloaded and/or repaired. Typically has docks, moorings, or supplies for small watercrafts.

Mud. Means any area of mud/sand/slurry that cannot be easily assessed as being safe. I.e. it is of an unknown depth or consistency. It will often be linked to mud flats at the coast but could equally be a deep area of mud in a woodland environment or a farmer's slurry pit.

Non-tidal water. Means any water that is not affected by the sun and moon, i.e. the depth and/or flow of current is unaffected by tidal affects. This includes all upper river areas, streams, ponds, canals, lakes, swimming pools, etc.

Personal Floatation Device (PFD).

- Type III Floatation Aid – generally the most comfortable, have at least 15.5 pounds of buoyancy in the adult size. They do no turn face-up, and therefore do not provide protection from downing if a victim falls face down into the water in an unconscious state. They can be jackets or vests.
- Type IV Throw able Devices – include the horseshoe, ring, and cushion. They have at least 16.5 pounds of buoyancy, 70 feet (21.3 meters) of 3/8 inch solid braid polypropylene, or equivalent, line attached and must offer immediate access.

Pontoon. Means any structure, whether floating or fixed to the ground, which allows access by foot or vehicle to watercraft on moorings, whether or not watercraft are present.

Port Side. The left side of the boat looking forward.

Starboard. The right side of the boat looking forward.

Stern. The after part of the boat.

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Tidal water. Means any water that is affected by the position of the moon and sun, i.e. the depth and/or flow of current increases/decreases as a result of the tidal effects at the coast.

Watercraft. Means any vessel that floats and is designed to carry people or equipment. This could be a simple raft used as a working platform, or a ship. It could also include inflatable vessels from small children's beach dinghies to commercial rigid inflatable boats (RIBs).

Weather. Means the combined effects of temperature, wind speed and direction and rain.

Working near water. Means any environment where the staff member is working within 4 feet or 1.22 meters from water, whether tidal or non-tidal, where there is any potential for the member entering that water, either voluntarily or not. This includes working in, on, near and over water.

7. REVISION SUMMARY

Version	Author	Description of Change	Date
9	K. Heitman	Added diving, scuba prohibition for REH personnel	06/2015

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APPENDIX G
Traffic Control Plans

Date: 3/6/2019 **Author:** HSI **Project:** N River RD Closure Ramboll

Comments:

9th St N & N River Rd

Plan Scale

1 : 993 (1" = 83')

Legend

- Barrel
- barrier

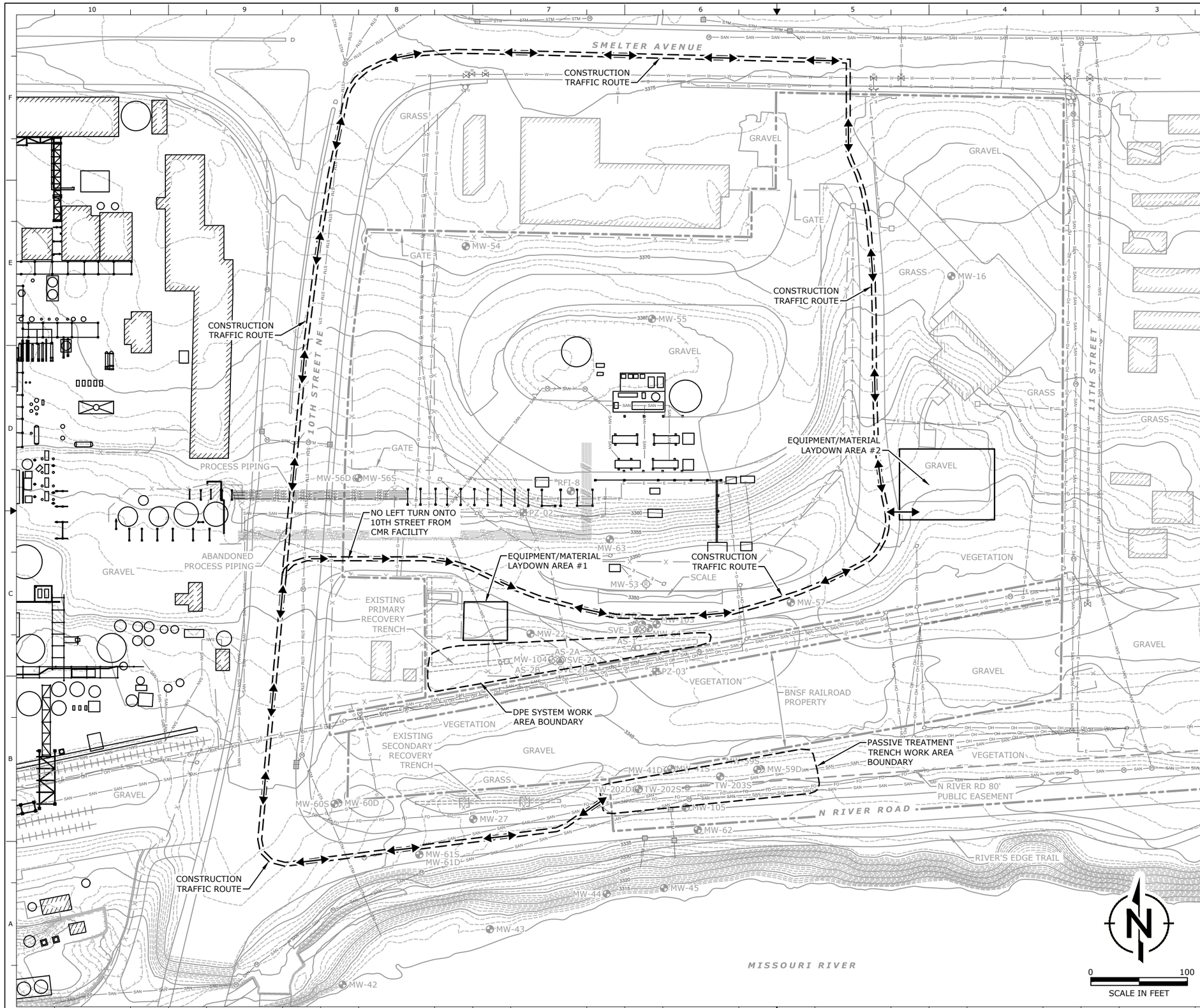
Manifest

15 x	Barrel
4 x	barrier
4 x	W20-1 road work ahead
2 x	R11-2 R11-2 road closed
2 x	R3-1 no right turn
2 x	R3-2 no left turn

Date: 3/6/2019 **Author:** HSI **Project:** N River RD Closure RamBoll

Comments:

15th St N & N River Rd



LEGEND

- MONITORING WELL
- PIEZOMETER
- SOIL VAPOR EXTRACTION PILOT TEST WELL
- AIR SPARGE PILOT TEST WELL
- PRODUCT RECOVERY WELL
- PROPERTY BOUNDARY (APPROXIMATE)
- MAJOR CONTOUR INTERVAL (5-FOOT)
- MINOR CONTOUR INTERVAL (1-FOOT)
- FENCE
- RAILROAD TRACKS
- FIRE HYDRANT
- SHUT-OFF VALVE
- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- STORM/SANITARY MANHOLE
- STORM SEWER INLET
- OVERHEAD ELECTRIC
- BURIED ELECTRIC
- UTILITY POLE
- UTILITY BOX
- NATURAL GAS
- BURIED TELEPHONE
- FIBER OPTIC
- PROCESS PIPING
- TRAFFIC FLOW DIRECTION

SOURCES:

1. SITE LAYOUT AND FEATURES FROM DRONE AERIAL PHOTOGRAPHY DATED 08/16/2019 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.
2. TOPOGRAPHY FROM 2017 LIDAR BY U.S. DEPARTMENT OF AGRICULTURE FARM SERVICES AGENCY AERIAL PHOTOGRAPHY FIELD OFFICE.
3. UTILITIES FROM TD&H ENGINEERING, 17-073_UTILITIES_AND_MW.DWG DATED 01/10/2018 AND CALUMET MONTANA REFINING, LLC., BASE_MAP_001_REV_8.DWG DATED 06/25/2019.

NOTE:

1. HORIZONTAL COORDINATES BASED ON NAD83 MONTANA STATE PLANE, US FEET.
2. ELEVATIONS BASED ON NAVD88 VERTICAL DATUM, FEET AMSL.

DRAFT

DATE

SIGNATURE

FILE LOCATION: M:\CAD\1690014124-003_Calumet_AOC-16\100% Design\Drawings\Work Area Boundaries and Equipment-Material Laydown Areas.dwg

DRAFTED BY: HJW

DESIGNED BY: AS/PL

DATE: 9/10/2020

APPROVED BY: ST

RAMBOLL

AOC-16 INTERIM MEASURE DESIGN DRAWINGS (100%)
DUAL-PHASE EXTRACTION AND
PASSIVE TREATMENT TRENCH INSTALLATION
CALUMET MONTANA REFINING, LLC.
1900 10TH STREET, GREAT FALLS, MONTANA

WORK AREA BOUNDARIES AND EQUIPMENT/MATERIAL LAYDOWN AREAS

PROJECT # 1690014124-003

DRAWING

C2

APPENDIX H

Standard Practice Instructions 27 – Subsurface and Overhead Clearance

Prepared By:
Ramboll Environ US Corporation
333 W. Wacker Drive, Suite 2700
Chicago, Illinois

Implementation Date
December 2013

Revision Date
June 2015

Version Number
2011 Version 7

STANDARD PRACTICE INSTRUCTION 27

SUBSURFACE AND OVERHEAD CLEARANCE

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RAMBOLL ENVIRON

STANDARD PRACTICE INSTRUCTION 27

IMPLEMENTATION DATE: December 2013

REVISION DATE: December 2015

SUBJECT: Subsurface Clearance

BASIS: The hazards posed by the presence of underground and overhead services are significant. When the hazards are correctly identified prior to subsurface work, the risks associated with such hazards can be minimized. As such, no intrusive work is to be conducted by Ramboll Environ US Corporation (Ramboll Environ) personnel or Ramboll Environ subcontractors until the hazards associated with the possible presence of underground and overhead services in and around the work area are identified and safe locations marked and agreed upon by site personnel and project team, as applicable. This Standard Practice Instruction (SPI) applies to intrusive site work including without limitation: test pit or trench excavations; borehole excavations using hand auger, shell and auger, rotary, hydraulic and percussive methods; gas spiking; manual excavations; hand digging; borings into vertical, indoor, or belowground surfaces greater than 6 inches (15 cm;) and/or, any other on-site activity where penetration of a surface is required.

GENERAL: The approach outlined in this SPI is designed to ensure the health, safety and welfare of Ramboll Environ staff, contractors and others potentially affected by Ramboll Environ's work. The aim of this SPI is to manage risk to the lowest practicable level, ensuring compliance with the relevant applicable legislation and Ramboll Environ Policy.

RESPONSIBILITY: This SPI will be implemented when conducting intrusive work and where overhead lines are present, and will be supplemented (or superseded, if necessary) only if additional requirements (e.g., local, regional or country specific regulation, client requirements) do not prevent adequate evaluation of utilities. The Director of Health and Safety ("Director of H&S") is solely responsible for all facets of this program and has full authority to make necessary decisions to ensure success of the program. The Director is the sole person authorized to amend these instructions. Nonetheless, all Ramboll Environ employees are authorized to stop work and have the duty to halt any operation where there is danger of serious personal injury, property damage, and/or harm to the environment.

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EXECUTIVE SUMMARY

The intent of this executive summary is to identify the general tasks that must be performed to reduce the likelihood of encountering subsurface structures during intrusive activities. It is not a substitute for following the requirements identified in the remainder of this document.

It is recognized that country specific procedures may slightly vary (e.g., commercial line location services may not be available in all geographical locations where Ramboll Environ conducts operations). Nonetheless, The minimum SSC requirements that are to be followed are outlined below.

Administration:

- ☐ Utilize a properly executed subcontract and Proof of Insurance, or its equivalent (See Section 4)

Field Work:

- ☐ Conduct a historical site information review (See Section 6.2)
- ☐ Develop a HASP/RA and complete the Pre-Project Planning Checklist (See Sections 6.3)
- ☐ Develop a Plot Plan that reflect Site utility conditions (See Section 6.4)
- ☐ Premark intrusive location(s)/area(s) (See Section 6.5)
- ☐ Contact a public locate (One Call Agency), where available (See Section 6.6)
- ☐ Contract a private locate, where available (See Section 6.6)
- ☐ Perform a site walkover-visual inspection (See Section 6.7)
- ☐ Ensure utilities are adequately marked (See Section 6.8)
- ☐ Ensure critical zones are identified and cleared (See Section 6.9)
- ☐ Ensure minimum distances are maintained from overhead lines (See Section 6.10)
- ☐ Complete the SSC Field Checklist (See Section 8.2 and Attachment B, Table 2)
- ☐ Conduct and document the daily project/safety meeting (See Section 8.3)
- ☐ Retain project-related documentation in project file (See Section 10)

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FIGURES

Figure 1: Critical Zone Definition

Figure 2: Clearing the Critical Zone

Figure 3: Overhead Utility Clearance

ATTACHMENTS

Attachment A: Pre-Project Planning Checklist

Attachment B: SSC Field Checklist

Attachment C: One Call Agency Contacts

Attachment D: Anatomy of Utilities

Attachment E: Underground Locating Equipment

Attachment F: Common Utility Markings

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ACRONYMS AND ABBREVIATIONS

CAT	Cable Avoidance Tool
GD	Ground Disturbance
HASP	Health and Safety Plan
H&S	Health and Safety
HSC	Health and Safety Coordinator (Ramboll Environ)
IA	Intrusive Activities
JSA	Job Safety Analysis
MP	Managing Principal (Ramboll Environ)
PD	Project Director (Ramboll Environ)
PIC	Principal-in-Charge (Ramboll Environ)
PM	Project Manager (Ramboll Environ)
PPE	Personal Protective Equipment
RA	Risk Assessment
Ramboll Environ	Ramboll Environ US Corporation, formerly ENVIRON International Corporation (ENVIRON)
SSC	Subsurface Clearance
SPI	Standard Practice Instruction

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DEFINITIONS

Critical Zone: The area bounded by a 5 foot (1.5 meter) radius extending horizontally from the intrusion point where subsurface objects may exist that if encountered could result in injuries, damaged equipment or property, or disruption of utility services.

See Figure 1 below for an example of a single intrusive location and the 5 foot (1.5 meter) critical zone around it that must be cleared.

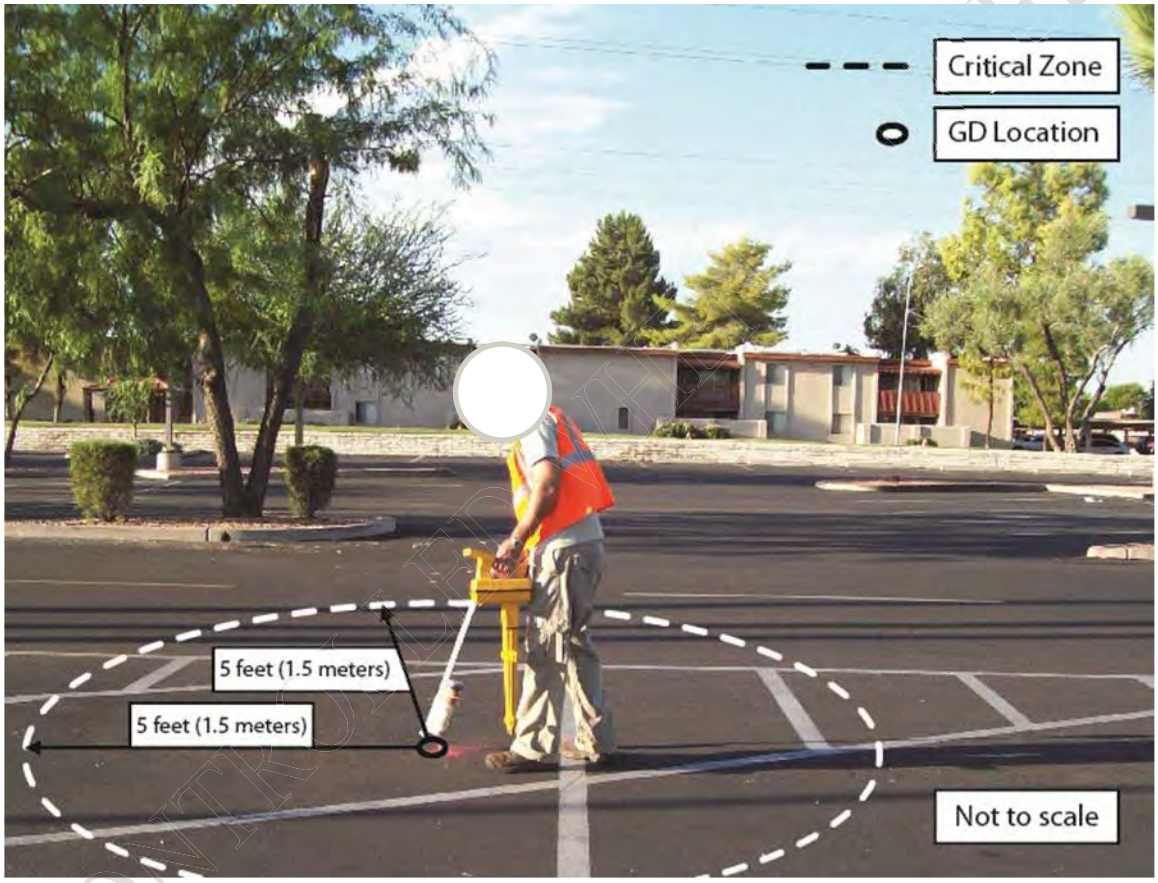

Figure 1:

The white dashed circle represents the critical zone of 5 feet (1.5 meters) radius from the Intrusion Point.

Designated Person: An employee assigned by the PM or PIC/PD that has sufficient professional or technical training, knowledge, experience and authority to implement the requirements in this SPI.

Dig/Drill Zone: The area of ground or surface to be disturbed during drilling or excavating.

Excavation: Any man-made cut, cavity, trench or depression in the earth's or other surface, formed or caused by earth or material removal.

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Director of H&S: When used in this document, this term refers to the Global and European Directors of Health & Safety and/or their designated person.

High Risk Area: Exploration/excavation locations that require a higher level of precaution due to the increased level of danger and/or potential complexity of underground systems/services. Examples include: the edge of any tank/basin, pump islands, and/or pump galleries; areas containing electrical transformers, compressors, production wells, loading racks or other process equipment associated with underground utilities and/or structures, and; areas with the potential for unexploded ordinances.

Ground Disturbance Point: The point on the ground surface where intrusive work will be performed. This may be a single point such as when using a hand augur or a large area where an excavator will remove the surface.

Intrusion Point: The point where intrusive work will be performed; this can include ground surfaces as well as building/structural surfaces.

Intrusive Activities (IA): Any indentation, interruption, intrusion, excavation, construction or other work activity that disturbs the surface of a building/structure material or the earth.

Line Location Organization: Commonly referred to as a "One Call," an organization that coordinates utility locating services with member utility companies. Line Location Organizations may not be located in all geographical regions and/or countries. Refer to your regional / country specific organizations for availability.

One Call: A commonly used term for a service that coordinates utility locating services (e.g., "One Call" system in North America, "Before You Dig" in Australia and UK). These organizations do not perform the locating service themselves but rather contact the affected local utility companies, which will then mark where their utility lines are buried, but only on public property. A summary of contact information for several One Call organizations is provided in Attachment C.

Plot Plan: A map of the site that reflects the known underground facilities, pipelines and/or utilities in the vicinity of the work areas, proposed ground disturbance and/or intrusive areas, and visual indicators of underground utilities present at the site. Map may be hand-drawn, on an existing site or pipeline plan, or computer generated as long as the distances and/or scale are reflected.

Search Zone: The parcel of land or definitive area where intrusive activities may be performed and which can be subject to locating of utilities.

Subsurface Clearance (SSC): Use of specialized equipment to locate subsurface structures and objects and mark them on a map and/or the surface in order to avoid them during intrusive work activities.

Sweep and Search: An electronic sweep of the critical zone or any other critical area using grid patterns and a locator capable of detecting buried objects. Note that some location equipment can only detect metallic objects; locators that can detect both metallic and non-metallic objects are required.

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Ticket: A service or request made to a One Call organization. Ticket life must be valid for the term of the project.

Tolerance Zone: The tolerance zone is the width of an underground utility plus a specified tolerance distance on both sides of that utility; this zone varies based on utility company requirements and/or local, city, county, State, and/or country specific regulations. Under NO circumstances are powered-digging equipment to be used within this zone.

Unobstructed Intrusive Locations: A series of locations in close physical proximity and unobstructed by an edifice(s) so that Designated Person can accurately infer the connectedness of the underground utilities in that area. For example, if ground disturbance points surround a large building on site and public utilities are also present, it would be prudent to perform SSC Checks for each unobstructed group of points.

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1. OVERVIEW

Ramboll Environ will review and evaluate this SPI on a triennial basis or when changes or incidents occur that prompt revision of this document. Effective implementation of this program requires support from all levels of Ramboll Environ management within Ramboll Environ and communication of its requirements to affected personnel.

2. SCOPE

The purpose of this Subsurface Clearance (SSC) SPI is to reduce the likelihood of subcontractors or Ramboll Environ employees encountering subsurface or overhead structures and utilities during intrusive activities being performed on Ramboll Environ projects. The SSC requirements outlined in this SPI are met by:

- Implementing the procedures presented in this SPI
- Developing and implementing a site-specific Health and Safety Plan (HASP) / Risk Assessment (RA)
- Completing the Intrusive Work Pre-Project and Field Checklist
- Training employees
- Complying with applicable regulatory requirements; and
- Following guidance provided by a utility company and/or One Call organization, as applicable.

It is recognized that country-specific procedures may slightly vary (e.g., commercial line location services may not be available). In these instances, the minimum SSC requirements to be followed are presented in Section 7.0 of this SPI, "Manual Verification".

Intrusive Activities (IA) include but are not necessarily limited to:

- Mechanical excavation (back hoes, drilling augers, probes, etc.);
- Manual ground penetration (other than surficial sampling and hand clearing when preapproved in critical zones);
- Intrusion in manmade surfaces (such as Sheetrock, asphalt, cement, flooring); and
- Mechanical scraping activity (e.g., road grading).

3. RISK ASSESSMENT

Conducting an effective risk assessment prior to commencing any job is an integral part of occupational health and safety management which identifies the potential hazards, assesses the risk and includes implementing control mechanisms. In general, the steps to be completed as part of a risk assessment are as follows:

1. Conduct a thorough review of the tasks that need to be performed to complete each job;

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2. Identify the hazards that may result in undesired events potentially causing injury, damage or environmental impacts;
3. Assess the level of risk based on these hazards that may arise when conducting the identified tasks; and
4. With a complete understanding of the proposed tasks, hazards and risks, implement the appropriate control mechanisms to mitigate the identified hazards.

Although a thorough risk assessment will need to be conducted for the entire proposed scope of work, at a minimum and in general, project personnel will need to include underground and/or overhead hazards as part of the overall risk assessment, as applicable. Some hazards to consider are as follows:

- **Chemical Hazards**: These may include the chemicals of concern on the site which personnel may come into contact with during work activities (e.g., drilling on a landfill, excavation of contaminated soils) and/or chemicals which are brought onto the site for use, if applicable;
- **Site Hazards**: The Site location and surrounding areas may have irritating plants/insects/animals, uneven walking/working surfaces, bodies of water, railroads, etc.;
- **Jobs/Tasks**: Specific jobs/tasks related to working around utilities (e.g., uncovering, striking and/or damaging an underground / overhead utility, heavy machinery/drill rigs, etc.); and
- **Safety Hazards**: Security issues, lone working, seasonal hunting, inclement weather, etc., as applicable.

The greatest risk when working around underground and/or overhead utilities is striking and/or damaging the utility. The risk varies with the type of line service for example, electricity versus water or telecommunication cables, etc.

Using the general hazards that are outlined above, the level of risk and the potential control mechanisms can now be assessed and implemented, respectively, which would complete an effective risk assessment. More importantly, the contents of this SPI should be used and considered as part of the risk assessment in order to understand and identify the specific task/job/project hazards, risks and control mechanisms associated with the type of work activities that is desired to be completed. In addition, other SPIs and/or country specific regulatory requirements (if more stringent than the applicable SPI) should also be considered as part of the overall risk assessment, as applicable.

4. ROLES AND RESPONSIBILITIES

- **Ramboll Environ H&S Director and Designated Representatives:**
  - Approving exceptions to this SPI and intrusive work in High Risk areas in advance, as required by this or HASP policy.

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- **Ramboll Environ Principal in Charge (PIC) / Project Director (PD):**
  - Define contractual and legal responsibilities associated with intrusive activities before site work begins.
  - Ensuring and verifying that intrusive project work activities are consistent with this SPI and any associated practices.
  - Approving exceptions to this SPI or in the site Health and Safety Plan (HASP) / Risk Assessment (RA) in advance and with H&S approval.
  - Assigning responsibilities to trained and experienced Ramboll Environ personnel (i.e., Designated Persons) in a manner consistent with goals and objectives of this SPI.
- **Ramboll Environ Project Manager:**
  - Implement the requirements of this SPI on each project that involves intrusive work activities
  - Approve the site-specific HASP for each project
  - Approve the SSC Field Checklist
  - Retain project-related documentation in project file
- **Ramboll Environ Personnel:**
  - Attend training in Ramboll Environs' SSC procedures by completing the SSC on-line module and must comply with this practice and site-specific procedures, as applicable.
  - If assigned the role of Designated Person, be responsible for implementing the requirements of this SPI as assigned by the PM or PIC/PD
  - Halt work activities that post a serious and imminent danger to persons, property or the environment.
- **SSC Contractor:**
  - Observe, with Ramboll Environ, the intrusive point and critical zone of each intrusive work area.
  - Perform work in accordance with regulatory and contractual requirements.

5. MINIMUM REQUIREMENTS FOR SUBCONTRACTOR ENGAGEMENT

Subcontractors who provide locating services to Ramboll Environ are required to meet the requirements in this SPI through use of their own standards, practices and procedures that meet or exceed those described in this SPI.

Each project that utilizes a locating subcontractor must have a fully executed subcontract agreement in place prior to initiating any field activities. The agreement must:

- Utilize the template subcontract agreement form, or equivalent;
- Be signed by the applicable Ramboll Environ representative;

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- Define the project scope, budget, and general terms and conditions (T&C), at a minimum;
- Be correctly and completely executed by both parties;
- Be retained either in hard copy or electronically; and
- Accompanied by a proof of insurance. For projects completed in North America, the certificate of insurance must be provided, and at a minimum:
  - Comply with our subcontract agreement
  - Name Ramboll Environ as additionally insured, and the client, as applicable;
  - Be valid and in effect for the entire project; and
  - Include the proper types and limits for the work being conducted (e.g., locator vs. driller).

Utility locating services without a fully executed subcontract agreement (or the equivalent) and proof of insurance are prohibited from working on Ramboll Environ projects. Any deviation from this requirement must be pre-approved in writing by the PIC/PD and/or the Director of H&S and described in the HASP/RA.

Locating contractors should be able to or provide evidence of appropriate training and experience in:

- Operating the required equipment for locating underground utilities and interpreting and processing raw data to define the type, location and size of subsurface utility lines, where applicable;
- Maintaining and calibrating locating equipment;
- Serving as a liaison with local asset owners to gain their knowledge/experience of the area; and
- Where applicable, coordinating a public utility mark-out by contacting the designated "One-Call" agency for the area.

6. PRE-JOB PLANNING

The following tasks should be completed and documented prior to initiating intrusive activities (each of which is fully described in the sections referenced below):

- Historical site information review (Section 6.2)
- Development of site-specific HASP/RA (Section 6.3)
- Preparation of a Plot Plan (Section 6.4)
- Pre-marking of intrusive locations (Section 6.5)
- Line location services (Section 6.6)
- Site walkover-visual inspection (Section 6.7)
- Utility mark out (Section 6.8)

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- Clearance of critical zones (Section 6.9)
- Overhead lines (Section 6.10)

6.1 General Requirements

The PM or Designated Person must ensure that where applicable:

- The appropriate Line Location Organization (e.g., One Call, Dial Before You Dig, etc.) and private utility locators are notified a minimum of 72 business hours in advance of planned intrusive activities, or as applicable by the local, state, region or country requirements/regulations;
- Utilities are appropriately marked, and
- The proposed intrusive locations have been cleared to the critical zone.

Where Line Location Organizations and private utility locators are not available in a project area, the PIC/PD is to be notified and guidelines presented in Section 7.0 must be applied.

6.2 Historical Site Information Review

The PM or designated representative will ensure that available historical site records are reviewed and interviews of knowledgeable site personnel are conducted and cross referenced to determine the potential existence and location of underground facilities/pipelines and utilities in the vicinity of the work areas. When sources are reviewed and/or interviewed, this information will be documented (e.g., in the HASP / RA, on the SSC Project Checklist, and/or contained in the logbook / field notes).

The following are examples of information associated with identifying subsurface structures:

6.2.1 Maps and Plans

Plot plans, facility maps or lease drawings, as available, can be one source that can be reviewed and cross referenced with other sources of information to verify accuracy and develop a Plot Plan showing existing utilities and intrusive activities planned at the site as accurately as possible. The Plot Plan can be created onsite by hand in the field log, on an existing site plan, or in electronic format as long as the measurements and/or scale are accurate. Sources of information relevant to underground utility location may include:

- Maps and figures showing under and aboveground equipment, piping, utilities and/or any surface or subsurface hazards;
- Historic site information (maps, photos, files);
- Site as-builts drawings;
- Easement maps and historical Plot Plans;
- Previous site investigations;
- Fire insurance plans;
- Tank dip charts; and

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- Elevations and coordinate maps.

It is important to note that as-builts and historic maps may not accurately reflect existing conditions including proposed utilities that were never built or more recent modifications. Therefore, do not negate the requirement for a public and private utility locate, where available.

6.2.2 Interviews

When available or is reasonable to do so, the names of personnel that are consulted for information about utilities and subsurface structures in the purposed work area will need to be documented (e.g., in the HASP / RA, on the SSC Project Checklist, and/or contained in the logbook / field notes). Potential sources can include but not be limited to the following:

- Client / facility / operator personnel that may be familiar with area operations and/or may have knowledge of facilities/pipelines and/or abandoned and/or recently installed lines not otherwise documented.
- Landowner and/or tenants may also have knowledge of buried utilities and other site information.

6.3 HASP / RA

A site-specific HASP and/or RA must be developed prior to initiating field activities. Concerning SSC, the HASP/RA must:

- Complete the pre-project planning checklist (refer to Attachment A, Table 1) which outlines the SSC tasks to be completed prior to intrusive activities. Proposed dates and activities should be as accurate as possible for planned field activities. When information is not available at the time the HASP is drafted and approved, the Designated Person must ensure the pre-project planning checklist is updated and completed prior to intrusive activities. In addition to planning SSC steps for the project, this checklist should also be used to provide justification for each exemption to the required clearance processes;
- When on Site, and prior to intrusive activities, complete the SSC Field Checklist (refer to Attachment B, Table 2) for <u>each location</u> where intrusive activities are anticipated to occur or for each group of unobstructed intrusive locations. Conservative, professional judgment is to be used in determining whether subsequent intrusion points are unobstructed and if one SSC Field Checklist can be used to clear all locations. As a reminder, the SSC Field Checklist is to be completed prior to intrusive activities being performed and be used as a tool for double checking that all actions that need to be completed;
- Include a Plot Plan indicating the location of known underground and overhead facilities and utilities within the search zone available for reference at the work site;
- In the event intrusive work is required within a high risk area, include approval from PIC/PD and the Director of H&S.
- Include a list of emergency response resources with telephone numbers; and

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- Include a list of client, regulatory, Ramboll Environ, utility, and subcontractor emergency contact information and procedures.

If proposed field activities differ from the scope of work, Plot Plan and/or the Pre-Project Planning Checklist, the Designated Person will ensure that the project-specific HASP and Pre-Project Planning Checklist are updated to reflect these changes and communicate those changes to project personnel. Deviations from specified requirements must be documented and approved prior to the commencement of intrusive activities.

6.4 Plot Plan

Intrusive activities are not to proceed without a Plot Plan clearly indicating the facilities/pipelines or utilities, locations and their alignments in the project area. A Plot Plan is a map of the site that reflects the known underground facilities, pipelines and/or utilities in the vicinity of the work areas, proposed ground disturbance and/or intrusive areas, and visual indicators of underground utilities present at the site. Map may be hand-drawn, on an existing site or pipeline plan, or computer generated as long as the distances and/or scale are reflected.

If the information needed to create a Plot Plan is not available and/or known in the pre-planning stage, at a minimum, the logbook or field notes will include a map to reflect the Site, the proposed intrusive locations, and the critical zone surrounding them. While in the field, existing information can then be added to reflect available information (e.g., above ground visual indicators like a transformer or a gas meter), and site conditions as accurately as possible. If the Plot Plan is a separate, stand-alone document (i.e., not part of the field logbook), this information should also be clearly identified and referenced in the field logbook / notes.

6.5 Pre-Marking of Intrusive Locations

If practical, intrusive points and critical zones should be pre-marked with easily visible, identifiable markings such as brightly colored stakes, white paint or white flags (or black in cases where snow is on the ground) prior to the public and/or private utility mark-outs. Pre-marking provides the utility line locators with visual boundaries as guidance in clearing locations and placing marks.

During subsurface pre-project planning consider additional locations for clearance in the event that refusal is met at specific boring locations. A twenty-five percent (25%) buffer is recommended (i.e., one alternate boring location for every four (4) borings planned). Alternate borings also be located and cleared using the requirements outlined in this SPI.

6.6 Line Location Services

In areas where public <u>and</u> private resources are available, Ramboll Environ or a designated subcontractor will contact both public and private utility locate services for projects that involve intrusive activities.

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In order to give utility line operators sufficient time to respond to a request to locate, a minimum of 3 business days should be provided prior to the planned start of work, or as required by local, state, region or country regulations.

In rare instances, confidentiality agreements may restrict notification of public utilities. In these cases, and when allowed by local regulations, this exception and justification must be noted in the HASP/RA and approved by the PM, PIC/PD and Director of H&S. In the event that a subcontractor performs the location, Ramboll Environ will confirm with the subcontractor the utility locate information (including, but not limited to, the One Call (Attachment C) and /or private locate service contacted, confirmed public utilities on the site, positive responses from utility companies).

6.6.1 Public Utility Locate

Public utility locators may only mark lines on public property, easements or rights-of-way. This means private lines running from the main line may not be marked. To ensure that these lines are also located and marked, a Private Locating Company must be retained (see Section 6.6.2 below) entitled "Private Utility Locate".

Nonetheless, it is important to provide an accurate location to the One Call service. Address, City, Township, County and other location designations can change and should be confirmed prior to submitting the clearance location to the One Call service. Universal search tools, such as Google, mapping tools, and the most up-to-date area maps, can be used to aid in verifying information where uncertainty exists.

When a One Call service order is made, otherwise known as a "ticket", the One Call organization contacts each utility company that is a "member" of their service. Then, each member utility then sends out a One Call Utility Locator to mark their services in the area specified. The person who makes the call must confirm which utility companies are and are NOT included in their service and record this information in the Pre-Project Planning Checklist (Attachment A, Table 1).

It is important to provide as accurate a location for locating as possible to the One Call service. In some instances, a location may be annexed or moved from a township/county/location it had previously listed as an address, which can create confusion regarding the locate ticket request sent to the facility company. City, Township, County and other location designations should be confirmed prior to submitting the clearance location to the One Call service to ensure public locators clear the appropriate location(s). Universal search tools, such as Google, mapping tools, and the most up-to-date area maps, can be used to aid in verifying information where uncertainty exists.

It should be noted that in some areas, not all of the utility companies have agreements with the One Call service. This means that not all utility companies are part of the One Call process. For example, a city water or sewer department may not participate whereby their utilities would not be included nor marked by the One Call service. Hence, the Designated Person who places the One Call public locate request should follow-up with the One Call service to identify which utility companies are being dispatched to the location and record this information in the Pre-Project Planning Checklist (Attachment A, Table 1).

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Crosscheck the list of member utilities in the proposed area with the following list of common utilities to ensure potential facilities have been identified on the site. This comparison can be documented on the SSC Field Checklist (Attachment B, Table 2) and/or field logbook:

- Telephone
- Cable television/communications
- Natural gas
- Electricity
- Water
- Sewer/stormwater
- Optical fiber

Before intrusive activities begin, utilities must be marked or an "all clear" received, unless an exemption has been pre-approved. An "all clear" can consist of a mark at the site (such as "no electric" painted on the ground) or direct contact from the utility via fax, email or a phone call indicating the lack of facilities in the project area. If contact is not made by the agencies identified by the public utility locate process, it should **NOT** be assumed that such utilities are not present. Instead, the One Call service should be re-contacted to determine the status.

One Call services often provide a "positive" call back. This may mean that:

- Each member company notified the ticket originator that they do not have any facilities in the proposed dig area, or that they have marked the approximate locations (usually within a 48 hour period).
- The One Call service may have only posted a comment (e.g., they need an extension).

Therefore the nature of the positive call back must be confirmed. Communications regarding utilities for a specific project should be kept with the HASP/RA in the project file and/or written in the field logbook.

If contact is not made by the agencies identified by the public utility locate process, it should **NOT** be assumed that such utilities are not present. Instead, the public utility locate agency should be re-contacted to determine the status. If you arrive at the site and the public utilities have not been marked and /or "all clear" communications have not been received, **INTRUSIVE WORK IS TO BE HALTED** and a follow-up call made to the One Call service. Allow adequate time for the utility companies to respond to the re-mark request. Consider checking the work area for facilities/pipelines or utility markers or meters in order to verify the correct company has been contacted to clear utilities or supply additional information.

Most public "One Call" utility mark-outs have a limited time period for which they remain valid. It is critical that this time period be taken into account to prevent the expiration of clearance prior to the completion of intrusive field activities. Confirm the ticket life is valid for the extent of the project. The applicable ticket life varies from locale to locale. An

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extension can be requested when there are no changes to the jobsite address or extent of work.

Generally, most standard public utility locators will only mark the main line for the utility company to which they are contracted and only mark up to the property line. Water and sewer companies locate main water lines in easements and rights-of-way and lines to a water meter, but may not locate the water facilities from a meter to a home or sewer lateral. Electric companies **usually** locate their lines to homes and businesses, but not those running to swimming pools pumps, irrigation systems or other buildings on the property. **This means private lines running from the main line may not be marked.** To locate and mark these lines, a Private Locating Company (see section 6.6.2 below) must be retained.

6.6.2 Private Utility Locate

When intrusive work occurs on or near private property, a private locator must be retained to locate utilities, as available. Many private locators will only locate from the marked utilities located by the public utility locate service by placing a trace signal on those lines and identifying where the lines are buried. While this is an accurate method for locating those specific lines, it is possible to miss utilities that are not identified by the public utility locate service.

A more comprehensive underground inspection will be conducted by the private locator, with special attention paid to any visual indicators or utilities, high risk areas and **the specific intrusive location(s), and critical zone(s)** using a search and sweep method, as project conditions warrant.

Some of the most common private facilities include:

- Fiber optic telecommunication cables
- Aboveground and underground tanks and delivery systems
- Industrial steam and condensate pipes
- Satellite television cables
- Stadium and security lights
- Lighted commercial signs
- Process water and fire protection systems
- Low voltage electrical wiring
- Electric fence / animal containment systems

Upon completion of their work, the private locator should contact the Designated Person to present their results. In addition to providing an overall summary of their work, the private locator should also identify any unique circumstance(s) that limited their ability in locating the potential presence of underground utilities (e.g., the existence of overhead electrical lines); if they encountered any abnormalities (e.g., concrete surfaces with reinforced rebar); and/or any other condition which may have diminished the validity of their results and efforts (e.g., concrete reinforced with rebar).

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Further, designated Ramboll Environ personnel technically trained and competent in using Cable Avoidance Tools (CATs) are required to clear Intrusive locations and/or areas prior to intrusive activities. This is both in areas where private and public locators are and are not available.

6.7 Site Walk-Visual Inspection

The Designated Person must complete the SSC Field Checklist (Attachment B, Table 2) during a site walk-visual inspection to identify above ground indicators which may identify the potential existence of subsurface issues and to confirm that common and/or expected utilities have been accounted for, located and verified prior to commencing intrusive activities. The site walkover and visual inspection is most effective when done during the private locate, because the extent of locating efforts can be verified and questions regarding visual indicators answered. Where possible, a site representative with knowledge of subsurface utilities/structures should also participate in the site walk/visual inspection.

Visible indicators are evidence of underground utilities within the proposed work area and search zone, examples of which are contained in Attachment D, "Anatomy of Utilities". These may include:

- Facilities/pipelines
- Power lines
- Natural gas pipelines
- Gas meters
- Aboveground and underground tanks
- Electric service risers
- Utility cables
- Nearby lines and structures
- Patches in concrete or asphalt
- New clearings
- Spoil piles
- Road construction
- Previously disturbed soils
- Service pits
- Buildings with no visible evidence of service
- New vegetation, color changes or growth
- Edge of any tank basin, pump island, pump gallery, manifold, electrical transformer, compressor, production well, explosive magazines, loading rack, or other process equipment with associated underground lines.

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If any visual indicators are discovered during the site walk that are not reflected on the Plot Plan, the field book and the Plot Plan must be accurately marked to reflect these observations. Intrusive work will not commence until identified issues with the indicators have been resolved.

Where doubt exists over the location of a service, request a site visit from the appropriate utility provider or abandon locations in the immediate area and contact the PM and/or PIC/PD.

6.8 Utility Mark-out

Known pipelines and utilities that pass within the search zone will be located, identified and marked to indicate location and alignment and be documented.

If possible, the Designated Person should meet with the private locator to provide him or her with:

- Intrusive plans pre-marked with intrusive locations and critical zones as well as an appropriate number of alternate locations
- A Plot Plan and/or the results of the visual inspection
- Plans depicting proposed exploration / excavation locations.

If an onsite meeting with the private locator is not possible, conduct a phone call with the private locator to ensure they understand the scope of the proposed subsurface work and the extent of activities.

A qualified and competent line locator (as outlined in Section 4) should:

- Conduct private line-locating practices utilizing appropriate equipment (Attachment E provides a brief description of the types and attributes of commonly used locator tools) and Plot Plans for all areas within the search zone.
- Directly connect (clamp on) to possible nearby underground services to increase the success rate/reliability in locating.
- Energize electrical sources within the vicinity (e.g., light poles, signs, pumps, etc.) at the time of locating. This increases the chance of identifying potential underground electrical services.

If anticipated services have not been identified or located, drilling or intrusive work will not occur until the service is visually identified or confirmed to be absent. Examples include: when a visual indicator of a line is present (such as a sewer grate) and no line is traced from it, or if a utility line is indicated on a historical site drawing, but no investigation has occurred in the field to confirm or deny its presence. Potential intrusive locations with suspected subsurface utilities/structures present must be avoided and a new location at least five feet (1.5 meters) away must be cleared.

Using the information obtained during the visual inspection, public One Call mark-out and the private utility mark-out, the proposed exploration/excavation locations will be confirmed

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in the field. The markings of locations should be made in accordance with the generally accepted color code for facilities identification for the region. Attachment F provides examples of commonly used utility mark out colors and identifiers, which may differ by area, region or country. Check local regulations prior to intrusive activities to ensure that markings are clearly understood by the field staff.

Further, where Ramboll Environ personnel are trained and competent in their use, Cable Avoidance Tools (CATs) will be used to clear intrusive locations and/or areas to the critical zone prior to intrusive activities.

6.8.1 Line Location Methods

A variety of remote sensing technologies can be used for detecting underground facilities depending on structural composition of the buried materials, soil composition, and surface access. There is no one procedure or tool that can provide accurate location information for all types of facilities in all types of situations. Attachment E entitled "Underground Locating Equipment" provides a brief description of the types and attributes of commonly used locator tools.

In addition to equipment choice, there are situational variables that affect detection accuracy. For example, the more conductive the soil, the more shallow the conductor can appear. Sandy, loose soil with a high mineral content can give sensitive readings; pipe locations under these conditions may be deeper than the locator equipment readings indicate. Moisture content or water table levels can also affect depth readings. Locating indoors provides additional difficulties, including but not limited to interference from reinforced concrete, canopies, and metallic structures.

For equipment that determines location by sensing an electronic signal introduced into the underground system, the strength of the equipment depends on where the signal was introduced into the system, proximity of structural uprights connected to the underground system, and nearby surface obstructions that dissipate the signal. Selection of radio signal frequency can also affect signal clarity. **Equipment readings cannot be taken as absolute values.** They depend on situational effects associated with locator equipment calibration, field conditions, and the operator's familiarity with the particular operating characteristics.

Plastic and concrete pipe and fiber optic cable are difficult to detect with common locator tools because they do not contain metal. A metal tracer wire or detectable warning tape may be buried with or attached to the pipe/facility when they are first installed to aid in locating these structures at a future date. Varieties of tracer wire and detectable tape are designed to be sturdy enough to be plowed into the trench during backfill operations.

6.9 Clearance of Disturbance Locations within Critical Zones

After anticipated utilities have been located and marked, use the available information along with regulatory requirements and project objectives to select final intrusive locations **that have been cleared to the edge of the critical zone**. Ensure that detected services and those featured on location plans are outside of the critical zone.

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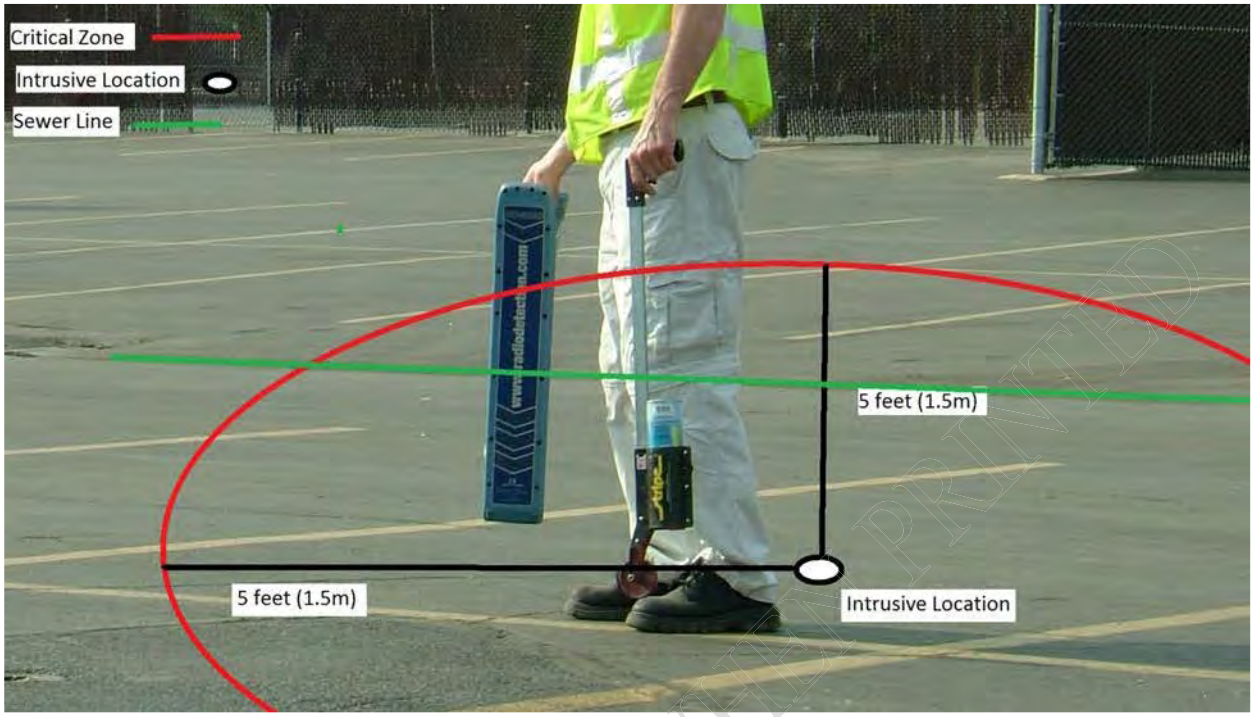

Figure 2:

A private locator clears the critical zone for a boring location. In this figure, the visual indicator of the sewer line is outside the critical zone, but the line has been laterally traced to the edge of the critical zone, therefore a new boring location should be chosen.

The critical zone takes into account minimum tolerance distances from facility lines (which vary by location) and uncertainties introduced by onsite conditions, human factors, and equipment. When known utilities intersect critical zones, the PM must be notified and ideally, the intrusive location would be moved to a pre-cleared alternate location. Intrusive activities will not take place within a critical zone where utilities or visual indicators intersect without the prior approval of the H&S Director.

In the event that work must be conducted in a critical zone containing a marked utility or visual indicator, approval must be obtained from the PIC/PD and Director of H&S prior to conducting intrusive activities. The approval and approved methodology for intrusive work closer than 5 feet (1.5 meters) from utilities will be made on a case-by-case basis once adequate information has been provided and reviewed by the Director of H&S, and PIC/PD. The decision will be made based on:

- Location criteria (the reason a boring/sample is needed in that location);
- Distance from the utility;
- Drilling method;
- Confidence in location methods;
- Geophysical conditions at the site;

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- Pipe construction and contents;
- Regulated tolerance distance at the location; and
- Other influencing factors.

At a minimum, any mechanical intrusive activities that occur within 5 feet (1.5 meters) of a utility or indicator AND have been authorized by the PIC/PD, and Director of H&S, will be hand cleared or vacuum excavated to a depth of 6 feet (1.8 meters). **Hand digging or auguring, manual excavation or soft-dig techniques may not be used in lieu of the SSC requirements presented in this SPI.** Any deviation from these requirements stated must be approved in advance by the PIC/PD and Director of H&S.

6.10 Overhead Lines

Overhead power lines that may pose a hazard during movement of equipment must be clearly documented and minimum clearance distances will be maintained. Regulated minimum distances vary by voltage, area, region, and country. When voltage(s) of nearby power lines have been determined and confirmed by the utility company, Ramboll Environ personnel will maintain the minimum distance required by applicable regulations or requirements.

When the specific voltage and minimum clearance distances are **unknown**, the following clearance distances will be maintained:

- Intrusive activities performed by raised mechanical equipment must be located a minimum clearance distance of:
  - 28 feet (8.5m) horizontally from any overhead electric cable supported on wooden poles; or
  - 50 feet (15.25m) horizontally from any overhead electric cable supported on metal poles/towers.

If clearance distances cannot be achieved, the relevant electricity provider must be contacted for guidance; the PIC/PD and Director H&S will be notified as well.

To apply the clearance distances described above:

1. Estimate the ground position parallel to the power line overhead based on visual observations. Do NOT come in physical contact with the line or use vertical tools to estimate positioning.
2. From that ground position, measure the lateral distance from the line as required above
3. Ensure intrusive locations are further than the required distance from overhead lines. Repeat steps 1 and 2 at different locations, as necessary to address larger intrusive areas.
4. Take strong winds that may cause the lines to move or droop, into consideration and give the drill mast a 3-foot (0.9m) buffer zone.

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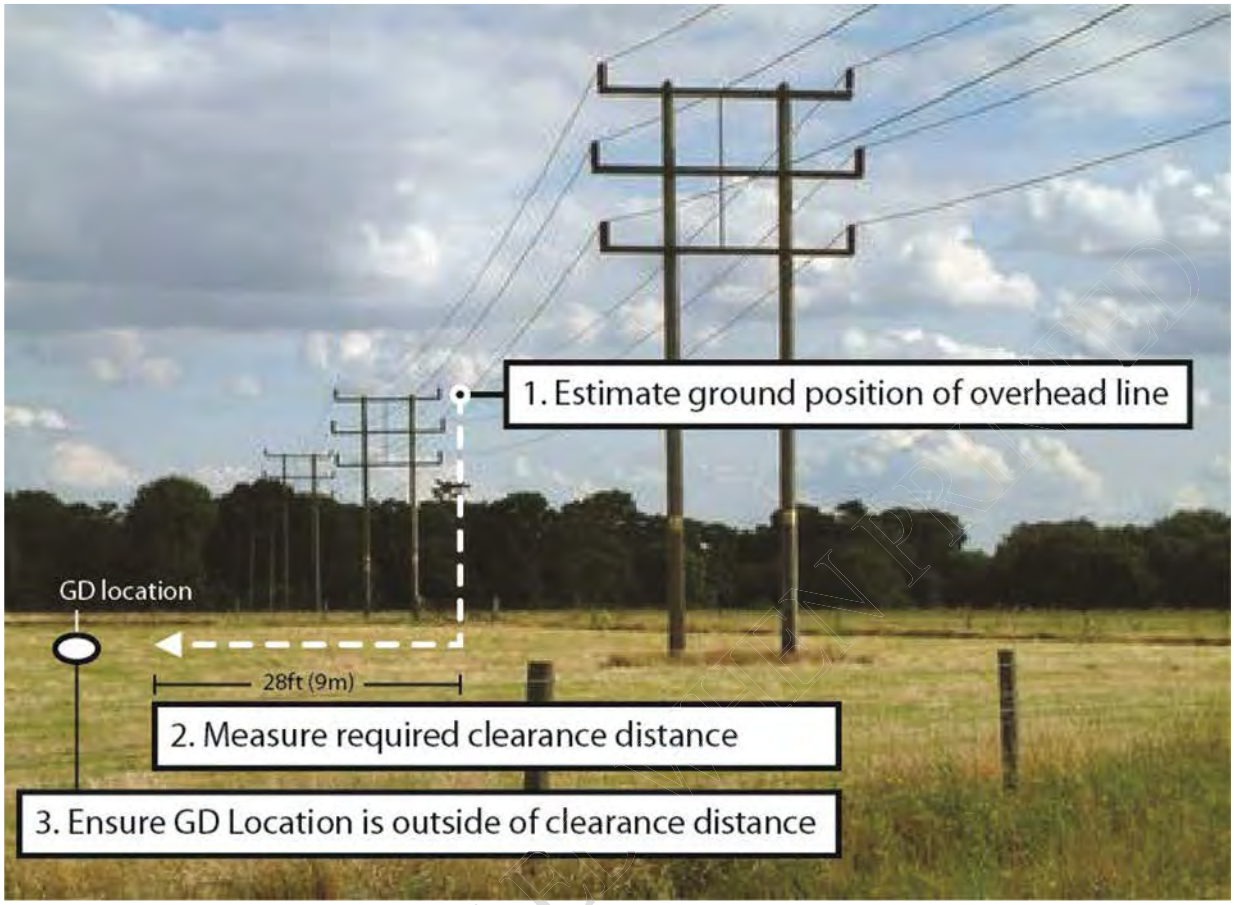

Figure 3:

To measure the ground distance from an overhead utility line, estimate the ground position of the line, measure the lateral distance from that point, and ensure the boring location is outside the clearance area.

A spotter must be used when mechanical equipment is being raised or lowered, to ensure safe distances are maintained. Keep in mind that the angle changes as the mast moves and travels into its vertical position.

7. MANUAL VERIFICATION

In areas where public and private utility locators are **not** available or cannot access the site, in general, the work practices conducted prior to intrusive activities are exactly the same as when private locates are available, with the exception that Ramboll Environ employees have the responsibility of clearing the critical zone surrounding each intrusive location. More specifically, the requirements to be followed for areas where public and private utility locators are **not** available or cannot access the site, verify that:

- A local One Call organization and private utility locators are not available for the area;

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- Due diligence regarding historical site information has been performed and a site-specific Plot Plan has been developed;
- A visual inspection has been performed;
- The proposed intrusive locations are cleared to a minimum of 5 feet (1.5 meter) extending in the horizontal direction where intrusive work is planned, and;.
- Hand digging, hand auguring, or soft-dig methods (i.e., vacuum excavation) will be employed to a depth of 6 feet (1.8 meter) below ground surface (bgs).

7.1 Historical Site Information Review

The PM or designated representative will ensure that available historical site records are reviewed and interviews of knowledgeable site personnel are conducted and cross referenced to determine the potential existence and location of underground facilities/pipelines and utilities in the vicinity of the work areas. When sources are reviewed and/or interviewed, this information will be documented (e.g., in the HASP / RA, on the SSC Project Checklist, and/or contained in the logbook / field notes).

The following are examples of information associated with identifying subsurface structures:

7.1.1 Maps and Plans

Plot plans, facility maps or lease drawings, as available, can be one source that can be reviewed and cross referenced with other sources of information to verify accuracy and develop a Plot Plan showing existing utilities and intrusive activities planned at the site as accurately as possible. The Plot Plan can be created onsite by hand in the field log, on an existing site plan, or in electronic format as long as the measurements and/or scale are accurate. Sources of information relevant to underground utility location may include:

- Maps and figures showing under and aboveground equipment, piping, utilities and/or any surface or subsurface hazards;
- Historic site information (maps, photos, files);
- Site as-builts drawings;
- Easement maps and historical Plot Plans;
- Previous site investigations;
- Fire insurance plans;
- Tank dip charts; and
- Elevations and coordinate maps.

It is important to note that as-builts and historic maps may not accurately reflect existing conditions including proposed utilities that were never built or more recent modifications. Therefore, do not negate the requirement for a public and private utility locate, where available.

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7.1.2 Interviews

When available or is reasonable to do so, the names of personnel that are consulted for information about utilities and subsurface structures in the purposed work area will need to be documented (e.g., in the HASP / RA, on the SSC Project Checklist, and/or contained in the logbook / field notes). Potential sources can include but not be limited to the following:

- Client / facility / operator personnel that may be familiar with area operations and/or may have knowledge of facilities/pipelines and/or abandoned and/or recently installed lines not otherwise documented.
- Landowner and/or tenants may also have knowledge of buried utilities and other site information.

7.2 HASP / RA

A site-specific HASP and/or RA must be developed prior to initiating field activities. Concerning SSC, the HASP/RA must:

- Complete the pre-project planning checklist (refer to Attachment A, Table 1) which outlines the SSC tasks to be completed prior to intrusive activities. Proposed dates and activities should be as accurate as possible for planned field activities. When information is not available at the time the HASP is drafted and approved, the Designated Person must ensure the pre-project planning checklist is updated and completed prior to intrusive activities. In addition to planning SSC steps for the project, this checklist should also be used to provide justification for each exemption to the required clearance processes;
- When on Site, and prior to intrusive activities, complete the SSC Field Checklist (refer to Attachment B, Table 2) for <u>each location</u> where intrusive activities are anticipated to occur or for each group of unobstructed intrusive locations. Conservative, professional judgment is to be used in determining whether subsequent intrusion points are unobstructed and if one SSC Field Checklist can be used to clear all locations. As a reminder, the SSC Field Checklist is to be completed prior to intrusive activities being performed and be used as a tool for double checking that all actions that need to be completed;
- Include a Plot Plan indicating the location of known underground and overhead facilities and utilities within the search zone available for reference at the work site;
- In the event intrusive work is required within a high risk area, include approval from PIC/PD and the Director of H&S.
- Include a list of emergency response resources with telephone numbers; and
- Include a list of client, regulatory, Ramboll Environ, utility, and subcontractor emergency contact information and procedures.

If proposed field activities differ from the scope of work, Plot Plan and/or the Pre-Project Planning Checklist, the Designated Person will ensure that the project-specific HASP and Pre-Project Planning Checklist are updated to reflect these changes and communicate those

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changes to project personnel. Deviations from specified requirements must be documented and approved prior to the commencement of intrusive activities.

7.1 **7.3 Plot Plan**

Intrusive activities are not to proceed without a Plot Plan clearly indicating the facilities/pipelines or utilities, locations and their alignments in the project area. A Plot Plan is a map of the site that reflects the known underground facilities, pipelines and/or utilities in the vicinity of the work areas, proposed ground disturbance and/or intrusive areas, and visual indicators of underground utilities present at the site. Map may be hand-drawn, on an existing site or pipeline plan, or computer generated as long as the distances and/or scale are reflected.

If the information needed to create a Plot Plan is not available and/or known in the pre-planning stage, at a minimum, the logbook or field notes will include a map to reflect the Site, the proposed intrusive locations, and the critical zone surrounding them. While in the field, existing information can then be added to reflect available information (e.g., above ground visual indicators like a transformer or a gas meter), and site conditions as accurately as possible. If the Plot Plan is a separate, stand-alone document (i.e., not part of the field logbook), this information should also be clearly identified and referenced in the field logbook / notes.

7.4 Site Walkover-Visual Inspection

The Designated Person must complete the SSC Field Checklist (Attachment B, Table 2) during a site walk-visual inspection to identify above ground indicators which may identify the potential existence of subsurface issues and to confirm that common and/or expected utilities have been accounted for, located and verified prior to commencing intrusive activities. The site walkover and visual inspection is most effective when done during the private locate, because the extent of locating efforts can be verified and questions regarding visual indicators answered. Where possible, a site representative with knowledge of subsurface utilities/structures should also participate in the site walk/visual inspection.

Visible indicators are evidence of underground utilities within the proposed work area and search zone, examples of which are contained in Attachment D, “Anatomy of Utilities”. These may include:

- Facilities/pipelines
- Power lines
- Natural gas pipelines
- Gas meters
- Aboveground and underground tanks
- Electric service risers
- Utility cables
- Nearby lines and structures
- Patches in concrete or asphalt

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- New clearings
- Spoil piles
- Road construction
- Previously disturbed soils
- Service pits
- Buildings with no visible evidence of service
- New vegetation, color changes or growth
- Edge of any tank basin, pump island, pump gallery, manifold, electrical transformer, compressor, production well, explosive magazines, loading rack, or other process equipment with associated underground lines.

If any visual indicators are discovered during the site walk that are not reflected on the Plot Plan, the field book and the Plot Plan must be accurately marked to reflect these observations. Intrusive work will not commence until identified issues with the indicators have been resolved.

Where doubt exists over the location of a service, request a site visit from the appropriate utility provider or abandon locations in the immediate area and contact the PM and/or PIC/PD.

7.5 Utility Mark-out

Known pipelines and utilities that pass within the search zone will be located, identified and marked to indicate location and alignment and be documented using, but not limited to:

- Intrusive plans pre-marked with intrusive locations and critical zones as well as an appropriate number of alternate locations
- A Plot Plan and/or the results of the visual inspection
- Plans depicting proposed exploration / excavation locations.

If anticipated services are not identified or located, intrusive work is not to occur until the service is visually identified or confirmed to be absent. Where doubt exists over the location of a service, request a site visit from the appropriate utility provider or abandon locations in the immediate area and contact the PM and/or PIC/PD. Examples include: when a visual indicator of a line is present (such as a sewer grate) and no line is traced from it, or if a utility line is indicated on a historical site drawing, but no investigation has occurred in the field to confirm or deny its presence. Potential exploration locations with suspected subsurface utilities/structures present are to be avoided and a new location at least five feet (1.5 meters) away will be similarly cleared.

Further, where Ramboll Environ personnel have been trained and are competent in the use of Cable Avoidance Tools (CATs), in general, the information discussed above should be reviewed and the following first steps taken to locate utilities:

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- Conduct line-locating practices utilizing appropriate equipment and Plot Plans for all areas within the search zone.
- Directly connect (clamp on) to possible nearby underground services to increase the success rate/reliability in locating.
- Energize electrical sources within the vicinity (e.g., light poles, signs, pumps, etc.) at the time of locating. This increases the chance of identifying potential underground electrical services.

7.6 Clearance of Disturbance Locations within Critical Zones

After anticipated utilities have been located and marked, use the available information along with regulatory requirements and project objectives to select final intrusive locations **that have been cleared to the edge of the critical zone**. Ensure that detected services and those featured on location plans are outside of the critical zone.

The critical zone takes into account minimum tolerance distances from facility lines (which vary by location) and uncertainties introduced by onsite conditions, human factors, and equipment. When known utilities intersect critical zones, the PM must be notified and ideally, the intrusive location would be moved to a pre-cleared alternate location. Intrusive activities will not take place within a critical zone where utilities or visual indicators intersect without the prior approval of the H&S Director.

In the event that work must be conducted in a critical zone containing a marked utility or visual indicator, approval must be obtained from the PIC/PD and Director of H&S prior to intrusive activities. The approval and approved methodology for intrusive work closer than 5 feet (1.5 meters) from utilities will be made on a case-by-case basis once adequate information has been provided and reviewed by the Director of H&S, and PIC/PD. The decision will be made based on:

- Location criteria (the reason a boring/sample is needed in that location);
- Distance from the utility;
- Drilling method;
- Confidence in location methods;
- Geophysical conditions at the site;
- Pipe construction and contents;
- Regulated tolerance distance at the location; and
- Other influencing factors.

At a minimum, any mechanical intrusive activities that occur within 5 feet (1.5 meters) of a utility or indicator AND have been authorized by the PIC/PD, and Director of H&S, will be hand cleared or vacuum excavated to a depth of 6 feet (1.8 meters). **Hand digging or auguring, manual excavation or soft-dig techniques may not be used in lieu of the SSC requirements presented in this SPI.** Any deviation from these requirements stated must be approved in advance by the PIC/PD and Director of H&S.

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8. ON-SITE ACTIVITIES

8.1 General

The following requirements will be completed before beginning work:

- Confirm the written approvals and agreements discussed in Section 5 of this SPI, have been obtained;
- Confirm underground and overhead utilities have been located in the general search area, critical zone/proposed intrusive location(s);
- Electrical sources on-site must be de-energized during intrusive activities, where possible;
- Emergency shutoffs should be located and noted on plot plan;
- NEVER allow mechanical equipment to be moved when elements are in the extended position, such as a drill rig with the mast in the raised or partially raised, or a dump truck with a raised bed; and
- Notify landowners and/or tenant, where necessary and practicable.

8.2 SSC Field Checklist

In general, the Checklist serves as an intrusive activity permit. Intrusive activities will only begin once the Checklist has been reviewed, completed and accepted by the Designated Person on-site. Prior to commencing intrusive activities, the Designated Person on-site will review the information contained in Attachment A, Table 1 and complete the Subsurface Clearance (SSC) Field Checklist (Attachment B, Table 2) .

The Subsurface Field Checklist must be completed for each location (e.g., each drilling location) where intrusive activities will occur or each group of unobstructed locations. The completed form must be retained with the HASP in the project file, and acknowledgement that the SSC Field Checklist has been completed will be documented in the field logbook. Alternatively, it is acceptable to note that each item on the Checklist has been reviewed in the field logbook, in lieu of completing the separate form.

8.3 Daily Safety Meeting

A daily safety meeting will be conducted and documented in the HASP / RA or the field log book including the topics discussed and a signed attendance list with the printed name of the attendee, their signature, and company affiliation .

The following topics, at a minimum, will be included in the meeting:

- Review of the HASP/RA including the Hazard Analysis and Control Summary (i.e., potential hazards and safe work practices), Emergency Response Plan, applicable permitting requirements, etc.
- Review of the SSC Checklist.

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- Proposed intrusive locations/areas will be adequately marked and the critical zone cleared. Locations that have been marked on the ground and have been cleared by the private locator are considered **FIXED**. Intrusive operations MAY NOT be conducted at any position within the critical zone, other than that point or area at the center specifically cleared to 5 feet (1.5 meters) unless approval has been granted by the PIC/PD and the Director of H&S.
- Agree that project field staff have the right and responsibility to 'Stop Work' as outlined in Section 7.5.
- Donning proper personal protective equipment (PPE) as outlined in the respective HASP / RA, as required.
- Accidents, injuries, provision of first aid, near misses and unsafe acts or conditions are to be reported in accordance with SPI 19. "Incident Reporting".

8.4 Stop Work Authority

Ramboll Environ personnel have the responsibility and authority to stop work or decline to perform an assigned task without fear of reprisal should they believe such work presents an unacceptable or unmitigated hazard. The Stop Work Authority may include, but is not limited to, discussions with co-workers, supervisors, or safety representatives to resolve work related issues or concerns, address potential unsafe conditions, clarify work instructions, and/or propose additional controls.

Under NO circumstances are work activities to be performed if:

- There is an uncertainty with the results of the public and/or private locate;
- Additional information is provided after the public/private locates have been performed that contradicts/conflicts with existing information;
- Work is required within the critical zone surrounding proposed intrusive location that has not been agreed upon by the PIC/PD and Director of H&S; and/or
- Identified unsafe conditions or safety concerns have not been resolved.

In these instances, the PIC/PD, PM and/or Director of H&S **MUST** be contacted for further input and guidance **PRIOR** to proceeding with work activities.

9. INCIDENT MANAGEMENT

Uncovering, damaging, or dislocating of an underground utility and/or contact with overhead utility lines are considered a reportable incident to Ramboll Environ and will follow the requirements set forth in SPI 19 Incident Reporting.

Nonetheless, in the event of uncovering an underground or overhead utility intact and undamaged:

- Cease work activities in the area of the facility/pipeline or utility.
- Clear all personnel from the area.

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- Immediately call the applicable emergency phone number(s).
- Notify the affected utility and One Call services, if applicable. The One Call service may be able to assist with contact numbers for notifying member companies in the event of any damage.
- DO NOT attempt to repair, clamp or constrict the damaged utility.
- Notify the PM, PIC/PD, HSC and the Director of H&S. The PM or PIC/PD will contact the Client/Property Owner/Tenant and MP.
- ALWAYS ASSUME THAT ANY UNDERGROUND PIPE OR SUBSURFACE LINE IS LIVE!
- Take photographs from a distance that is safe to do so. Take statements from witnesses at the scene.
- Mark the underground structure(s) on the Plot Plan and move to an alternate cleared location, if available, once the Directors of H&S or their designated representatives have given approval for work to continue.

9.1 Damaging an Underground Electrical/Telecom Cable

- Stop work.
- Evacuate all personnel from the immediate area to a safe distance as site conditions warrant, giving consideration to employees which may not be able to safely evacuate (e.g., the excavator that hit the line may now be energized and the operator may not be able to safely exit the vehicle).
- Call the emergency number (e.g., fire, police, site-specific emergency service).
- Provide first aid and summon medical assistance, as needed.
- Contact the One Call/utility member for guidance, if applicable.
- Notify the PM, PIC/PD, HSC and the Director of H&S. The PM or PIC/PD will contact the Client/Property Owner/Tenant and MP.
- Do not allow anyone to enter the area until the electricity/utility provider has made the cable safe.

9.2 Damaging a Pressurized Gas Pipeline

- Stop work.
- Leave tools in-place but shut off any running/energized equipment, and/or potential sources of ignition in the area
- Evacuate the immediate area to a safe distance as site conditions warrant.
- Call the emergency number.
- Contact the pipeline owner and/or One Call, if applicable.
- Notify the PM, PIC/PD, HSC and the Director of H&S. The PM or PIC/PD will contact the Client/Property Owner/Tenant and MP.
- Do not re-enter the immediate area.

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9.3 Damaging a Pressurized Water Main

- Stop work, remove tools and confine jetting water if safe and necessary to do so.
- Evacuate immediate area.
- Call the emergency number.
- Contact the water utility and/or One Call, if applicable.
- Ensure that water is not creating additional potential hazards (e.g., electrical shorting, flooding, contaminant migration etc.) and where possible warn those likely to be affected.
- Notify the PM, PIC/PD, HSC and the Director of H&S. The PM or PIC/PD will contact the Client/Property Owner/Tenant and MP. Do not re-enter the immediate area.

9.4 Mandatory Follow-up Procedures

If a site employee is injured on-site and immediate medical treatment beyond first aid is needed, the designated site supervisor is instructed to call 911 (or other designated emergency phone number) and then report the incident via Ramboll Environ's Incident Reporting System (SPI 19).

If the post-incident investigations and root cause analysis result in amendments to the HASP, they will be approved and implemented by the Project HSC or the Director of H&S. All site personnel will be informed of the revisions to the HASP and the resolution of any outstanding safety concerns prior to returning to their Site functions.

The necessary steps to ensure that operations can safely resume include:

- Receiving an "all-clear" from the impacted utility.
- Ensuring that all emergency equipment (fire extinguisher, communication system, first aid kits and first aid station) is in functional order;
- Clearing all incident-caused debris from the Site, if safe to do so;
- Inspecting area and equipment that may have been impacted by the incident; and
- Approval by the Directors of H&S or their designated representative.

10. RECORDKEEPING

The following records will be maintained in the onsite project files and transferred to the main project file when the project is complete:

- A complete Pre-Project Planning Checklist (Attachment A, Table 1) summarizing SSC methods and providing justification for any exemptions to the required clearance process.
- Field Log Book including:

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  - A detailed summary of the site visual inspection conducted prior to the initiation of intrusive field activities including the names/titles of site representatives interviewed, the areas reviewed for intrusive activities, and the potential presence of subsurface utilities/structures as reported by the site representatives.
  - Potential underground utilities or subsurface structures identified during the public and/or private utility mark-out.
  - Applicable information regarding the public "One Call" mark-out, ticket number, existing utilities, etc..
- Subsurface Clearance Field Checklist included in the site-specific Health and Safety Plan (Attachment B, Table 2) for each drilling location where intrusive activities might occur.
- Plot Plan, including any updates, reflecting the location(s) of known underground and overhead facilities and utilities with the search zone.

11. REFERENCES

American Public Works Association. April 1999. Uniform Color Code (http://www.apwa.net/).

American Society for Testing and Materials. September 1999. Standard Guide for Selecting Surface Geophysical Methods (D 6429-99).

NJUG Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus. Volume 1. October 2013.

SPI 19 Incident Reporting

12. REVISION SUMMARY

Version	Author	Description of Change	Date
6.0	KMH, CD	Update to existing language/organization; updated definition/acronyms; updated pictures; added Risk Assessment section; updated tables.	11/2013

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ATTACHMENT A
PRE-PROJECT PLANNING CHECKLIST

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Table 1: Pre-Project Planning Checklist

Pre-Project Planning Checklist for Intrusive Work
Document the steps that must be followed and justify any exceptions.
This checklist MUST be completed in its entirety.

SSC Requirements	Yes	No	NA	Comments
Prequalification of Contractor for capability of locating work (See Section 4)	☐	☐	☐	Name of subcontractor(s)
Historical Site Information Review	☐	☐	☐	Specify what information was reviewed (e.g., maps, figures, photos, as-built drawings)
Interviews Conducted	☐	☐	☐	List personnel interviews conducted
Development of site-specific Plot Plan	☐	☐	☐	Denote where a copy can be found (i.e., Attachment D to project HASP, Specific project file name, will be developed on-site, etc.
Intrusive location(s) will be marked prior to locate(s) and alternate locations chosen	☐	☐	☐	Describe reason for exception if not performed or not applicable
Service notifications provided to clear/locate **public** utilities	☐	☐	☐	List companies notified for public locate (for example): ☐ Electric: Ameren ☐ Telephone: AT&T ☐ Cable: Comcast ☐ Gas: Marathon ☐ Sewer: City of Chicago Who contacted One Call: Driller, Ramboll Environ One Call #: 811, 800-892-0123 Locate ticket #: XCR1234
Private locate contracted for on-site utilities	☐	☐	☐	Name of subcontractor(s)
Designated Person or duly authorized representative will be present during private locating	☐	☐	☐	Name of Designated Person: Describe reason for exception if not performed or not applicable
Pre-Project Checklist for Intrusive Work completed by:				

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ATTACHMENT B
SSC FIELD CHECKLIST

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RAMBOLL ENVIRON

SUBSURFACE CLEARANCE (SSC) FIELD CHECK LIST

(Use this form to document & identify field elements of SSC. Retain the completed form with the project file)

Site Name/Project No.: _____ Designated Person: _____

Walkover Date: _____ PIC/PM: _____

Intrusive Locations Surveyed: _____

(Ramboll Environ MANAGED SUBSURFACE CLEARANCE ACTIVITIES)	Yes	No	N/A	Comments
1. The potential for unexploded ordnance (UXO) has been assessed and a UXO survey performed, if applicable.	☐	☐	☐	
2. Public utility markings are present for all utility companies notified. List the companies with public utilities present on-site and cross check with expected utilities and on-site indicators:	☐	☐	☐	
Natural gas/oil/petroleum lines and associated tanks:	☐	☐	☐	
Electric:	☐	☐	☐	
Potable water pipes, hydrants:	☐	☐	☐	
Sewers (storm/process water/sanitary) and/or Manways/Grates/Culverts:	☐	☐	☐	
Public lighting (street and traffic):	☐	☐	☐	
Telephone and Data Lines:	☐	☐	☐	
Other underground utilities:	☐	☐	☐	
3. Private utilities marked and scope discussed with/provided to locator	☐	☐	☐	Subcontractor Name: Contact #:
Alternate intrusive locations chosen in case of refusal or presence of utilities/indicators in Critical Zone	☐	☐	☐	
Describe nonconformity or unexpected conditions found by locator	☐	☐	☐	
4. Site Walkover performed to confirm utility markouts and assess the presence of Visual Indicators. If visual indicators are present, note location in comments/Plot Plan:	☐	☐	☐	
Indication of underground storage tank/piping and dispense islands	☐	☐	☐	
Non-native soils, surface depressions, new/dead vegetation	☐	☐	☐	
Saw cuts, patched surfaces, warning tape or other surficial indicators of below ground work	☐	☐	☐	
Pumps, pump galleries, piping manifolds and/or racks, process equipment, compressors, etc.	☐	☐	☐	
On or below-grade transformers	☐	☐	☐	
Fuel oil lines, tanks, fill ports, observation wells, vent stacks, hydraulic lift systems	☐	☐	☐	
Adjacent/supplemental buildings with no apparent utility feeds (electricity, water, gas)	☐	☐	☐	
Other:	☐	☐	☐	
5. Plot Plan updated to reflect most accurate site SSC information. Describe any on-site additions/changes	☐	☐	☐	
6. Ground Disturbance location(s) and Critical Zones (5ft/1.5m distance in every horizontal direction surrounding disturbance locations) cleared of utilities and visual indicators	☐	☐	☐	Contact PIC/PM and H&S Director if utilities pass through the Critical Zone of a planned ground disturbance location
A mark has been placed on each intrusive location and radial marks extending to the edge of the Critical Zone	☐	☐	☐	
Intrusive locations and Critical Zones cleared of utilities using sweep and search method or other applicable SSC investigative methods.	☐	☐	☐	
Once evaluated and cleared of utilities, intrusive locations cannot be moved and a Critical Zone must be maintained around the locations	☐	☐	☐	
Alternative intrusive locations used due to obstructions within Critical Zone. Describe abandoned and alternative locations	☐	☐	☐	
7. Pre-start H&S meeting conducted and SSC risk/hazards discussed	☐	☐	☐	
Locate results and intrusive locations/Critical Zones understood by all parties involved	☐	☐	☐	

Form completed by _____ _____ _____

Name Date Signature

ATTACHMENT C
ONE CALL AGENCY CONTACTS

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One-Call Agency Contacts

Agency	Phone Number
United States	
811 Dig Safe (MA, ME, NH, RI, VT)	811
Alabama Alabama 811 www.al811.com	811 or 1-800-292-8525
Alaska Alaska Digline, Inc. www.akonecal.com	811 or 1-800-748-3121
Arizona Arizona Blue Stake www.azbluestake.com	811 or 1-800-782-5348
Arkansas Arkansas One Call	811 or 1-800-482-8998
California (North) Underground Service Alert of North www.usanorth.org	811 or 1-800-227-2600
California (South) Underground Service Alert Dig Alert www.digalert.org	811 or 1-800-227-2600
Colorado Colorado 811 www.co811.org	811 or 1-800-922-1987
Connecticut Call Before You Dig www.cbyd.com	811 or 1-800-922-4455
Delaware Miss Utility of Delmarva www.missutilitydelmarva.com	811 or 1-800-282-8555
District of Columbia District One Call www.missutility.net	811 or 811 or1-202-265-7177
Florida Sunshine Sate One Call www.callsunshine.com	811 or 1-800-432-4770
Georgia Georgia 811 www.georgia811.com	811 or 1-800-282-7411
Hawaii Hawaii One Call www.callbeforeyoudig.org	811 or 1-866-423-7287

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One-Call Agency Contacts	
Agency	**Phone Number**
United States	
Idaho Pass Word Dig Line, Inc. www.digline.com	811 or 1-800-342-1585
Idaho (Bonner/Boundry) Pass Word www.passwordinc.com	811 or 1-800-626-4950
Idaho (Kootenai County) Pass Word www.passwordinc.com	811 or 1-800-428-4950
Idaho (Shoeshone-Benewah) Pass Word www.passwordinc.com	811 or 1-800-398-3285
Illinois (Outside of Chicago) Julie www.illinois1call.com	811 or 1-800-892-0123
Illinois (Chicago) Digger – Chicago Utility Alert Network egov.cityofchicago.org	811 or 1-312-744-7000
Indiana Indiana 811 www.indiana811.com	811 or 1-800-382-5544
Iowa Iowa One Call www.iowaoncecall.com	811 or 1-800-292-8989
Kansas Kansas One Call www.kansasonecall.com	811 or 1-800-344-7233
Kentucky Kentucky 811 www.kentucky811.org	811 or 1-800-752-6007
Louisiana LA One Call www.laonecall.com	1-800-272-3020
Maine Dig Safe www.digsafe.com	811 or 1-888-344-7233
Maryland (West of Chesapeake Bay) Miss Utility of Maryland www.missutility.net	811 or 1-800-257-7777

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One-Call Agency Contacts

Agency	Phone Number
United States	
Maryland (East of Chesapeake Bay) Miss Utility of Delmarva www.missutilitydelmarva.com	811 or 1-800-282-8555
Massachusetts Dig Safe System, Inc. www.digsafe.com	811 or 1-888-344-7233
Michigan Miss Dig www.missdig.org	811 1-800-482-7171
Mississippi Mississippi 811 www.ms811.org	811 or 1-800-227-6477
Missouri Missouri One Call System www.mo1call.org	811 or 1-800-344-7483
Montana Montana 811 www.montana811.com	811 or 1-800-424-5555
Montana (Flathead and Lincoln Counties) Montana Once Call Center www.udig.org	811 or 1-800-551-8344
Nebraska Diggers Hotline of Nebraska www.ne-diggers.com	811 or 1-800-331-5666
Nevada USA North www.usanorth.org	811 or 1-800-227-2600
New Hampshire Dig Safe System, Inc. www.digsafe.com	811 or 1-800344-7233
New Jersey New Jersey One Call www.nj1-call.org	811 or 1-800-272-1000
New Mexico New Mexico One Call, Inc. www.nmonecall.org	811 or 1-800-321-2537
New York (North of 5 Boroughs) Dig Safely New York www.digsafelynewyork.com	811 or 1-800-962-7962

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One-Call Agency Contacts

Agency	Phone Number
United States	
New York (5 Boroughs and Long Island) New York 811, Inc. www.newyork-811.com	811 or 1-800-272-4480
North Carolina North Carolina 811 www.nc811.org	811 or 1-800-632-4949
North Dakota North Dakota One Call www.ndonecall.com	811 or 1-800-795-0555
Ohio Ohio Utilities Protection Service www.oups.org	811 or 1-800-362-2764
Oklahoma Call Okie www.callokie.com	811 or 1-800-522-6543
Oregon Oregon Utility Notification Center www.digsafelyoregon.com	811 or 1-800-332-2344
Pennsylvania Pennsylvania One Call System, Inc, www.paonecall.org	811 or 1-800-242-1776
Rhode Island Dig Safe System, Inc. www.digsafe.com	811 or 1-888-344-7233
South Carolina South Carolina 811 www.sc811.org	811 or 1-888-721-7877
South Dakota South Dakota One Call www.sdonecall.com	811 or 1-800-781-7474
Tennessee Tennessee 811 www.tennessee811.com	811 or 1-800-351-1111
Texas Texas811 www.texas811.org	811
Utah Blue Stakes of Utah www.bluestakes.org	811 or 1-800-662-4111

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One-Call Agency Contacts

Agency	Phone Number
United States	
Vermont Dig Safe System, Inc. www.digsafe.com	811 or 1-888-344-7233
Virginia Virginia 811 www.va811.com	811 or 1-800-552-7001
Washington Utility Notification Center www.callbeforeyoudig.org	811 or 1-800-424-5555
West Virginia Miss Utility of West Virginia www.muwv.org	811 or 1-800-245-4848
Wisconsin Diggers Hotline www.diggershotline.com	811 1-800-242-8511
Wyoming One-Call of Wyoming www.onecallof wyomng.com	811 or 1-800-849-2476
Australia	
Dial Before You Dig (Australia)	1100
Canada	
Alberta Alberta One Call www.alberta1call.com	1-800-242-3447
British Columbia BC One Call www.bconecall.bc.ca	1-800-474-6886
Manitoba Call Before You Dig www.callb4udig.mb.ca Does not complete locate requests, but provides a list of utility companies	Various
Ontario Ontario One Call www.on1call.com	1-800-400-2255
Quebec Info Excavation www.info-ex.com	1-800-663-9228
Saskatchewan Sask 1st Cal www.sask1stcall.com	1-866-828-4888

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One-Call Agency Contacts	
Agency	**Phone Number**
United Kingdom	
National One-Call (United Kingdom)	0844 800 9957

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ATTACHMENT D
ANATOMY OF UTILITIES

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Anatomy of Utilities

General

Although the different utility systems (i.e., electrical, natural gas, water, cable television, and telephone) provide different types of services, how these services get from the producer to the end user aren't so different. In order to create, capture, transport, and distribute their product to the customer, all utility systems must follow the same process, each must:

1. Build "It" up or light "It" up - this is production or generation; then
2. Push "It" through – transmitting the utility through lines or pipes; then
3. Take "It" down or "change "It" around" – at substations, from one big line to many smaller lines; and lastly
4. Break "It" down – distributing the utility to the end user.

The "It" can only be one of 4 things:

- Electrons
- Gases
- Photons
- Liquids

In general, the terms "transmission", "feeder", and "distribution" are the stages for the delivery of utility products (i.e., electricity, natural gas, water, and telecommunications). And in order for the utility company to deliver their products or "push" their products to the customer, they must "build up" their product in order for the product to move. For example, to get electricity to flow over a long distance, the voltage must be built up to flow. To transport natural gas and water a long distance, the pressure must be built up. This means that the product starts out under high voltage or pressure on reduces to a level that consumer products and devices can handle. Cable and television products slightly differ in their mode of transmission (i.e., they use a combination of electrons and photons. Nonetheless, all of these utilities have devices, equipment, and distribution items which, many times, are indicators that the respective utility is present in a particular area.

The intent of this attachment is two-fold: first, to quickly present how each utility works, and secondly but more important, what these devices, equipment, and distribution items look like so they can be left undistributed and/or be indicators that a specific utility is present.

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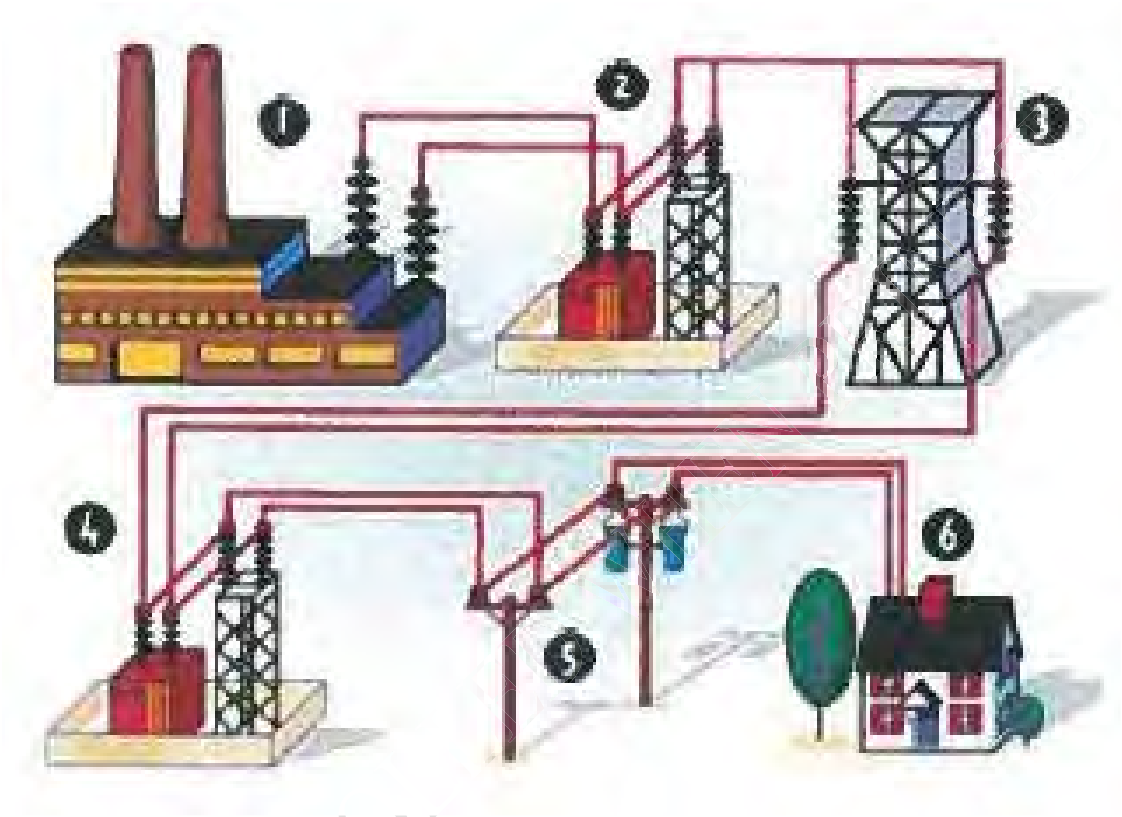
Electricity

Generally, when electricity leaves a power plant (1), its voltage is increased at a step-up substation (2). Next the energy travels along a transmission line where the power is needed (3). Once there, the voltage is decreased or stepped-down at another substation (4), and a distribution power line (5) carries the electricity until it reaches a home or business (6).



Build it up (Production)

The power plant houses electromagnetic generators and turbines, spun by steam or falling water, to produce three independent streams of electricity.

Step-up substations at the power plant use large transformers to greatly increase the generated voltage to transmission levels. A transformer can work in two ways:

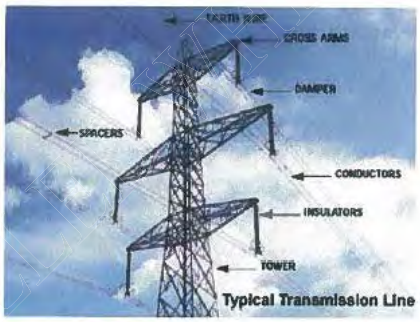
1. Raise voltage while reducing current
2. Lower voltage while increasing current

Transmission distances can be as great as 300 miles (483 km), so voltage is increased from 20kV to 500 kV to minimize power loss over the distance.

Push it through (Transmission)

Aerial high-voltage transmission lines are raised high into the air to prevent dangerous contact of any sort with the lines. They carry electricity at 500 kV and 230 kV. A by-product of flowing electrons (electricity) on a metal conductor is heat, and the winds at higher elevations cool the overhead line. Typically, the higher the transmission line, the higher the voltage.

To keep the current flowing on the conductor rather than into the towers, and then to earth, insulating arrestors are used. These are commonly made from porcelain, glass, or a polymer, and are composed of a series of disks that dissipate current over their surface area. The more disks the arrestor has, the higher the voltage on the line.



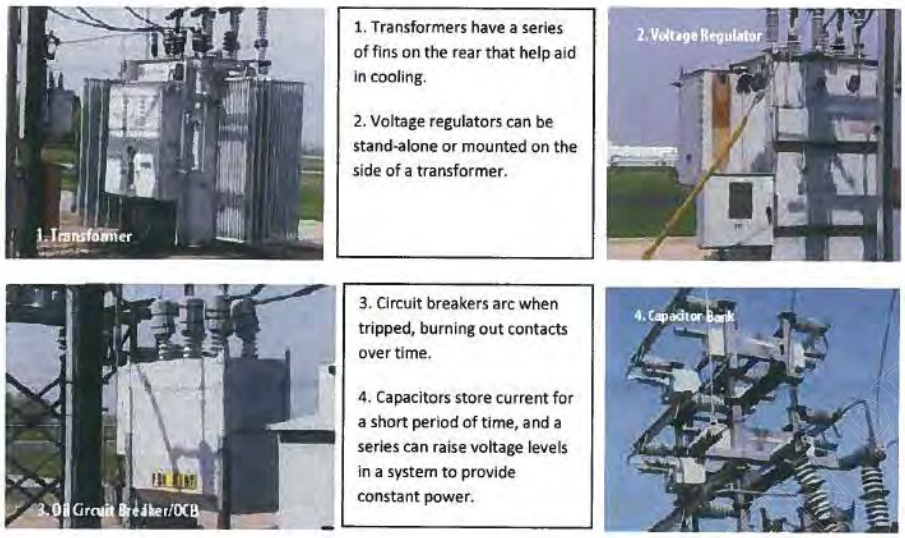
Take it down

While the voltage was dialed way up to travel, it must be dialed back down for use. The next stop is a power substation, where the high-voltage electricity comes off the transmission lines and is stepped down for distribution. Some large industrial users have so great a need for electricity that they're supplied directly from major transmission circuits.

At a transmission-fed substation or step-down substations, voltage is reduced from hundreds of kilo-volts to sub-transmission levels of 69 kV and 34.5 kV. Transformers, with the help of voltage regulators, circuit breakers, and capacitor banks, induce energy from a large coil to a small coil or set of coils to reduce the voltage. Transformers and circuit breakers are often filled with oil to help dissipate the heat produced by high voltage electricity passing through them.

1. Transformers have a series of fins on the rear that help aid in cooling them by pulling heat away, as more air contacts the surface area of the fins.
2. Voltage regulators can be stand-alone or mounted on the side of a transformer, and by constantly monitoring voltage, the voltage regulator automatically adjusts to keep the voltage at a pre-determined level.

3. Circuit breakers arc when tripped, burning out contacts on the switch over time.
4. Capacitors store current for a short period of time, and a series of capacitors can raise voltage levels in a system to provide constant power.



From a part of the substation called the “bus,” sub-transmission lines are split out and re-directed into multiple directions. These sub-transmission lines, also known as feeder circuits, feed substations that reduce the voltage to distribution voltages, such as 13.2 kV, 12.8 kV, or 12.5 kV, or go directly to industrial or commercial users that require more power. The bus bars connecting the capacitors are not insulated, and can contain tens-of-thousands of volts.

Sub-transmission lines can be aerial or underground. Lines that transition from aerial to underground require an insulator commonly referred to as a pothead, or potential head, which reduces the electrostatic energy on the line.

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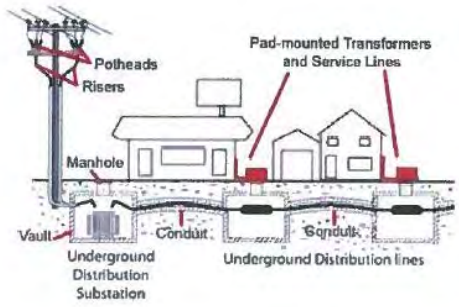
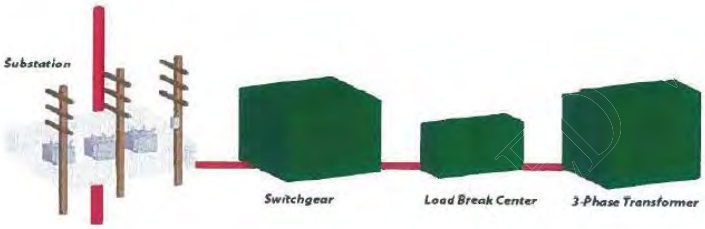


Break it down (Distribution)

3-Phase Users

The 3-phases leaving the substation are called primary cables, and they travel towards end users with a few transitional points along the way.



The first structure where a transition may occur is at a switchgear, or switching cubicle, which changes the path of current flow. A switchgear consists of a series of switches connected in a loop that can be used to rearrange the path of current flow for issues like repairs to be completed on a distribution line, without a major service disruption.

The next structure downstream of a switchgear is called a load break center, or LBC. Its function is to branch out the direction of current flow.

Everything in the electrical system is interconnected. On the left of the picture above, a large diameter 3-phase cable, a bulk feeder, enters and exits a switchgear to feed a smaller diameter cable that will serve customers. The bulk feeder cable continues on to do the same thing at the next enclosure.

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In the middle of the series of pictures above, you see an LBC directly in-line with the switchgear in the background. Electrical cables run from one structure to the next as voltage is broken down and distributed to the end user. The final structure one may encountered before reaching the end user is a transformer, on the right. At a 3-phase transformer, the primary cables enter on the left side, and a secondary cable headed to the customer exit at the right side.

Break it down (Distribution)

Single Phase Users

As electricity leaves the substation, it travels on 3-phase cables. Single-phase begins by tapping into one of the three phases. A single-phase tapped from a 12.5 kV 3-phase is typically 7,200 volts. A single-phase transformer decreases the 7,200 volts down to the 120 or 240 volts, which is needed for residential use.

On the left of the figure below, two single-phase cables are tapped from a 3-phase. On the right, a single=phase transitions from aerial to underground, often called a pole drop.

The distribution electricity is reduced to the end use voltage of 120 or 240 volts by a pole-mounted or pad-mounted transformer. Then, power is delivered to the residential customer through a service drop line that leads from the pole transformer to the customer's structure, for both overhead and underground lines.

A single-phase transformer is much smaller than a 3-phase transformer and typically has a hinged lid rather than a door in the front.

These pad-mounted transformers (shown in the figure below) are fed from an underground line and can produce multiple secondary voltage services going in multiple directions.

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In addition to single-phase transformers, several other secondary enclosures, as shown in the figures below, serve as junction boxes where a large secondary cable is broken down into several smaller secondary cables.

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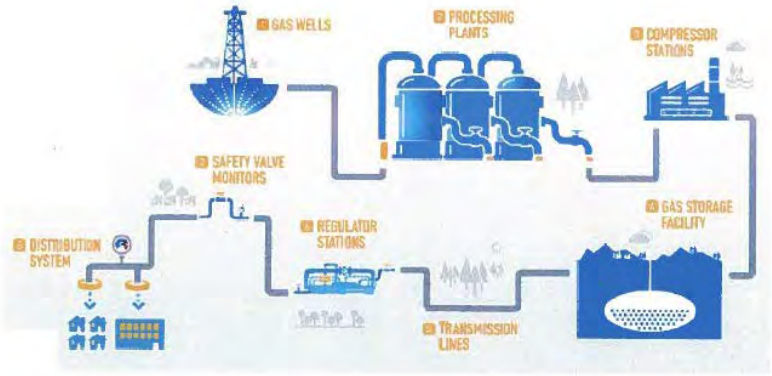
Natural Gas

Deep wells extract natural gas deposits and deliver the gas to processing plants where heavier hydrocarbons like butane, propane, and ethane are removed. The resulting methane-rich gas moves from the processing plant to the local natural gas utility company through what could be up to a 150,000-mile (241,402 km) network of underground pipes, made mostly of high-strength steel.



Build it up (Production)

Once it leaves the processing plant, natural gas must be compressed and brought up to pipeline pressure, as high as 1,900 psi (98,259 mmHg). Compressor stations are located approximately every 70 miles (113 km) along the transmission line superhighway to pressurize the gas and keep it moving at approximately 15 miles per hour (24 km/hr).

Excess natural gas, unlike electricity, can be stored for use when demand is high, like in the winter. Natural gas is stored along the pipeline route in large geological formations.

Push it through (Transmission)

While some larger industrial, commercial, and electric companies receive natural gas from inter and intrastate pipelines, most other users receive it from their local gas utility. Gate stations are where a transmission pipeline company sells its gas to a local distribution company, or LDC. Regulators and metering instruments are used to monitor flow. At this point, the gas is odorized with mercaptans and sulphides to create the distinct rotten egg odor that serves an indication of natural gas leakage.

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Take it down

Pressure is reduced from transmission levels to distribution levels at gate stations. The gas is passed into beltlines, also known as feeder or transfer lines, which are the highest pressure mains found in the distribution system. Beltlines are generally built to form a rectangle or loop, with no beginning or end, and serve as feeders to district regulator stations.

Beltlines loop together a series of distribution regulator stations and maintain the necessary station-to-station pressure to ensure ample pressure to all parts of the system. Because beltlines are looped, beltline valves can be closed to isolate a segment of the pipeline without shutting down an entire station.

Beltline valves may be aboveground, while the beltline system is underground. Beltlines that traverse under busy roads or railways are protected by steel casings and have vent pipes to allow for quick detection of leaks

From the gate station, natural gas moves into distribution lines. Generally, the closer the natural gas gets to a customer, the smaller the pipe diameter and the lower the pressure. Regulators control the pressure within each distribution system by opening or closing when gas pressure drops below or rises above a predetermined level.

Break it down (Distribution)

Service regulators reduce the pressure so it's usable inside the customer's premises. One regulator on the service indicates the inlet pressure is 60 psi (3,103 mmHg), or less. Two regulators on the service line indicate that the inlet pressure downstream of the service tap on the main is greater than 60 psi (3,103 mmHg).

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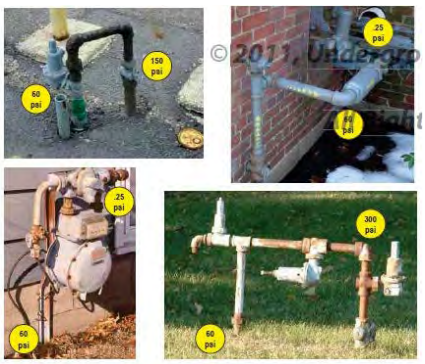
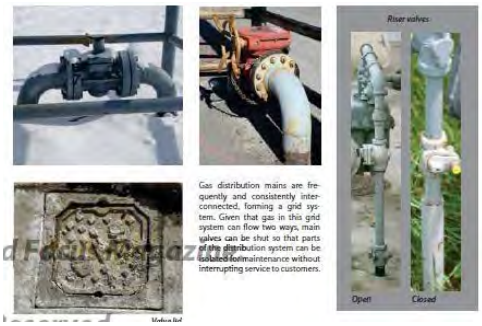


Gas distribution mains are frequently interconnected, forming a grid system. Given that gas in this grid system can flow two ways, main valves can be shut so that parts of the distribution system can be isolated for maintenance without interrupting service to customers.



When gas main leaks occur and closing valves is not a strategically viable option, the gas flow can be stopped by applying an “as needed” solution. The type of gas stoppage solution used is dictated by the size and type of pipe.

The hydrostatic pressure of ground water is greater than the gas pressure in a low pressure system, permitting water ingress into the piping system if the system is damaged. Water is pumped to the surface at drips, gravity-fed reservoirs attached to low pressure pipes.

Original low pressure systems typically consisted of cast iron mains and uncoated bare steel services, which corroded over time.

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Curb valves, like this one in the middle figure above, are typically installed near property lines, creating an emergency shut off option in an easement away from the property. Low pressure systems utilize larger pipes, such as this pipe exiting a regulator station, in order to compensate for volume that cannot be supplied by the low pressure.

A service regulator isn't needed in a low pressure system since the pressure in the main is what's used inside the customer's premises. In addition, the service pipe needs to be of larger diameter to provide the volume of gas needed for customer demand. Since a regulator is a safeguard against unintended increases in pressure, low pressure systems are inherently more dangerous due to the absence of a regulator on the customer's premises.

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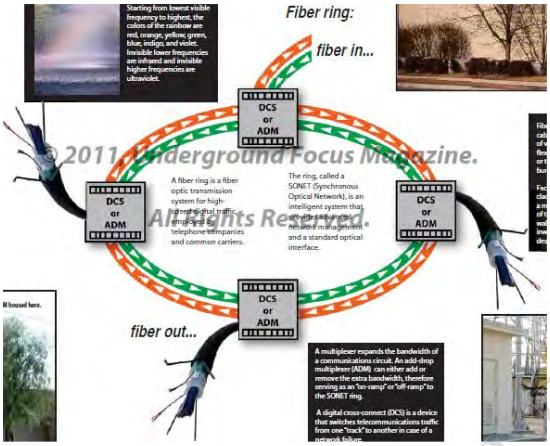
Fiber optics

Fiber serves as the backbone for telephone, cable television, and the internet. Fiber is made of very pure glass, remarkably strong, yet flexible and bendable like a wire. Hundreds or thousands of fibers can be arranged in bundles, called an optical cable.

Each strand of a single fiber is covered by cladding, a protective coating made from a material that reflects light into the center of the cable. Cladding creates a mirror-lined wall that allows light to reflect and bounce inwards, traveling around corners to its destination.

Light it up

A fiber ring is a fiber optic transmission system for high-speed digital traffic employed by telephone carriers. The ring is called a SONET (Synchronous Optical Network) and provides advanced network management and a standard optical interface.



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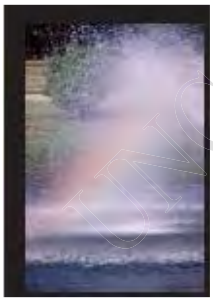
The capacity of a fiber optic cable is quantified by its bandwidth. A rainbow reveals optical bandwidth. A multiplexer expands the bandwidth of a communications circuit. An add-drop multiplexer (ADM) can either add or remove the extra bandwidth, therefore serving as an “on-ramp” or “off-ramp” to the SONET ring.



A digital cross-connect (DCS) is a device that switches telecommunications traffic from one “track” to another in case of a network failure.

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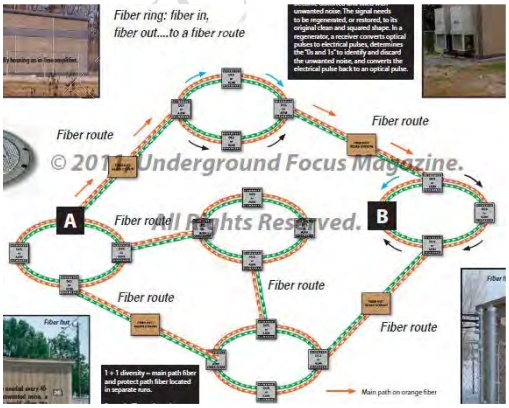
Fiber cable exits cell sites and heads to DCS or ADM, as shown in the figures below.

DCS and ADM are housed in facilities like these shown in the figures below.

<u>Push it through</u>

Photons—Electrons—Photons

Digital signals become distorted and filled with unwanted noise during transmission. In a regenerator, a receiver converts optical pulses to electrical pulses, identifies and discards the unwanted noise, and converts the electrical pulse back to an optical pulse.



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A fiber hut, or regeneration center, houses an in-line amplifier. Regeneration centers are needed every 40-60 miles (64-97 km). By removing unwanted noise, a cascade of regeneration centers would allow the signal to continue on forever.

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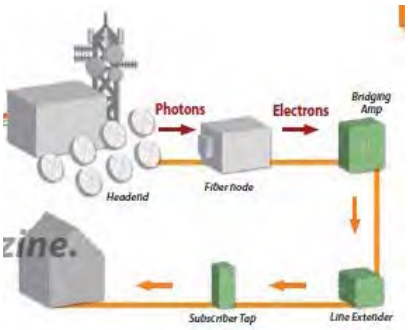
Cable TV

The physical makeup of a cable television (CATV) system is known as a Hybrid Fiber Coaxial (HFC) network. Fiber runs deep into the distribution system, terminating at fiber nodes located near clusters of customers. Photons are converted into electrons at a node. A low electrical signal exits the node and is pushed onto large diameter coaxial cables, termed trunk cables.

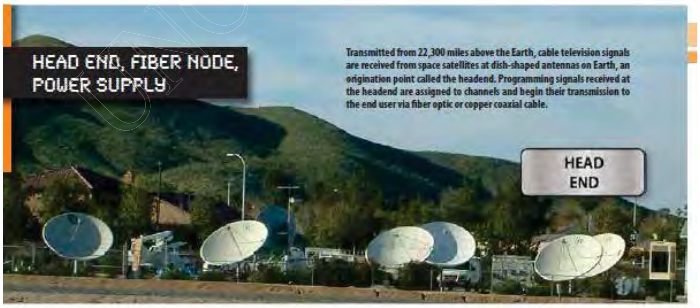
The trunk system loops the service area, feeding bridging amplifiers along the way. At a bridging amplifier, the electrical signal is raised up (amplified) for distribution onto smaller diameter coaxial cables, known as feeder cables, which are then tapped into for delivery to the customer.



Change it around

A fiber node, or an optical receiver, converts light into electrical energy. Light comes into the node and is "changed around" into electricity. The act of changing light into electricity cannot be done without electricity.

Cable television signals are received from space satellites at dish-shaped antennas on Earth, an origination point called the headend. Programming signals received at the headend are assigned to channels and begin their transmission to the end user via fiber optic or copper coaxial cable.



Today, most feeds from a headend are fiber cables running to fiber nodes, where light energy is "changed around" to electrical energy.

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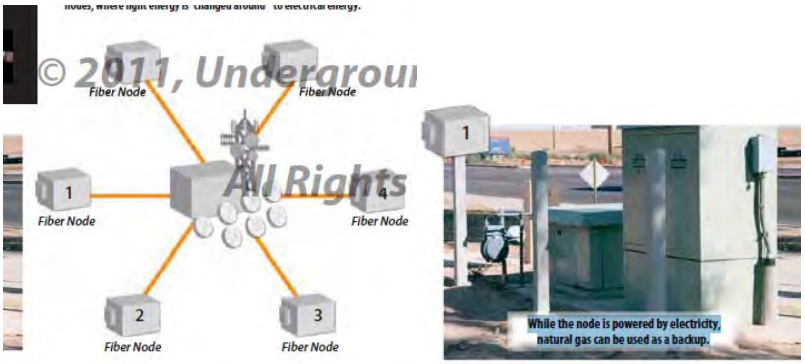

(1) While the node is powered by electricity, natural gas can be used as a backup.

(2) A power supply is pictured with this curb-side fiber node. A fiber optic line feeds the node and terminates, as traditional coaxial cable exits the node providing last mile (km) service to the surrounding neighborhood. A node serves several hundred customers in a radius of 5000 feet (1524 m), providing broadband services like high-speed internet.

Supplied by secondary voltage, a power supply drops the voltage to 90 volts. To provide power to downstream amplifiers, the AC current is placed on the cable and converted to DC current at each amplifier.

(4) The trunk system begins in a vault, like the one shown in the figure above.

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A trunk system's origin is at the fiber node. The coaxial trunk cable serves the CATV feeder system much like the sub-transmission feeder serves the electric distribution system and the beltline serves the gas distribution system.

The fiber cable enters the node on the lid side of the amplifier case opposite the trunk and feeder ports.

The fiber cable enters the node on the lid side of the amplifier case opposite the trunk and feeder ports.

Build it up / Break it down

Bridging amplifiers tap low-powered trunk signals and convert them to high-powered feeder signals. Within each bridging amp is a directional coupler, a passive device that induces the transfer of energy from the trunk system to the feeder system.

Coaxial trunk cables are larger than coaxial feeder cables because larger diameter cables experience less signal loss than smaller cables, resulting in the need for fewer amplifiers. Trunk lines need amplification every 1,500-2,200 feet (457-671 m) while feeder lines need more frequent amplification.

A coaxial cable has two conductors, the central copper wire, known as the inner conductor or "stinger", and an aluminum tubular shield, known as the outer conductor. At any moment, the current is traveling outward from the source on one of the conductors while returning on the other. This type of construction prevents power losses by reducing the production of an electromagnetic field.

A line extender works like a step-up transformer and builds up the radio frequency current weakened by resistance as it travels over a coaxial cable. AC current from the power supply arrives at the line extender via the coaxial cable, is inverted to DC, and used to boost the signal.

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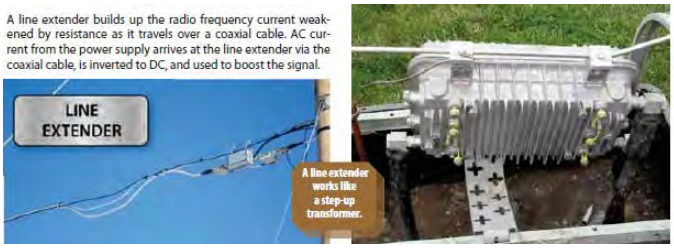
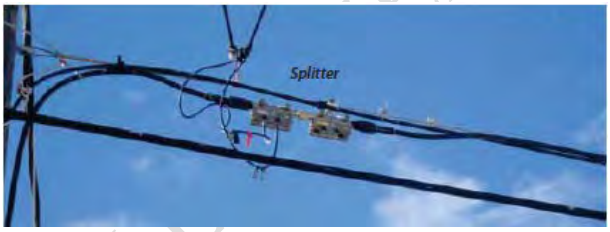


The enclosures that house amplifiers are vented, allowing heat produced by the amplifier to escape.



When it comes to feeder cables, splitters may send more signal to one route over that of another, such as a 60/40 split of the signal.

Subscriber taps transfer signal from the feeder cable to the customer's premises.

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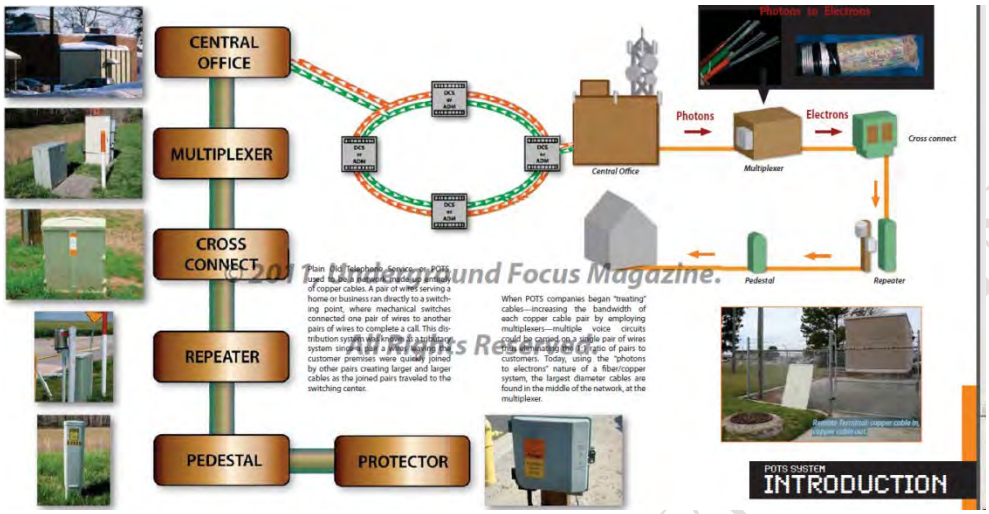
Telephone

Plain Old Telephone Service, or POTS, used to be a network made up entirely of copper cables. When POTS companies began “treating” cables, or increasing the bandwidth of each copper cable pair by employing multiplexers, multiple voice circuits could be carried on a single pair of wires. Today, using the “photons to electrons” nature of a fiber/copper system, the largest diameter cables are found in the middle of the network, at the multiplexer.



Remote Terminal: copper cable in, copper cable out is shown in the figure below.

Light it up

A central office, or CO, is a telephone company building housing switching equipment and is considered the “brains” of a telephone system. The switching equipment generally serves up to 100,000 customer lines within a geographical area known as an exchange, or wire center.

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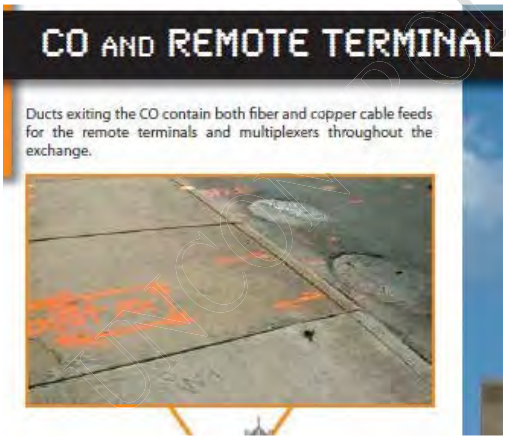
The CO connects to downstream remote switching sites with either copper or fiber cables, although today newly constructed feeds are exclusively fiber. A toll cable connects a CO to another CO, while a carrier cable connects the CO with remote switching equipment.

The term “carrier” denotes that the cable’s function is within a single exchange.

Ducts exiting the CO contain both fiber and copper cable feeds for the remote terminals and multiplexers throughout the exchange.



Connected by a carrier cable to the CO, a remote terminal (RT) is a “mini CO” that brings switching and multiplexing functions closer to the customer, creating greater copper cable functionality between the RT and the customer.

A copper carrier cable is a “treated” cable, or multiplexed cable, meaning that the bandwidth has been multiplied.

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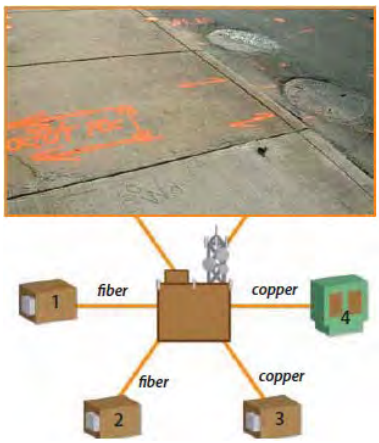

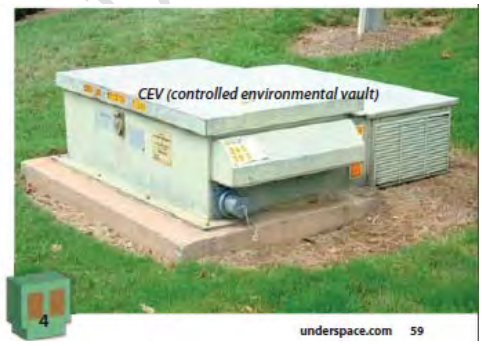

<u>Change it around</u>

Multiplexers perform switching functions identical to those performed at the central office. The fiber or copper carrier circuit connects the CO with the multiplexer. Equipment at the CO and at the multiplexer assign circuits to specific bandwidths of the carrier cable. These unique frequencies are then assigned to specific copper pairs at the multiplexer.

The act of changing light into electricity cannot be done without electricity provided by the power company.

Types of equipment found at multiplexer sites:

- SLC: Subscriber Loop Carrier
- DLC: Digital Loop Carrier
- DSLAM: Digital Subscriber Line Access Multiplier
- VRAD: Video Ready Access Device

A VRAD can serve 200–400 households, depending on its configuration.

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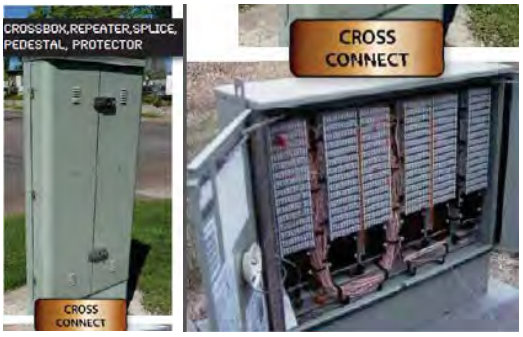
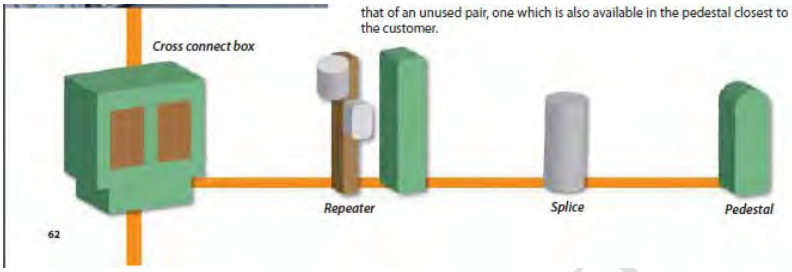
Build it up / Break it down

A feeder cable enters a cross connect box, or crossbox, and one or more distribution cables exit the crossbox. Inside the crossbox is a large panel with punch-down blocks. Ends of feeder pair wires are connected to beginnings of distribution pair wires using the punch-down blocks and orange and white-ended tin jumpers.





Single copper wire telephone circuits, known as a pair, utilize a ten-color code in order to identify the circuit on each end of the line, such as at a crossbox and downstream at a splice point or pedestal.

Because a signal loses quality and strength over distance on a copper system, an electronic device called a repeater is used at regular intervals to boost and amplify the signal. A repeater can regenerate a digital signal, cleaning it up and removing noise for retransmission.

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A splice cabinet generally has one entrance cable and two exit cables, such as a 300-pair entrance and a 200-pair exit and a 100-pair exit.

A pedestal houses cables coming in, cables going out, and cables spliced together. A copper circuit, known as a pair, originating at a CO, remote terminal or multiplexer is diverted to the customer premises at a pedestal.

The point where the telephone company's service lines meet the subscriber's wiring or protective equipment is a network interface. The network interface is located on the customer's side of the phone company's protector.

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ATTACHMENT E
UNDERGROUND LOCATING EQUIPMENT

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Common Types of Locator Equipment

Due to specific site conditions, no single method of locating subsurface utilities is universally fail proof. Surface and subsurface conditions may interfere with the effective use of specific utility locating technology. Following is a discussion of some technologies available and the relative merits of each.

1. Radio Frequency/Electromagnetic Detection

The radio frequency or electromagnetic technique locates buried materials having a high conductance (e.g., steel and copper). Examples of these utilities include water, natural gas, fuel lines, electricity and telephone. When installed with a metallic tracer wire, plastic pipes made of materials such as polyethylene and PVC, are also easily located.

Electromagnetic utility locators comprise a transmitter coil used for applying an electromagnetic signal and a receiver used to pick up that signal. Alternating electromagnetic waves generated at the surface are induced into the ground or directly injected into the utility during the survey. When the waves pass through a conducting body, they induce an alternating electrical current in the conductive materials. These currents become the source of secondary magnetic fields, which can be detected at the surface by the antennas in the receiver.

Picture 1: A locator searching for a conductive signal.

Picture 2: Signal transmitted to reciever.

These instruments typically utilize frequencies between roughly 400 hertz and 480 kilohertz. Lower frequencies tend to remain on the target utility better than higher frequencies, which have the tendency to “bleed over” onto adjacent conductors, causing errors and distortions. Similarly, aboveground or buried metallic structures, such as USTs, metal fences, and/or vehicles parked nearby, can also interfere with readings.

Direct connection (conduction) is the preferred method for locating utility lines. The transmitter is placed next to an access point for the target line being traced (typically attached to a valve, utility box, or other point where direct contact with the line can be made). A connection lead from the transmitter is connected to the target line and the second lead is connected to the ground. The transmitter is then adjusted for frequency and power output to match the properties of the target line, surrounding soil and other utilities nearby. Application of the correct frequency is essential to prevent electromagnetic coupling. The receiver is then set to the same frequency as the transmitter, gain control adjusted accordingly, and the signal is traced and marked on the surface.

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Photo 3: Direct connection to gas service tracer wire

Ring clamp induction is used to induce a signal onto an individual cable or conduit where direct connection is not an option. A ring clamp is connected to the transmitter and clamped around desired pipe or cable. The signal then travels from the transmitter to a coil within the clamp and onto the target line. The same care should be used in setting the correct frequency and gain as with direct connection.

Photo 4: Ring clamp induction

Induction is used when there is no surface access to the target line. Induction is the least desirable method of electromagnetic locating due to the massive amount of electromagnetic coupling or bleed off that is created from other inductive structures in the area. This method is also used to perform an inductive search to locate unknown or abandoned lines. The transmitter is placed on the surface, and over the point where the target line is thought to run. Once the target is located, it is traced with the receiver using the same method as direct connection.

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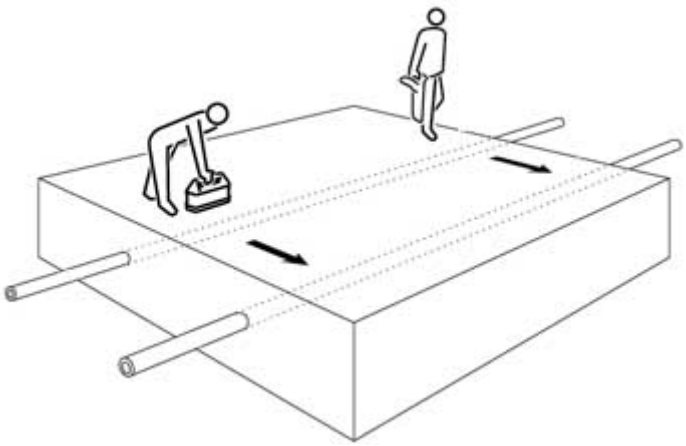

Photo 5: Inductive search

By detecting the maximum signal strength at several locations, the surface trace of an underground utility can be determined. The strength of the field is directly proportional to the average conductivity of the subsurface materials. If infrastructure made of non-conductive materials, such as concrete, asbestos, plastics, or clay needs to be found, electromagnetic locating instruments will only be effective if a metallic trace line was installed with the utility.

Detection depth of EM instruments is a function of the transmitter-to-receiver coil separation and the coil orientation (horizontal or vertical). Small coil separations, as in metal detectors and pipe locators, may reveal objects at depths between 2 and 6 feet below the ground surface.

Soil conditions have a large effect on how well electromagnetic locating devices perform. Moist clay is the ideal operating condition for more Electromagnetic locating, as well as other soil conditions that promote conductivity. Dry, sandy soils are the worst conditions for electromagnetic locating.

2. Ground Penetrating Radar (GPR)

Ground Penetrating Radar (GPR) is similar to Electromagnetic locating in that both technologies use electromagnetic frequencies, but that is where their similarities end. GPR uses radar pulses to image the subsurface and detect the reflected signals. The scanning antenna of the GPR continuously transmits pulses of radar-frequency electromagnetic energy directly into the ground as it is towed along a survey profile. When this energy reaches an object or the interface of materials with differing dielectric properties, it echoes and is captured by the antenna's receiver. Computer software uses the frequency of pulses transmitted and the amount of time delay between transmitting pulses and receiving echoes to depict a continuous subsurface cross-section in real time.

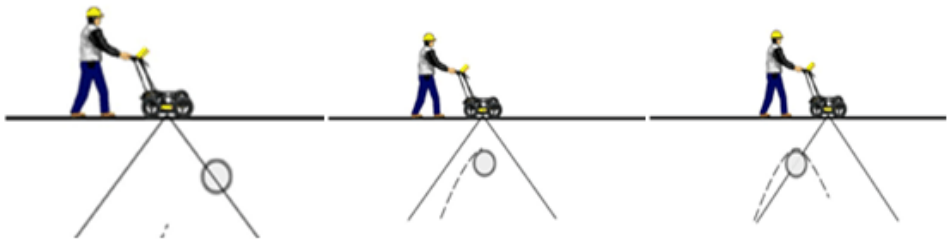

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Photo 6: Ground Penetrating Radar detection

GPR can be used to locate both metallic and non-metallic objects, but the depth range and resolution are directly dependent on radar frequency, transmitted power, electromagnetic properties of the ground material, as well as to the shape and characteristics of the underground targets. Since the electrical properties of metallic tanks, pipes, and wastes are distinctly different from soil and backfill materials, metallic targets produce dramatic and characteristic reflections. Fiberglass, plastic, concrete, and terra-cotta targets as well as subsurface voids, rock surfaces, soil type changes and concentrations of many types of non-metallic wastes also produce recognizable, but less dramatic reflections.

The most common method of locating is cross and mark as you go. This method works well in favorable soils and uncluttered settings. The GPR cart is moved along in sweeps, perpendicular to the anticipated utility axis. When the GPR sensor crosses the utility, the image shows an arch. The top of the arch is the **estimated** position of the utility and the depth to the top of the arch is the **estimated** depth.

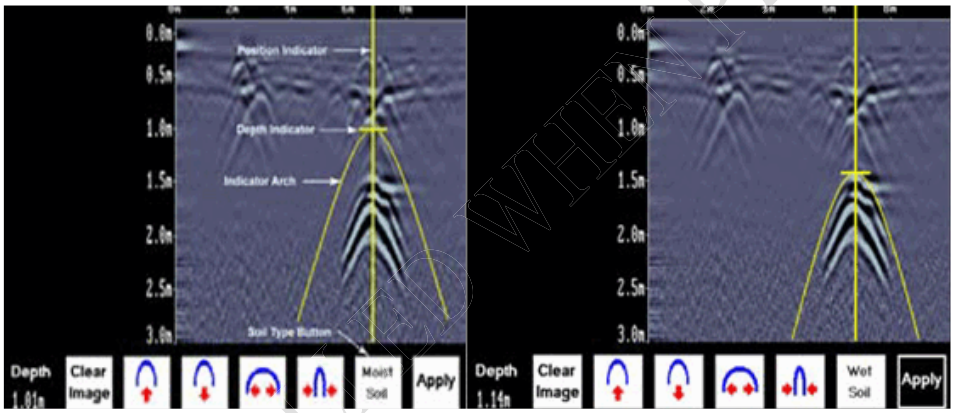

Photo 7: Screen shot of GPR

Although GPR has been applied at greater depths, it is generally considered to be more effective down to approximately 10-15 feet below ground surface in most lithologies, although this may vary greatly depending on location and composition bgs. Resolution is degraded with depths exceeding 20-30 feet.

Soil types and compaction of the soil determine visibility of unknown utilities. GPR works better in gravelly or sandy soil, and poorer in heavy clay materials. The efficiency of GPR is strongly affected by the target soil's conductivity (the soil's ability to carry a charge) and dielectric permittivity (the soil's capacity to hold a charge). Since different soils have different electrical characteristics, the effectiveness of GPR is highly dependent on the subsurface conditions at a particular site. For example, clay soils and subsurface brackish or salt water generally attenuate (absorb) the radar signal used by the GPR, thereby limiting its scan depth.

The best conditions for GPR are sandy or gravelly soils, such as silica sands, fresh water, ice, and most solid rocks of low conductivity. Maps that have been developed by the certain natural resource agencies (e.g., in the US, the Natural Resources Conservation Service) that show the relative suitability of soils for many GPR applications, can be found here: http://soils.usda.gov/survey/geography/maps/GPR/index.html.

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The other main factor influencing GPR's maximum scan depth and resolution is the type of antenna used. Generally, the lower the antenna frequency the deeper the scan, but the lower the resolution – so only large objects will be detected. Conversely, a higher frequency antenna will give a shallower scan depth, but a much higher scan resolution, allowing for smaller subsurface features to be detected.

3. Vibrocators/Water Pipe Tracers

Vibrocators are used to detect and trace fluid-filled, non-metallic utilities (e.g., PVC or concrete water lines). A vibrocator system involves a low-frequency pressure wave generator called a transonde. The transonde is fitted to a faucet, hydrant, or other available fitting and the hand held receiver is used to trace buried pipe. The transonde produces a distinctive pressure wave signal along the pipe that is located by the seismic sensor in the receiver.

Photo 8: A vibrocator being demonstrated

Best performance is in locating a single pipe running under grass or verges. Locating may be reduced when the pipe runs under paving or concrete, as these materials dissipate the pressure wave signal causing the receiver peak response to spread over a wider area. Locate range may also be reduced at T-points or when the transmitter pipe joins a larger pipe, when the pressure wave signal can be split or reduced.

There are two limitations to this technology. One is that all non-metallic pipes to be traced must be available for connection directly to the transmitter. The second is that the excessive energy imparted to the pipe may cause damage.

4. Magnetic Metal Detection

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Magnetic methods involve the measurement of anomalies in the earth's magnetic field. Anomalies are caused by induced or remnant magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferrous body by the earth's magnetic field. The shape and amplitude of these anomalies are a function of the orientation, geometry, size, depth, and magnetic susceptibility of the object, as well as the intensity and inclination of the earth's magnetic field in the area.

Magnetic locators will only locate metal objects that are made of ferrous material, like iron and steel utilities / facilities. It is an effective way to search for small metallic objects, such as buried ordinances, drums or utilities, because magnetic anomalies have spatial dimensions larger than those of the object themselves.

Photo 9: A metal detector being demonstrated

The depth in the ground at which a magnetic metal detector works depends on the mass of the object. A surveying nail can be detected to a depth of about 2-3 feet bgs (0.7 to 1m bgs), while an underground tank can be detected to a depth of about 15-17 feet bgs (5 to 5.6m bgs).

5. Vacuum Excavating

Small test holes are dug from the surface by vacuuming out soil, an activity commonly referred to as "potholing". This commonly follows more preliminary locating work to identify particularly difficult to trace utilities. It is also used when digging has been approved by the utility owner in the tolerance or critical zone of a particular utility to safely expose the line to excavate or sample in the surrounding area.

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Photo 10: A pothole exposing buried pipe

Photo 11: Vacuum excavation being demonstrated

Typically, vacuum excavation loosens the soil with a blunt-nosed high pressure air lance or water source and immediately vacuums away loosened material. Potholes are thus created, verifying the location and depth of a utility.

6. Subsurface Utility Engineering (SUE)

Subsurface Utility Engineering combines civil engineering, surveying and geophysics and utilizes several technologies, including vacuum excavation and surface geophysics. SUE is typically broken into four levels of quality pertaining to the methods, interpretation and precision of the subsurface utility data collected. These Quality Levels serve as a guide for engineers to determine the level of detail they require to map:

- Quality Level A: Designating & Location. Recommended during the design and construction phases.
- Quality Level B: Designation Only. Recommended during design stages and where utility records are generally unreliable.
- Quality Level C: Visible Features. Recommended during project planning stages to air site layout decisions.
- Quality Level D: Recommended for feasibility studies during the pre-design stage.

Photo 12: Subsurface Utility Engineering map

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ATTACHMENT F
COMMON UTILITY MARKINGS

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Common Utility Marking

Utility mark out colors and identifiers may differ by area, region or country. Check local regulations prior to ground disturbance to ensure that all markings are clearly understood by the field staff. Following are some commonly used utility markings, as well as typical dimensions and identifiers:

American Public Works Association (APWA) Utility Color Codes

Color	*Fluid*
VERDE (RAL 6032)	**Acqua**
GRIGIO ARGENTO (RAL 9006)	**Vapore o Acqua surriscaldata**
AZZURRO	**Aria**
GIALLO OCRA (RAL 1024)	**Gas anche liquefatti (aria esclusa)**
GIALLO (RAL 1201)	**Fluidi pericolosi**
ROSSO (RAL 3000)	**Acqua Antincendio**
VIOLETTO	**Alcali**
ARANCIONE (RAL 2010)	**Acidi**

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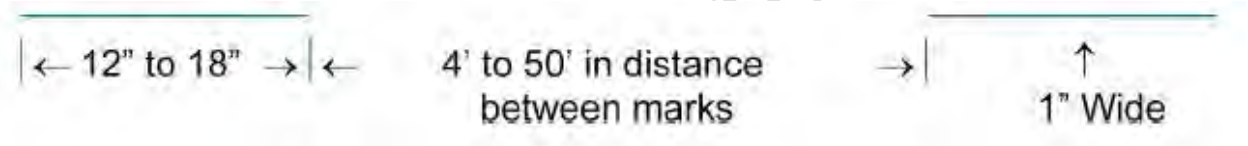
MARRONE (RAL 8007)	**Oli minerali, liquidi combustibili / infiammabili**
BIANCO	**Alta pressione**
NERO	**Altri Fluidi**

Italy: colors for industrial piping (ref. Technical Specification UNI 5634-1997):

Each marking should approximately be of the following dimensions:

- Width of each marking line should be approximately 1 to 2 inches (2.5cm to 5.0cm)
- Length of each marking line should be 12 to18 inches (30cm to 40cm)
- Distance between marks depends on-site conditions, but between 4 feet (1.2m) and 50 feet (15.2m) apart (i.e., the utility locator will NOT use a continuous marking line but instead a dashed line to indicate the existence of an underground pipe and/or line). In the example below, the approximate location of a long running potable water line will be marked as follows:



Example of "Utility/Facility Identifiers" in the United States

Utility/Facility Identifier			
CH	Chemical	SS	Storm Sewer
E	Electric	SL	Street Lighting
FO	Gas	STM	Steam
G	Liquefied Petroleum	SP	Slurry System
LPG	Gas	TEL	Telephone
PP	Petroleum Products	TS	Traffic Signal
RR	Railroad Signal	TV	Television
S	Sewer	W	Water
SD	Storm Drain	W	Reclaimed Water "Purple"
Underground Construction Descriptions			
C	Conduit	MH	Manhole
CDR	Corridor	PB	Pull Box
D	Distribution Facility	R	Radius
DB	Direct Buried	STR	Structure (vaults, junction box, inlet, lift station)
DE	Dead End		
JT	Joint Trench		
HP	High Pressure	T	Transmission Facility
HH	Hand Hole		
Infrastructure Material			
ABS	Acrylonitrile - Styrene	MTD	Multiple Tile Duct

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ACP	Asbestos Cement Pipe	PLA	Plastic
CI	Cast Iron	RCB	Reinforced Concrete Box
CMC	Cement Mortar Coated		
CML	Cement Mortar Lined	RCP	Reinforced Concrete Pipe
CPP	Corrugated Plastic Pipe		
CMP	Corrugated Metal Pipe	RF	Reinforced Fiberglass
CU	Copper	SCCP	Steel Cylinder Concrete Pipe
CWD	Creosote Wood Duct		
HDPE	High Density Polyethylene	STL	Steel
		VCP	Verified Clay Pipe

The marking may also provide some of the following additional information:

- Appropriate color for the utility (also referred to as a “Facility”) type;
- Total number of utilities / facilities of that type and their diameter;
- An abbreviation for the specific type of utility / facility present (e.g., HP, FO, STL,);
- Arrows would be provided if the line continues; and
- An End mark or a “T” would be present if the line ends.

Marking Samples

1. Electrical Duct Package: Red to represent electric, duct symbol represents multiple utilities running through a buried duct

2. 6” Natural Gas Line: Yellow to represent gas, straight line to symbolize a singular line

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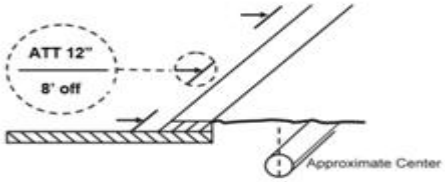
3. Termination Point of a Natural gas line: Yellow to represent natural gas, a T-shape to symbolize the termination location for the line

4. Offsets: Used when the marks cannot be placed directly above the buried utility / facility. In this case, a 6” gas line is located approximately 4 feet to the right from the marked line



5. No Conflict: Red represents electric, “OK” symbolizes no utilities of this type are present on the site

6. Buried Splices, Valves, Manhole Lids with the circle diameter indicating approximate size of buried utility / facility

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7. Street Lights: Red represents electric, combined with the SL symbol for street lights

8. Traffic Control: Red represents electric, combined with the TC symbol for traffic control

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APPENDIX I
Shared Learning Drilling Incident

CASCADE
DRILLING | TECHNICAL SERVICES

Shared Learning – Line of Fire – Ankle Injury

INCIDENT DESCRIPTION: 10/16/2019 – EE called to report that while he was assisting the driller remove/trip out casing from the well location. Driller attached to a stick of 10' x 6" casing & brought the stick of casing down with the rod handler. Driller intended to open the rod handler jaws to release to casing; however, the driller hit the incorrect lever & lowered the rod handler, with casing, down to the ground. When the rod handler lowered, the 10' piece of casing struck the EE's left thigh, pushed him backwards & then the 10' casing struck the EE's lower left leg/ankle, causing an injury

Date of Occurrence
10/16/2019

EHS Director: Brook King

CAO: Gary Crueger

Causal Factors:

- **Team failed to STOP WORK, perform proper risk assessment & implement proper controls**
- **Team failed to ensure correct body position before the task & ensure clear of NO-FLY ZONE.**
- **Team failed to ensure driller assistant was clear of pipe travel path while operators hands were on the controls/levers**
- **Team failed to utilize proper engineering controls, specific to pipe/rod stand for holding the casing in place**
- **Team failed to review the correct Rod Handling JSA SON14 before the task & ensure the required controls were properly in place.**

Corrective Actions:

- **Counseling & Coaching with crew regarding proper risk assessment for task**
- **Counseling & Coaching with the crew regarding NO-FLY ZONE & requirements for working near Rod Handler – Specific to pinch/crush points & line of fire hazards**
- **Review required JSA SON14 with crew. Communicate to workforce through Shared Learning & RCT process**
- **Counseling/Coaching & accountability actions with team on following JSA procedure(s) and STOP WORK authority use prior to task.**

A Shared Learning & RCT will be distributed company-wide

APPENDIX J
Chemical Information and Safety Data Sheets

HAZARDOUS PROPERTY INFORMATION

Check if Present	Material (CAS #)	Water Solubility[a]	Specific Gravity	Flash Point[c] (°F)	Vapor Pressure [d]	LEL UEL	Cal/OSHA PEL- TWA[f]	IDLH Level[h]	Range of Odor Values (ppm)	eV
Volatile Organic Compounds										
☒	Acetic acid (64-19-7)	Miscible	1.05	103	11 mm	4.0% 19.9%	10 ppm	50 ppm	0.0004-204	
☐	Acetone (67-64-1)	Miscible	0.79	0	180 mm	2.5% 12.8%	500 ppm	2,500 ppm	0.40-11,745	
☐	Acrolein (107-02-8)	40%	0.84	-15	210 mm	2.8% 31%	C 0.1 ppm Skin	2 ppm	0.0036-1.8	
☐	Acrylonitrile (107-13-1)	7%	0.81	30	83 mm	3% 17%	2 ppm Skin	85 ppm Ca	1.6 -22	
☒	Benzene (71-43-2)	0.07%	0.88	12	75 mm	1.2% 7.8%	1 ppm Skin	500 ppm Ca	0.47-313	
☐	Bromodichloro-methane (75-27-4)	4500 mg/l	1.98	--	50 mm	Non-flam	None established	None determined	--	
☐	Bromoform (75-25-2)	0.10%	2.89	--	5 mm	Non-flam	0.5 ppm Skin	850 ppm	0.19-15	
☐	Bromomethane (74-83-9)	2%	1.73	--	1.9 atm	10% 16.0%	1 ppm	250 ppm Ca	--	
☐	Carbon Tetrachloride (56-23-5)	0.05%	1.59	--	91 mm	Non-flam	2 ppm Skin	200 ppm Ca	1.68-720	
☐	Chlorobenzene (108-90-7)	0.05%	1.11	82	9 mm	1.3% 9.6%	10 ppm	1000 ppm	0.087-13	
☐	2-Chloroethyl-vinyl Ether (110-75-8)	0.02%	1.05	61	27 mm	--	None established	None determined	--	
☐	Chloroethane (75-00-3)	0.60%	0.92	-58	1000 mm	3.8% 15.4%	100 ppm Skin	3800 ppm	3.8-379[j]	
☐	Chloroform (67-66-3)	0.50%	1.48	--	160 mm	Non-flam	2 ppm	500 ppm Ca	0.102-1,413	
☐	Chloromethane (74-87-3)	0.50%	0.92	--	5.0 atm	8.1% 17.4%	50 ppm	2000 ppm Ca	>10	
☐	Dibromo-chloromethane (124-48-1)	2700 mg/l	2.5	--	76 mm	--	None established	None Determined	--	
☐	Dibutyl Phthalate (84-74-2)	0.001% (77°F)	1.05	315	0.00007 mm	0.5% --	5 mg/m^3	4,000 mg/m^3	0.023	
☐	1,2-Dichlorobenzene (95-50-1)	0.01%	1.3	151	1 mm	2.2% 9.2%	25 ppm Skin	200 ppm	0.02-50	
☐	1,1-Dichloroethane (75-34-3)	0.60%	1.18	2	182 mm	5.4% 11.40%	100 ppm	3,000 ppm	49-1,359	
☐	1,1-Dichloroethylene (75-35-4)	0.04%	1.21	-2	500 mm	6.5% 15.5%	1 ppm	None determined	50-1,387	
☐	1,2-Dichloroethane (107-06-2)	0.90%	1.24	56	64 mm	6.2% 16%	1 ppm	50 ppm Ca	4.3-988	
☐	1,2-Dichloroethylene (540-59-0)	0.40%	1.27	36-39	180-265 mm	5.6% 12.8%	200 ppm	1,000 ppm	277	
☐	1,2-Dichloropropane (78-87-5)	0.30%	1.16	60	40 mm	3.4% 14.5%	75 ppm	400 ppm Ca	0.26-8.66	
☐	1,3-Dichloropropene (542-75-6)	0.20%	1.21	77	28 mm	5.3% 14.5%	1 ppm Skin	None Determined Ca	<0.99	
☐	Bis-(2-Ethylhexyl)-phthalate (117-81-7)	0.00003%	0.99	420	<0.01 mm	0.3% --	5 mg/m^3	5,000 mg/m^3 Ca	--	
☐	Diethyl phthalate (84-66-2)	0.10%	1.12	322	0.002 mm	0.7% --	5 mg/m^3	None Determined	0.036-0.363	
☐	Dinitrotoluene (25321-14-6)	Insoluble	1.32	404	1 mm	-- --	0.15 mg/m^3 Skin	50 mg/m^3 Ca	--	
☐	Endrin (72-20-8)	Insoluble	1.7	--	0.00001 mm	--	0.1 mg/m^3 Skin	2 mg/m^3	--	
☐	Ethyl Benzene (100-41-4)	0.01%	0.87	55	7 mm	0.8% 6.7%	5 ppm	800 ppm	<0.002-18	
☐	Hydrazine (302-01-2)	Miscible	1.01	99	10 mm	2.9% 98%	0.01 ppm Skin	50 ppm Ca	3.0-4.0	

Check if Present	Material (CAS #)	Water Solubility[a]	Specific Gravity	Flash Point[c] (°F)	Vapor Pressure [d]	LEL UEL	Cal/OSHA PEL- TWA[f]	IDLH Level[h]	Range of Odor Values (ppm)	eV
☐	Methyl ethyl ketone (MEK) (78-93-3)	28%	0.81	16	78 mm	1.4% 11.4%	200 ppm	3000 ppm	0.07-339	
☐	Methyl Tert-butyl Ether (1634-04-4)	5.1 g/100ml	0.7	-18	245 mm	1.6% 8.4%	40 ppm	None determined	0.03-0.17	
☐	Methylene Chloride (75-09-2)	2%	1.33	--	350 mm	13% 23%	25 ppm	2,300 ppm Ca	1.2-440	
☐	Phenol (108-95-2)	9% (77°F)	1.06	175	0.4 mm	1.8% 8.6%	5 ppm Skin	250 ppm	0.0045-1.95	
☐	1,1,2,2-Tetrachloroethane (79-34-5)	0.30%	1.59	--	5 mm	Non-flam	1 ppm Skin	100ppm Ca	0.233-7.3	
☐	Tetrachloroethylene (127-18-4)	0.02%	1.62	--	14 mm	Non-flam	25 ppm	150 ppm Ca	0.767-71	
☐	Toluene (108-88-3)	0.07% (74°F)	0.87	40	21 mm	1.1% 7.1%	10 ppm Skin	500 ppm	0.021-157	
☐	1,1,1-Trichloroethane (71-55-6)	0.40%	1.34	--	100 mm	7.5% 12.5%	350 ppm	700 ppm	0.97-715	
☐	1,1,2-Trichloro-ethane (79-00-5)	0.40%	1.44	--	19 mm	6% 15.5%	10 ppm Skin	100 ppm Ca	--	
☐	1,2,4-Trichlorobenzene (120-82-1)	0.003%	1.45	222	1 mm	2.5% 6.6% (302 °F)	C 5 ppm	None Determined	2.96	
☐	Trichloroethylene (TCE) (79-01-6)	0.1% (77°F)	1.46	--	58 mm	8% 10.5%	25 ppm	1,000 ppm Ca	0.5-167	
☐	Trichlorofluoromethane (75-69-4)	0.1% (75°F)	1.47	--	690 mm	Non-flam	C 1,000 ppm	2000 ppm	5-200,057	
☐	1,1,2-Trichloro-1,2,2-trifluoroethane (76-13-1)	0.02%	1.56	--	285 mm	-- --	1,000 ppm	2,000 ppm	--	
☐	1,2,4-Trimethylbenzene (95-63-6)	0.006%	0.88	112	1 mm	0.9% 6.4%	25 ppm	None determined	0.006-2.4	
☐	Vinyl Chloride (75-01-4)	0.1% (77°F)	0.09	--	3.3 atm	3.6% 33%	1 ppm Skin	None Determined Ca	203-356	
☐	Xylene (o, p, m, mix) (1330-20-7)	Slightly soluble	0.86-0.88	81-90	7-9 mm	0.9% 7%	100 ppm	900 ppm	0.012-316	
Metals										
☐	Aluminum metal and oxide (as Al)	[b]	2.7	--	0 mm	[e]	10 mg/m^3 (respirable)	None determined	--	
☐	Antimony ()	[b]	6.69	--	0 mm	[e]	0.5 mg/m^3	50 mg/m^3	--	
☐	Arsenic (inorganic compounds, as As)	[b]	5.73	--	0 mm	[e]	0.01 mg/m^3	5 mg/m^3 Ca	--	
☐	Arsenic (organic compounds, as As)	Properties vary depending upon the specific organic arsenic compound.					0.2 mg/m^3	None determined	--	
☐	Barium chloride(as Ba) (10361-37-2)	38%	3.86	--	low	Non-flam	0.5 mg/m^3	50 mg/m^3	--	
☐	Barium nitrate (as Ba) (10022-31-8)	9%	3.24	--	Low	[e]	0.5 mg/m^3	50 mg/m^3	--	
☐	Beryllium and compounds (as Be)	[b]	1.85	--	0 mm	[e]	0.2 ☐g/m^3	4 mg/m^3 Ca	--	
☐	Cadmium dust (as Cd)	[b]	8.64	--	--	[e]	0.005 mg/m^3	9 mg/m^3 Ca	--	
☐	Chromium (III) compounds (as Cr)	[b]	Properties vary depending upon the specific compound.				0.5 mg/m^3	25 mg/m^3	--	
☐	Cobalt metal dust and fume (as Co) (7440-48-4)	Insoluble	8.92	--	0 mm	[e]	0.02 mg/m^3	20 mg/m^3	--	
☐	Copper dust and mist (as Cu)	[b]	8.94	--	0 mm	[e]	1 mg/m^3	100 mg/m^3	--	

Check if Present	Material (CAS #)	Water Solubility[a]	Specific Gravity	Flash Point[c] (°F)	Vapor Pressure [d]	LEL UEL	Cal/OSHA PEL- TWA[f]	IDLH Level[h]	Range of Odor Values (ppm)	eV
☐	Lead	Insoluble	11.34	--	0 mm	[e]	0.05 mg/m^3	100 mg/m^3	--	
☒	Tetraethyl Lead (78-00-2)	Insoluble	1.653	73	6 mm Hg	1.8% unknown	0.075 mg/m3 Skin	40 mg/m^3	--	
☐	Manganese, Fume and compounds (as Mn) (7439-96-5)	Insoluble	7.2	--	0 mm	Comb-ustible	0.2 mg/m^3	500 mg/m^3	--	
☐	Mercury compounds (as Hg) Except alkyl compound	[b]	13.6	--	0.0012 mm	[e]	0.025 mg/m^3 Skin	10 mg/m^3	--	
☐	Molybdenum (7439-98-7)	[b]	10.28	--	0 mm	Comb-ustible	10 mg/m^3 3 mg/m^3 (resp.)	5,000 mg/m^3	--	
☐	Nickel and other compounds (as Ni)	[b]	8.9	--	0 mm	[e]	0.5 mg/m^3	10 mg/m^3 Ca	--	
☐	Selenium (7782-49-2)	Insoluble	4.28	--	0 mm	Comb-ustible	0.2 mg/m^3	1 mg/m^3	--	
☐	Silver, metal dust and soluble compounds (as Ag)	[b]	10.49	--	0 mm	[e]	0.01 mg/m^3	10 mg/m^3	--	
☐	Thallium (soluble compouds, as Ti)	[b]	Properties vary depending upon the specific compound.				0.1 mg/m^3 Skin	15 mg/m^3	--	
☐	Vanadium pentoxide dust and Fume (1314-62-1)	0.8%	3.36	--	0 mm	[e]	0.05 mg/m^3 (Respirable)	35 mg/m^3	--	
☐	Zinc oxide (1314-13-2)	0.0004% (64°F)	5.61	--	0 mm	[e]	5 mg/m^3	500 mg/m^3	--	
Miscellaneous										
☐	Ammonia (7664-41-7)	34%	--	--	8.5 atm	15% 28%	25 ppm	300 ppm	0.043-60.3	
☐	Asbestos (1332-21-4)	Insoluble	--	--	0 mm	Non-flam	0.1 fibers/cc	None determined	--	
☐	Chromic Acid and chromates (1333-82-0)	63%	2.7	--	Very low	Non-flam	0.005 mg/m^3	15 mg/m^3 Ca	--	
☐	Cyanide (as CN)	--	--	--	--	Non-flam	5 mg/m^3 Skin	--	--	
☐	DDT (50-29-3)	Insoluble	0.99	162-171	0.0000002 mm	--	1 mg/m^3 Skin	500 mg/m^3 Ca	--	
☐	Diesel Fuel #2 (68476-34-6)	Insoluble	0.81-0.90	130	--	0.6-1.3 6-7.5	None established	None determined	--	
☐	Fluorides, as F	--	--	--	--	--	2.5 mg/m^3	None determined	--	
☐	Gasoline (8006-61-9)	Insoluble	0.72-0.76	-45	38-300 mm	1.4% 7.6%	300 ppm	Ca None determined	--	
☒	Hydrofluoric Acid (7664-39-3)	Miscible	0.991	--	252 psig	Non-flam	3 ppm	100 ppm	0.01-1.5	
☒	Hydrogen Sulfide	0.4%	0.916	--	15,200 mm Hg	4.3% 45%		100 ppm		
☐	Kerosene (8008-20-6)	Insoluble	0.81	100-162	5mm (100°F)	0.7% 5.0%	200 mg/m^3[g] Skin	None determined	--	
☐	Naphthalene (91-20-3)	0.003%	1.15	174	0.08 mm	0.9% 5.9%	0.1 ppm	250 ppm	0.0019-1.02	
☐	PCB (42% chlorine) (53469-21-9)	Insoluble	1.39	--	0.001 mm	Non-flam	1 mg/m^3 Skin	5 mg/m^3 Ca	--	
☐	PCB (54% chlorine) (11097-69-1)	Insoluble	1.38	--	0.00006	Non-flam	0.5 mg/m^3 Skin	5 mg/m^3 Ca	--	
☐	Phosphorus (yellow) (7723-14-0)	0.00%	1.82	--	0.03 mm	-- --	0.1 mg/m^3	5 mg/m^3	--	
☐	Polycyclic Aromatic Hydrocarbons (PAH)	Properties vary depending upon the specific compound. Listed in NIOSH as Coal Tar Pitch Volatiles					0.2 mg/m^3	80 mg/m^3 Ca	--	

SITE-SPECIFIC SUBSTANCES:
(Add hazardous property information on any substances that are of concern at the site but are not listed above.)

Check if Present	Material (CAS #)	Water Solubility[a]	Specific Gravity	Flash Point[c] (°F)	Vapor Pressure [d]	LEL UEL	Cal/OSHA PEL- TWA[f]	IDLH Level[h]	Range of Odor Values (ppm)	eV

EXPLANATIONS AND FOOTNOTES:

[a] Water solubility is expressed in different terms in different references. Many references use the term "insoluble" for materials that will not readily mix with water, such as gasoline. However, most of these materials are water soluble at the part per million or part per billion level. Gasoline, for example, is insoluble in the gross sense and will be found as a discrete layer on top of the ground water. But certain gasoline constituents, such as benzene, toluene and xylene, will also be found in solution in the ground water at the part per million or part per billion levels.

[b] Solubility of metals depends on the compound in which they are present.

[c] Several chlorinated hydrocarbons exhibit no flash point in a conventional sense, but will burn in the presence of high energy ignition source or will form explosive mixtures at temperatures above 200 ☐F.

[d] Expressed as mm Hg under standard conditions.

[e] Explosive concentrations of airborne dust can occur in confined areas.

[f] Cal/OSHA Time-weighted Average (TWA) PELs except where noted in g. The substances designated by "Skin" in the PEL column may be absorbed into the bloodstream through the skin, the mucous membranes and/or the eye and contribute to the overall exposure. "C" notation indicates the number given is a ceiling value.

[g] TLV-TWA adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). Currently, there is no Cal/OSHA PEL.

[h] The substances with a "Ca" notation in the IDLH column are considered to be potential occupational carcinogens by NIOSH.

[i] Odor thresholds values extracted from "*ODOR THRESHOLDS for Chemicals with established Occupational Health Standards*", American Industrial Hygiene Association, 1997.

(d) Odor detection threshold: Lowest concentration at which a stimulus is being detected.

(r) Odor recognition threshold: Lowest concentration at which a definite odor character is detected.

[j] Values extracted from the US Environmental Protection Agency Technology Transfer Network, Air Toxics website. URL: www.epa.gov/ttn/atw/, 2006

[k] Value extracted from "*HESIS Guide to Solvent Safety*" California Department of Health Services, 2004. URL: http://www.dhs.ca.gov/ohb/HESIS/solv_cht.htm

[l] Value extracted from "*Chemical Summary For Methyl-Tert-Butyl Ether*", US Environmental Protection Agency, Office Of Pollution Prevention and Toxics, August 1994. URL: http://www.epa.gov/chemfact/s_mtbe.txt

SAFETY DATA SHEET

Revision Date 10-Feb-2015 **Revision Number** 1

1. Identification

Product Name **Benzene**

Cat No. : **AC167660000; AC167660010; AC167660025; AC167660250; AC167665000**

Synonyms Cyclohexatriene; Phenyl hydride.; Benzol

Recommended Use Laboratory chemicals.

Uses advised against No Information available

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Entity / Business Name
Acros Organics
One Reagent Lane
Fair Lawn, NJ 07410

Emergency Telephone Number
For information **US** call: 001-800-ACROS-01 / **Europe** call: +32 14 57 52 11
Emergency Number **US:**001-201-796-7100 / **Europe:** +32 14 57 52 99
CHEMTREC Tel. No.**US:**001-800-424-9300 / **Europe:**001-703-527-3887

2. Hazard(s) identification

Classification
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Flammable liquids	Category 2
Skin Corrosion/irritation	Category 2
Serious Eye Damage/Eye Irritation	Category 2
Germ Cell Mutagenicity	Category 1A
Carcinogenicity	Category 1A
Specific target organ toxicity - (repeated exposure)	Category 1
Aspiration Toxicity	Category 1

Label Elements

Signal Word
Danger

Hazard Statements
Highly flammable liquid and vapor
May be fatal if swallowed and enters airways
Causes skin irritation
Causes serious eye irritation
May cause genetic defects
May cause cancer
Causes damage to organs through prolonged or repeated exposure

Precautionary Statements
Prevention
Obtain special instructions before use
Do not handle until all safety precautions have been read and understood
Use personal protective equipment as required
Wash face, hands and any exposed skin thoroughly after handling
Wear eye/face protection
Do not breathe dust/fume/gas/mist/vapors/spray
Do not eat, drink or smoke when using this product
Keep away from heat/sparks/open flames/hot surfaces. - No smoking
Keep container tightly closed
Ground/bond container and receiving equipment
Use explosion-proof electrical/ventilating/lighting/equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Response
IF exposed or concerned: Get medical attention/advice
Skin
If skin irritation occurs: Get medical advice/attention
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower
Wash contaminated clothing before reuse
Eyes
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
If eye irritation persists: Get medical advice/attention
Ingestion
IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician
Do NOT induce vomiting
Fire
In case of fire: Use CO2, dry chemical, or foam for extinction
Storage
Store locked up
Store in a well-ventilated place. Keep cool
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
None identified

3. Composition / information on ingredients

Component	CAS-No	Weight %
Benzene	71-43-2	> 99

4. First-aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Immediate medical attention is required.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Immediate medical attention is required.

Inhalation Move to fresh air. If breathing is difficult, give oxygen. Do not use mouth-to-mouth resuscitation if victim ingested or inhaled the substance; induce artificial respiration with a respiratory medical device. Immediate medical attention is required.

Ingestion Do not induce vomiting. Call a physician or Poison Control Center immediately.

Most important symptoms/effects Breathing difficulties. Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting

Notes to Physician Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. Cool closed containers exposed to fire with water spray.

Unsuitable Extinguishing Media No information available

Flash Point -11 °C / 12.2 °F
Method - No information available

Autoignition Temperature 498 °C / 928.4 °F
Explosion Limits
Upper No data available
Lower No data available
Sensitivity to Mechanical Impact No information available
Sensitivity to Static Discharge No information available

Specific Hazards Arising from the Chemical
Flammable. Containers may explode when heated. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back.

Hazardous Combustion Products
Carbon monoxide (CO) Carbon dioxide (CO_2)
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear. Thermal decomposition can lead to release of irritating gases and vapors.

NFPA

Health	Flammability	Instability	Physical hazards
3	3	0	N/A

6. Accidental release measures

Personal Precautions Use personal protective equipment. Keep people away from and upwind of spill/leak. Evacuate personnel to safe areas. Remove all sources of ignition. Take precautionary measures against static discharges.

Environmental Precautions Should not be released into the environment. See Section 12 for additional ecological information.

Methods for Containment and Clean Up Soak up with inert absorbent material. Keep in suitable, closed containers for disposal. Remove all sources of ignition. Use spark-proof tools and explosion-proof equipment.

7. Handling and storage

Handling Use only under a chemical fume hood. Wear personal protective equipment. Do not get in eyes, on skin, or on clothing. Keep away from open flames, hot surfaces and sources of ignition. Use only non-sparking tools. Use explosion-proof equipment. Do not breathe vapors/dust. Do not ingest. Take precautionary measures against static discharges.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place. Flammables area. Keep away from heat and sources of ignition.

8. Exposure controls / personal protection

Exposure Guidelines

Component	ACGIH TLV	OSHA PEL	NIOSH IDLH
Benzene	TWA: 0.5 ppm STEL: 2.5 ppm Skin	(Vacated) TWA: 10 ppm Ceiling: 25 ppm (Vacated) STEL: 50 ppm (Vacated) Ceiling: 25 ppm TWA: 10 ppm TWA: 1 ppm STEL: 5 ppm	IDLH: 500 ppm TWA: 0.1 ppm STEL: 1 ppm

Component	Quebec	Mexico OEL (TWA)	Ontario TWAEV
Benzene	TWA: 1 ppm TWA: 3 mg/m^3 STEL: 5 ppm STEL: 15.5 mg/m^3	TWA: 1 ppm TWA: 3.2 mg/m^3 STEL: 5 ppm STEL: 16 mg/m^3	TWA: 0.5 ppm STEL: 2.5 ppm Skin

Legend

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration
NIOSH IDLH: The National Institute for Occupational Safety and Health Immediately Dangerous to Life or Health

Engineering Measures Use only under a chemical fume hood. Ensure that eyewash stations and safety showers are close to the workstation location. Use explosion-proof electrical/ventilating/lighting/equipment.

Personal Protective Equipment

Eye/face Protection Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin and body protection Wear appropriate protective gloves and clothing to prevent skin exposure.

Respiratory Protection Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Liquid
Appearance	Clear Colorless
Odor	aromatic
Odor Threshold	No information available
pH	No information available
Melting Point/Range	5.5 °C / 41.9 °F
Boiling Point/Range	80.1 °C / 176.2 °F
Flash Point	-11 °C / 12.2 °F
Evaporation Rate	No information available
Flammability (solid,gas)	No information available
Flammability or explosive limits	
Upper	No data available
Lower	No data available
Vapor Pressure	75 mmHg @ 20 °C
Vapor Density	2.8 (Air = 1.0)
Relative Density	0.8765 @ 20°C
Solubility	Insoluble in water
Partition coefficient; n-octanol/water	No data available

Autoignition Temperature	498 °C / 928.4 °F
Decomposition Temperature	No information available
Viscosity	No information available
Molecular Formula	C6H6
Molecular Weight	78.11

10. Stability and reactivity

Reactive Hazard None known, based on information available

Stability Stable under normal conditions.

Conditions to Avoid Incompatible products. Excess heat. Keep away from open flames, hot surfaces and sources of ignition.

Incompatible Materials Strong oxidizing agents

Hazardous Decomposition Products Carbon monoxide (CO), Carbon dioxide (CO_2)

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions None under normal processing.

11. Toxicological information

Acute Toxicity

Component Information

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Benzene	810 mg/kg (Rat) 1800 mg/kg (Rat)	8200 mg/kg (Rabbit)	44.66 mg/L (Rat) 4 h

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation No information available

Sensitization No information available

Carcinogenicity May cause cancer.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Benzene	71-43-2	Group 1	Known	A1	X	A2

Mutagenic Effects May cause heritable genetic damage

Reproductive Effects No information available.

Developmental Effects No information available.

Teratogenicity No information available.

STOT - single exposure None known
STOT - repeated exposure None known

Aspiration hazard No information available

Symptoms / effects,both acute and delayed Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting
Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity

Do not empty into drains.

Component	Freshwater Algae	Freshwater Fish	Microtox	Water Flea
Benzene	29 mg/L EC50 = 72 h	70000 - 142000 µg/L LC50 96 h 22330 - 41160 µg/L LC50 96 h 28.6 mg/L LC50 96 h 22.49 mg/L LC50 96 h 5.3 mg/L LC50 96 h 10.7 - 14.7 mg/L LC50 96 h	Not listed	10 mg/L EC50 = 48 h 8.76 - 15.6 mg/L EC50 48 h

Persistence and Degradability No information available

Bioaccumulation/ Accumulation No information available.

Mobility No information available.

Component	log Pow
Benzene	1.83

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

Component	RCRA - U Series Wastes	RCRA - P Series Wastes
Benzene - 71-43-2	U019	-

14. Transport information

DOT Not regulated

TDG Not regulated

IATA

- **UN-No** UN1114
- **Hazard Class** 3
- **Packing Group** II

IMDG/IMO

- **UN-No** UN1114
- **Hazard Class** 3
- **Packing Group** II

15. Regulatory information

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
Benzene	X	X	-	200-753-7	-		X	X	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).
Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b) Not applicable

SARA 313

Component	CAS-No	Weight %	SARA 313 - Threshold Values %
Benzene	71-43-2	> 99	0.1

SARA 311/312 Hazardous Categorization

Acute Health Hazard	Yes
Chronic Health Hazard	Yes
Fire Hazard	Yes
Sudden Release of Pressure Hazard	No
Reactive Hazard	No

Clean Water Act

Component	CWA - Hazardous Substances	CWA - Reportable Quantities	CWA - Toxic Pollutants	CWA - Priority Pollutants
Benzene	X	10 lb	X	X

Clean Air Act

Component	HAPS Data	Class 1 Ozone Depletors	Class 2 Ozone Depletors
Benzene	X		-

OSHA Occupational Safety and Health Administration
Not applicable

Component	Specifically Regulated Chemicals	Highly Hazardous Chemicals
Benzene	5 ppm STEL 0.5 ppm Action Level 1 ppm TWA	-

CERCLA
Not applicable

Component	Hazardous Substances RQs	CERCLA EHS RQs
Benzene	10 lb	-

California Proposition 65 This product does not contain any Proposition 65 chemicals

Component	CAS-No	California Prop. 65	Prop 65 NSRL	Category
Benzene	71-43-2	Carcinogen Developmental Male Reproductive	6.4 µg/day 13 µg/day	Developmental Carcinogen

State Right-to-Know

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Benzene	X	X	X	X	X

U.S. Department of Transportation

Reportable Quantity (RQ):	N
DOT Marine Pollutant	N
DOT Severe Marine Pollutant	N

U.S. Department of Homeland Security
This product does not contain any DHS chemicals.

Other International Regulations

Mexico - Grade No information available

Canada
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR

WHMIS Hazard Class	B2 Flammable liquid D2A Very toxic materials

16. Other information

Prepared By	Regulatory Affairs Thermo Fisher Scientific Email: EMSDS.RA@thermofisher.com
Revision Date	10-Feb-2015
Print Date	10-Feb-2015
Revision Summary	This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

Disclaimer
The information provided on this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

End of SDS

SAFETY DATA SHEET

Creation Date 06-Jul-2010 **Revision Date** 18-Jan-2018 **Revision Number** 4

1. Identification

Product Name **HYDROFLUORIC ACID**

Cat No. : **A463-1; A463-2; A463-250; A463-500**

Synonyms Hydrofluoric acid solution; Fluohydric acid; Fluoric acid

Recommended Use Laboratory chemicals.
Uses advised against Not for food, drug, pesticide or biocidal product use

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Emergency Telephone Number
CHEMTREC®, Inside the USA: 800-424-9300
CHEMTREC®, Outside the USA: 001-703-527-3887

2. Hazard(s) identification

Classification
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Corrosive to metals	Category 1
Acute oral toxicity	Category 2
Acute dermal toxicity	Category 1
Acute Inhalation Toxicity - Vapors	Category 2
Skin Corrosion/irritation	Category 1 A
Serious Eye Damage/Eye Irritation	Category 1
Specific target organ toxicity (single exposure)	Category 3
Target Organs - Respiratory system.	

Label Elements

Signal Word
Danger

Hazard Statements
May be corrosive to metals
Fatal if swallowed
Fatal in contact with skin
Causes severe skin burns and eye damage
May cause respiratory irritation
Fatal if inhaled

Precautionary Statements
Prevention
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product
Do not get in eyes, on skin, or on clothing
Wear protective gloves/protective clothing/eye protection/face protection
Do not breathe dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Wear respiratory protection
Keep only in original container
Response
Immediately call a POISON CENTER or doctor/physician
Inhalation
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Skin
Wash contaminated clothing before reuse
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower
Eyes
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
Ingestion
Rinse mouth
Do NOT induce vomiting
Spills
Absorb spillage to prevent material damage
Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed
Store in corrosive resistant polypropylene container with a resistant inliner
Store in a dry place
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
None identified

3. Composition/Information on Ingredients

Component	CAS-No	Weight %
Hydrogen fluoride	7664-39-3	40-60
Water	7732-18-5	40-60

4. First-aid measures

General Advice Show this safety data sheet to the doctor in attendance. Immediate medical attention is required.

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Immediate medical attention is required.

Inhalation If not breathing, give artificial respiration. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Move to fresh air. Immediate medical attention is required.

Ingestion Do not induce vomiting. Call a physician or Poison Control Center immediately.

Most important symptoms and effects Causes burns by all exposure routes. Product is a corrosive material. Use of gastric lavage or emesis is contraindicated. Possible perforation of stomach or esophagus should be investigated: Ingestion causes severe swelling, severe damage to the delicate tissue and danger of perforation

Notes to Physician Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Unsuitable Extinguishing Media No information available

Flash Point No information available
Method - No information available

Autoignition Temperature No information available
Explosion Limits
Upper No data available
Lower No data available
Sensitivity to Mechanical Impact No information available
Sensitivity to Static Discharge No information available

Specific Hazards Arising from the Chemical
The product causes burns of eyes, skin and mucous membranes. Thermal decomposition can lead to release of irritating gases and vapors.

Hazardous Combustion Products
Gaseous hydrogen fluoride (HF)
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear. Thermal decomposition can lead to release of irritating gases and vapors.

NFPA

Health	Flammability	Instability	Physical hazards
4	0	1	N/A

6. Accidental release measures

Personal Precautions Use personal protective equipment. Ensure adequate ventilation. Evacuate personnel to safe areas. Keep people away from and upwind of spill/leak.

Environmental Precautions Should not be released into the environment.

Methods for Containment and Clean Up Soak up with inert absorbent material. Keep in suitable, closed containers for disposal.

7. Handling and storage

Handling Wear personal protective equipment. Do not get in eyes, on skin, or on clothing. Use only under a chemical fume hood. Do not breathe vapors or spray mist. Do not ingest.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place. Corrosives area. Do not store in metal containers.

8. Exposure controls / personal protection

Exposure Guidelines

Component	ACGIH TLV	OSHA PEL	NIOSH IDLH	Mexico OEL (TWA)
Hydrogen fluoride	TWA: 0.5 ppm TWA: 2.5 mg/m³ Ceiling: 2 ppm Skin	(Vacated) TWA: 3 ppm (Vacated) TWA: 2.5 mg/m³ (Vacated) STEL: 6 ppm TWA: 3 ppm	IDLH: 30 ppm IDLH: 250 mg/m³ TWA: 3 ppm TWA: 2.5 mg/m³ Ceiling: 6 ppm Ceiling: 5 mg/m³	TWA: 2.5 mg/m³ Ceiling: 3 ppm Ceiling: 2.5 mg/m³

Legend

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration
NIOSH IDLH: The National Institute for Occupational Safety and Health Immediately Dangerous to Life or Health

Engineering Measures Use only under a chemical fume hood. Ensure adequate ventilation, especially in confined areas. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal Protective Equipment

Eye/face Protection Tightly fitting safety goggles. Face-shield.

Skin and body protection Long sleeved clothing.

Respiratory Protection Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Liquid
Appearance	Colorless
Odor	pungent
Odor Threshold	No information available
pH	< 1.0
Melting Point/Range	-35 °C / -31 °F
Boiling Point/Range	105 °C / 221 °F
Flash Point	No information available
Evaporation Rate	No information available
Flammability (solid,gas)	Not applicable
Flammability or explosive limits	
Upper	No data available
Lower	No data available
Vapor Pressure	No information available
Vapor Density	2.21
Specific Gravity	1.15-1.20
Solubility	miscible
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	No information available
Decomposition Temperature	No information available
Viscosity	No information available
Molecular Formula	H F
Molecular Weight	20

10. Stability and reactivity

Reactive Hazard None known, based on information available

Stability Stable under normal conditions.

Conditions to Avoid Incompatible products. Excess heat.

Incompatible Materials Metals, Cyanides, Sulfides, Bases, Fluorine

Hazardous Decomposition Products Gaseous hydrogen fluoride (HF)

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions Corrosive to metals. Contact with metals may evolve flammable hydrogen gas.

11. Toxicological information

Acute Toxicity

Product Information
Oral LD50 Category 2. ATE = 5 - 50 mg/kg.
Dermal LD50 Category 1. ATE < 50 mg/kg.
Vapor LC50 Category 2. ATE = 0.5 - 2 mg/l.
Component Information

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Hydrogen fluoride	Not listed	Not listed	LC50 = 0.79 mg/L (Rat) 1 h
Water	-	Not listed	Not listed

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation Causes severe burns by all exposure routes

Sensitization No information available

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Hydrogen fluoride	7664-39-3	Not listed	Not listed	Not listed	Not listed	Not listed
Water	7732-18-5	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects No information available

Reproductive Effects No information available.

Developmental Effects No information available.

Teratogenicity No information available.

STOT - single exposure Respiratory system
STOT - repeated exposure None known

Aspiration hazard No information available

Symptoms / effects,both acute and delayed Product is a corrosive material. Use of gastric lavage or emesis is contraindicated. Possible perforation of stomach or esophagus should be investigated: Ingestion causes severe swelling, severe damage to the delicate tissue and danger of perforation

Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity

Do not empty into drains. .

Component	Freshwater Algae	Freshwater Fish	Microtox	Water Flea
Hydrogen fluoride	Not listed	LC50 = 660 mg/L, 48h (Leuciscus idus)	Not listed	EC50 = 270 mg/L, 48h (Daphnia species)

Persistence and Degradability Soluble in water Persistence is unlikely based on information available. Miscible with water

Bioaccumulation/ Accumulation No information available.

Mobility Will likely be mobile in the environment due to its water solubility.

Component	log Pow
Hydrogen fluoride	-1.4

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

Component	RCRA - U Series Wastes	RCRA - P Series Wastes
Hydrogen fluoride - 7664-39-3	U134	-

14. Transport information

DOT

UN-No UN1790
Proper Shipping Name HYDROFLUORIC ACID
Hazard Class 8
Subsidiary Hazard Class 6.1
Packing Group II

TDG

UN-No UN1790
Proper Shipping Name HYDROFLUORIC ACID
Hazard Class 8
Subsidiary Hazard Class 6.1
Packing Group II

IATA

UN-No UN1790
Proper Shipping Name HYDROFLUORIC ACID
Hazard Class 8
Subsidiary Hazard Class 6.1
Packing Group II

IMDG/IMO

UN-No UN1790
Proper Shipping Name HYDROFLUORIC ACID
Hazard Class 8
Subsidiary Hazard Class 6.1
Packing Group II

15. Regulatory information

All of the components in the product are on the following Inventory lists: X = listed

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
Hydrogen fluoride	X	X	-	231-634-8	-		X	X	X	X	X
Water	X	X	-	231-791-2	-		X	-	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).
Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b) Not applicable

SARA 313

Component	CAS-No	Weight %	SARA 313 - Threshold Values %
Hydrogen fluoride	7664-39-3	40-60	1.0

SARA 311/312 Hazard Categories See section 2 for more information

CWA (Clean Water Act)

Component	CWA - Hazardous Substances	CWA - Reportable Quantities	CWA - Toxic Pollutants	CWA - Priority Pollutants
Hydrogen fluoride	X	100 lb	-	-

Clean Air Act

Component	HAPS Data	Class 1 Ozone Depletors	Class 2 Ozone Depletors
Hydrogen fluoride	X		-

OSHA Occupational Safety and Health Administration
Not applicable

Component	Specifically Regulated Chemicals	Highly Hazardous Chemicals
Hydrogen fluoride	-	TQ: 1000 lb

CERCLA This material, as supplied, contains one or more substances regulated as a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302)

Component	Hazardous Substances RQs	CERCLA EHS RQs
Hydrogen fluoride	100 lb	100 lb

California Proposition 65 This product does not contain any Proposition 65 chemicals

U.S. State Right-to-Know Regulations

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Hydrogen fluoride	X	X	X	X	X
Water	-	-	X	-	-

U.S. Department of Transportation

Reportable Quantity (RQ): N

DOT Marine Pollutant N
DOT Severe Marine Pollutant N

U.S. Department of Homeland Security
This product contains the following DHS chemicals:

Component	DHS Chemical Facility Anti-Terrorism Standard
Hydrogen fluoride	750 lb STQ (50% concentration or greater)

Other International Regulations

Mexico - Grade No information available

16. Other information

Prepared By Regulatory Affairs
Thermo Fisher Scientific
Email: EMSDS.RA@thermofisher.com

Creation Date 06-Jul-2010
Revision Date 18-Jan-2018
Print Date 18-Jan-2018
Revision Summary This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

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End of SDS

SAFETY DATA SHEET

Hydrogen Sulfide

Section 1. Identification

GHS product identifier : Hydrogen Sulfide

Chemical name : hydrogen sulfide

Other means of identification : Hydrogen sulfide; Hydrogen sulfide (H2S); Sulfuretted hydrogen; Sewer gas; Hydrosulfuric acid; dihydrogen sulfide

Product type : Gas.

Product use : Synthetic/Analytical chemistry.

Synonym : Hydrogen sulfide; Hydrogen sulfide (H2S); Sulfuretted hydrogen; Sewer gas; Hydrosulfuric acid; dihydrogen sulfide

SDS # : 001029

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE GASES - Category 1
GASES UNDER PRESSURE - Liquefied gas
ACUTE TOXICITY (inhalation) - Category 2
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3
AQUATIC HAZARD (ACUTE) - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Extremely flammable gas.
May form explosive mixtures with air.
Contains gas under pressure; may explode if heated.
Fatal if inhaled.
May cause respiratory irritation.
Very toxic to aquatic life.
Extended exposure to gas reduces the ability to smell sulfides.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Always keep container in upright position. Do not depend on odor to detect presence of gas. Approach suspected leak area with caution.

Prevention : Wear respiratory protection. Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Use only outdoors or in a well-ventilated area. Avoid release to the environment. Do not breathe gas.

Section 2. Hazards identification

Response : Collect spillage. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician. Leaking gas fire: Do not extinguish, unless leak can be stopped safely. Eliminate all ignition sources if safe to do so.

Storage : Store locked up. Protect from sunlight. Store in a well-ventilated place.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : hydrogen sulfide

Other means of identification : Hydrogen sulfide; Hydrogen sulfide (H2S); Sulfuretted hydrogen; Sewer gas; Hydrosulfuric acid; dihydrogen sulfide

Product code : 001029

CAS number/other identifiers

CAS number : 7783-06-4

Ingredient name	%	CAS number
hydrogen sulfide	100	7783-06-4

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : Fatal if inhaled. May cause respiratory irritation.

Skin contact : No known significant effects or critical hazards.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Section 4. First aid measures

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:, respiratory tract irritation, coughing

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Extremely flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. This material is very toxic to aquatic life. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
sulfur oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. If involved in fire, shut off flow immediately if it can be done without risk. If this is impossible, withdraw from area and allow fire to burn. Fight fire from protected location or maximum possible distance. Eliminate all ignition sources if safe to do so.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : Accidental releases pose a serious fire or explosion hazard. No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. Do not breathe gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Section 6. Accidental release measures

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air). Water polluting material. May be harmful to the environment if released in large quantities. Collect spillage.

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Do not get in eyes or on skin or clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Use only non-sparking tools. Avoid release to the environment. Empty containers retain product residue and can be hazardous. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Do not breathe gas.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Eliminate all ignition sources. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Store locked up. Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
hydrogen sulfide	**ACGIH TLV (United States, 3/2017).** STEL: 5 ppm 15 minutes. TWA: 1 ppm 8 hours. **NIOSH REL (United States, 10/2016).** CEIL: 15 mg/m³ 10 minutes. CEIL: 10 ppm 10 minutes. **OSHA PEL 1989 (United States, 3/1989).** STEL: 21 mg/m³ 15 minutes. STEL: 15 ppm 15 minutes. TWA: 14 mg/m³ 8 hours. TWA: 10 ppm 8 hours. **OSHA PEL Z2 (United States, 2/2013).** AMP: 50 ppm 10 minutes. CEIL: 20 ppm

Section 8. Exposure controls/personal protection

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas. [Compressed gas.]

Color : Colorless.

Odor : Rotten eggs.

Odor threshold : Not available.

pH : Not available.

Melting point : -82°C (-115.6°F)

Boiling point : -60°C (-76°F)

Critical temperature : 100.5°C (212.9°F)

Flash point : Not available.

Evaporation rate : Not available.

Section 9. Physical and chemical properties

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Lower: 4.3%
Upper: 45%

Vapor pressure : 252 (psig)

Vapor density : 1.19 (Air = 1)

Specific Volume (ft ^{3}/lb) : 11.236

Gas Density (lb/ft ^{3}) : 0.089

Relative density : Not applicable.

Solubility : Not available.

Solubility in water : 5 g/l

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : 270°C (518°F)

Decomposition temperature : Not available.

Viscosity : Not applicable.

Flow time (ISO 2431) : Not available.

Molecular weight : 34.08 g/mole

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.

Incompatible materials : Oxidizers

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
hydrogen sulfide	LC50 Inhalation Gas.	Rat	712 ppm	1 hours

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Section 11. Toxicological information

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Name	Category	Route of exposure	Target organs
hydrogen sulfide	Category 3	Not applicable.	Respiratory tract irritation

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : Fatal if inhaled. May cause respiratory irritation.

Skin contact : No known significant effects or critical hazards.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:, respiratory tract irritation, coughing

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Section 11. Toxicological information

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Other information : IDLH : 100 ppm

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
hydrogen sulfide	Acute EC50 62 µg/l Fresh water Acute LC50 2 µg/l Fresh water	Crustaceans - Gammarus pseudolimnaeus Fish - Coregonus clupeaformis - Yolk-sac fry	2 days 96 hours

Persistence and degradability

Not available.

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

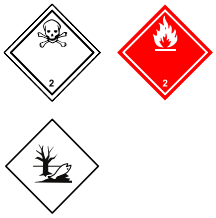
Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

United States - RCRA Toxic hazardous waste "U" List

Ingredient	CAS #	Status	Reference number
Hydrogen sulfide; Hydrogen sulfide H2S	7783-06-4	Listed	U135

Section 14. Transport information

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1053	UN1053	UN1053	UN1053	UN1053
UN proper shipping name	HYDROGEN SULFIDE	HYDROGEN SULFIDE; OR HYDROGEN SULPHIDE	HYDROGEN SULFIDE	HYDROGEN SULPHIDE	HYDROGEN SULPHIDE
Transport hazard class(es)	2.3 (2.1)	2.3 (2.1) 	2.3 (2.1)	2.3 (2.1)	2.3 (2.1)
Packing group	-	-	-	-	-
Environmental hazards	No.	Yes.	Yes. The environmentally hazardous substance mark is not required.	Yes.	Yes. The environmentally hazardous substance mark is not required.

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Additional information

DOT Classification : Toxic - Inhalation hazard Zone B
Reportable quantity 100 lbs / 45.4 kg. Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.
Limited quantity Yes.
Quantity limitation Passenger aircraft/rail: Forbidden. Cargo aircraft: Forbidden.
Special provisions 2, B9, B14

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2), 2.13-2.17 (Class 2), 2.7 (Marine pollutant mark).
The marine pollutant mark is not required when transported by road or rail.
Explosive Limit and Limited Quantity Index 0
ERAP Index 0
Passenger Carrying Ship Index Forbidden
Passenger Carrying Road or Rail Index Forbidden

IMDG : The marine pollutant mark is not required when transported in sizes of ≤5 L or ≤5 kg.

IATA : The environmentally hazardous substance mark may appear if required by other transportation regulations.
Quantity limitation Passenger and Cargo Aircraft: Forbidden. Cargo Aircraft Only: Forbidden.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

Clean Water Act (CWA) 311: hydrogen sulfide

Clean Air Act (CAA) 112 regulated toxic substances: hydrogen sulfide

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

Name	%	EHS	SARA 302 TPQ		SARA 304 RQ	
			(lbs)	(gallons)	(lbs)	(gallons)
hydrogen sulfide	100	Yes.	500	-	100	-

SARA 304 RQ : 100 lbs / 45.4 kg

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	hydrogen sulfide	7783-06-4	100
Supplier notification	hydrogen sulfide	7783-06-4	100

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : This material is listed.

New York : This material is listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Section 15. Regulatory information

Inventory list

Australia	:	This material is listed or exempted.
Canada	:	This material is listed or exempted.
China	:	This material is listed or exempted.
Europe	:	This material is listed or exempted.
Japan	:	**Japan inventory (ENCS)**: This material is listed or exempted. **Japan inventory (ISHL)**: Not determined.
Malaysia	:	Not determined.
New Zealand	:	This material is listed or exempted.
Philippines	:	This material is listed or exempted.
Republic of Korea	:	This material is listed or exempted.
Taiwan	:	This material is listed or exempted.
Thailand	:	Not determined.
Turkey	:	Not determined.
United States	:	This material is listed or exempted.
Viet Nam	:	Not determined.

Section 16. Other information

Hazardous Material Information System (U.S.A.)

Health	/	4
Flammability		4
Physical hazards		3

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)

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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Section 16. Other information

Classification	Justification
FLAMMABLE GASES - Category 1	Expert judgment
GASES UNDER PRESSURE - Liquefied gas	Expert judgment
ACUTE TOXICITY (inhalation) - Category 2	On basis of test data
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3	Expert judgment
AQUATIC HAZARD (ACUTE) - Category 1	Expert judgment

History

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Version : 1

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

TETRAETHYLLEAD

Safety Data Sheet PBL6459.5

Date of issue: 04/02/2015 Revision date: 08/28/2015 Version: 2.0

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product form	:	Substance
Physical state	:	Liquid
Substance name	:	TETRAETHYLLEAD
Product code	:	PBL6459.5
Formula	:	C8H20Pb
Synonyms	:	TETRAETHYL; TETRAETHYLPLUMBANE
Chemical family	:	METAL COMPOUND

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture	:	Chemical intermediate For research and industrial use only

1.3. Details of the supplier of the safety data sheet

GELEST, INC.
11 East Steel Road
Morrisville, PA 19067
USA
T 215-547-1015 - F 215-547-2484 - (M-F): 8:00 AM - 5:30 PM EST
info@gelest.com - www.gelest.com

1.4. Emergency telephone number

Emergency number	:	CHEMTREC: 1-800-424-9300 (USA); +1 703-527-3887 (International)

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Classification (GHS-US)

Flam. Liq. 4	H227
Acute Tox. 2 (Oral)	H300
Acute Tox. 4 (Dermal)	H312
STOT SE 3	H335
Aquatic Acute 1	H400

Full text of H-phrases: see section 16

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :

GHS06 GHS07 GHS09

Signal word (GHS-US) : Danger

Hazard statements (GHS-US) :
H227 - Combustible liquid
H300 - Fatal if swallowed
H312 - Harmful in contact with skin
H335 - May cause respiratory irritation
H400 - Very toxic to aquatic life

Precautionary statements (GHS-US) :
P280 - Wear protective gloves/protective clothing/eye protection/face protection
P210 - Keep away from heat, open flames, sparks. - No smoking
P261 - Avoid breathing vapors
P264 - Wash hands thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P271 - Use only outdoors or in a well-ventilated area
P273 - Avoid release to the environment
P330 - Rinse mouth
P301+P310 - If swallowed: Immediately call a doctor
P302+P352 - If on skin: Wash with plenty of water
P304+P340 - If inhaled: Remove person to fresh air and keep comfortable for breathing
P312 - Call a doctor if you feel unwell
P362+P364 - Take off contaminated clothing and wash it before reuse
P370+P378 - In case of fire: Use water spray, foam, carbon dioxide, dry chemical to extinguish

P391 - Collect spillage
P403+P233 - Store in a well-ventilated place. Keep container tightly closed
P403+P235 - Keep in a cool place
P405 - Store locked up
P501 - Dispose of contents/container to licensed waste disposal facility.

2.3. Other hazards

No additional information available

2.4. Unknown acute toxicity (GHS US)

No data available

SECTION 3: Composition/information on ingredients

3.1. Substance

Substance type : Mono-constituent
Name : TETRAETHYLLEAD
CAS No : 78-00-2
EC no : 201-075-4

Name	Product identifier	%	Classification (GHS-US)
Tetraethyllead	(CAS No) 78-00-2	95 - 100	Flam. Liq. 4, H227 Acute Tox. 2 (Oral), H300 Acute Tox. 3 (Dermal), H311 STOT SE 3, H335 Aquatic Acute 1, H400

3.2. Mixture

Not applicable

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : Remove contaminated clothing and shoes. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). If possible show this sheet; if not available show packaging or label.

First-aid measures after inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If you feel unwell, seek medical advice.

First-aid measures after skin contact : Wash with plenty of soap and water.

First-aid measures after eye contact : Immediately flush eyes thoroughly with water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical advice/attention.

First-aid measures after ingestion : Never give anything by mouth to an unconscious person. Get medical advice/attention.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/injuries after inhalation : May cause respiratory irritation. Volatile compounds of lead should be treated with extreme caution.

Symptoms/injuries after skin contact : May cause skin irritation.

Symptoms/injuries after eye contact : May cause eye irritation.

Symptoms/injuries after ingestion : Fatal if swallowed. Swallowing a small quantity of this material will result in serious health hazard.

Chronic symptoms : Exposure: Affects the central nervous system most strongly, with relatively little impact on hematopoietic organs. Immediate symptoms include dizziness, headaches, insomnia, loss of appetite. Progressive symptoms include mental euphoria, hallucinations, paranoia and death.

4.3. Indication of any immediate medical attention and special treatment needed

Physician note: Diagnostic mobilization of lead with calcium EDTA may be useful in questionable cases.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Water spray. Foam. Carbon dioxide. Dry chemical.

5.2. Special hazards arising from the substance or mixture

Fire hazard : Combustible liquid. Irritating fumes and organic acid vapors may develop when material is exposed to elevated temperatures or open flame.

Reactivity : IMPORTANT: AT ELEVATED TEMPERATURE IN LIQUID PHASE LEAD ALKYLS HAVE BEEN REPORTED TO EXPLODE. AN EXPLOSIVE CONDITION IS OFTEN PRECEDED BY THE LEAD ALKYL RAPIDLY TURNING BLACK. Stabilization has been reported by the addition of 0.5% stearic acid. Stearic acid is thought to getter lead metal which is catalytic for decomposition of lead alkyls.

5.3. Advice for firefighters

Firefighting instructions : Use water spray to cool exposed surfaces. Exercise caution when fighting any chemical fire.

Protection during firefighting : Do not enter fire area without proper protective equipment, including respiratory protection. Avoid all eye and skin contact and do not breathe vapor and mist.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures : Remove ignition sources. Use special care to avoid static electric charges.

6.1.1. For non-emergency personnel

Emergency procedures : Evacuate unnecessary personnel.

6.1.2. For emergency responders

Protective equipment : Equip cleanup crew with proper protection.

6.2. Environmental precautions

Notify authorities if liquid enters sewers or public waters.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Sweep or shovel spills into appropriate container for disposal.

6.4. Reference to other sections

See Heading 8. Exposure controls and personal protection.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Avoid all eye and skin contact and do not breathe vapor and mist. Provide good ventilation in process area to prevent accumulation of vapors. Use only non-sparking tools.

Hygiene measures : Wash hands and other exposed areas with mild soap and water before eating, drinking or smoking and when leaving work. Wash contaminated clothing before reuse.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Ground/bond container and receiving equipment.

Storage conditions : Keep container tightly closed.

Incompatible materials : Air.

Storage area : Store in a well-ventilated place. Store away from heat.

7.3. Specific end use(s)

No additional information available

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Tetraethyllead (78-00-2)		
USA ACGIH	ACGIH TWA (mg/m³)	0.1 mg/m³
USA NIOSH	NIOSH REL (TWA) (mg/m³)	0.075 mg/m³
USA OSHA	OSHA PEL (TWA) (mg/m³)	0.075 mg/m³
USA IDLH	US IDLH (mg/m³)	40 mg/m³

8.2. Exposure controls

Appropriate engineering controls : Handle in an enclosing hood with exhaust ventilation.

Personal protective equipment : Avoid all unnecessary exposure. Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.

Hand protection : Neoprene or nitrile rubber gloves.

Eye protection : Chemical goggles. Contact lenses should not be worn.

Skin and body protection : Wear suitable protective clothing.

Respiratory protection : Where exposure through inhalation may occur from use, respiratory protection equipment is recommended. NIOSH-certified full-face supplied air respirator.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state : Liquid

Appearance : Liquid.

Molecular mass : 323.44 g/mol

Color : Colorless. Amber hazy.

Odor : No data available

Odor threshold : No data available

Refractive index	:	1.519
pH	:	No data available
Relative evaporation rate (butyl acetate=1)	:	No data available
Melting point	:	No data available
Freezing point	:	-136 °C
Boiling point	:	84 - 85 °C @ 15 mm Hg
Flash point	:	73 °C
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Flammability (solid, gas)	:	Combustible liquid
Vapor pressure	:	6 mm Hg @ 25°C
Relative vapor density at 20 °C	:	8.6
Relative density	:	1.653
Solubility	:	Insoluble in water.
Log Pow	:	No data available
Log Kow	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	No data available
Explosive properties	:	No data available
Oxidizing properties	:	No data available
Explosion limits	:	No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

IMPORTANT: AT ELEVATED TEMPERATURE IN LIQUID PHASE LEAD ALKYLS HAVE BEEN REPORTED TO EXPLODE. AN EXPLOSIVE CONDITION IS OFTEN PRECEDED BY THE LEAD ALKYL RAPIDLY TURNING BLACK. Stabilization has been reported by the addition of 0.5% stearic acid. Stearic acid is thought to getter lead metal which is catalytic for decomposition of lead alkyls.

10.2. Chemical stability

Decomposes slowly above 85°C. May explode if heated above 110°C, particularly if confined. Decomposes on exposure to light.

10.3. Possibility of hazardous reactions

Material decomposes slowly in contact with air by reaction with oxygen.

10.4. Conditions to avoid

Light.

10.5. Incompatible materials

Air.

10.6. Hazardous decomposition products

Lead oxide fumes. Organic acid vapors.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Oral: Fatal if swallowed. Dermal: Harmful in contact with skin.

Tetraethyllead (78-00-2)	
LD50 oral rat	12.3 mg/kg
LD50 dermal rabbit	990 mg/kg
LC50 inhalation rat (mg/l)	850 mg/m³ (Exposure time: 1 h)
ATE US (oral)	12.300 mg/kg body weight
ATE US (dermal)	990.000 mg/kg body weight

Skin corrosion/irritation : Not classified

By analogy to tetraethyllead this compound is probably absorbed through the skin causing lead poisoning syndrome, which is associated with toxicity to the central nervous system.

Serious eye damage/irritation : Not classified

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified

An experimental carcinogen.

Tetraethyllead (78-00-2)	
IARC group	3 - Not classifiable

Reproductive toxicity : Not classified
An experimental teratogen.

Specific target organ toxicity (single exposure) : May cause respiratory irritation.

Specific target organ toxicity (repeated exposure) : Not classified

Aspiration hazard : Not classified

Symptoms/injuries after inhalation : May cause respiratory irritation. Volatile compounds of lead should be treated with extreme caution.

Symptoms/injuries after skin contact : May cause skin irritation.

Symptoms/injuries after eye contact : May cause eye irritation.

Symptoms/injuries after ingestion : Fatal if swallowed. Swallowing a small quantity of this material will result in serious health hazard.

Chronic symptoms : Exposure: Affects the central nervous system most strongly, with relatively little impact on hematopoietic organs. Immediate symptoms include dizziness, headaches, insomnia, loss of appetite. Progressive symptoms include mental euphoria, hallucinations, paranoia and death.

SECTION 12: Ecological information

12.1. Toxicity

Tetraethyllead (78-00-2)	
LC50 fish 1	84 mg/l (Exposure time: 96 h - Species: Lepomis macrochirus)
EC50 Daphnia 1	0.085 mg/l (Exposure time: 48 h - Species: Artemia salina)
LC50 fish 2	19.3 mg/l (Exposure time: 96 h - Species: Pimephales promelas)

12.2. Persistence and degradability

No additional information available

12.3. Bioaccumulative potential

Tetraethyllead (78-00-2)	
BCF fish 1	92 - 3189
Log Pow	4.32 (at 20 °C)

12.4. Mobility in soil

No additional information available

12.5. Other adverse effects

Other adverse effects : This substance may be hazardous to the environment.

Effect on ozone layer : No additional information available

Effect on the global warming : No known ecological damage caused by this product.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste disposal recommendations : Dispose of as lead waste. Dispose in a safe manner in accordance with local/national regulations.

Ecology - waste materials : Avoid release to the environment.

SECTION 14: Transport information

14.1. UN number

UN-No.(DOT) : 1649

DOT NA no. UN1649

14.2. UN proper shipping name

Proper Shipping Name (DOT) : Motor fuel anti-knock mixtures

Department of Transportation (DOT) Hazard Classes : 6.1 - Class 6.1 - Poisonous materials 49 CFR 173.132

Hazard labels (DOT) : 6.1 - Poison

DOT Symbols : + - Fixes (cannot be altered) proper shipping name, hazard class, and packing group

Packing group (DOT)	:	I - Great Danger
DOT Packaging Exceptions (49 CFR 173.xxx)	:	None
DOT Packaging Non Bulk (49 CFR 173.xxx)	:	201
DOT Packaging Bulk (49 CFR 173.xxx)	:	244

14.3. Additional information

Other information	:	No supplementary information available.

Transport by sea

DOT Vessel Stowage Location	:	D - The material must be stowed ''on deck only'' on a cargo vessel and on a passenger vessel carrying a number of passengers limited to not more than the larger of 25 passengers or one passenger per each 3 m of overall vessel length, but the material is prohibited on passenger vessels in which the limiting number of passengers is exceeded.
DOT Vessel Stowage Other	:	25 - Shade from radiant heat,40 - Stow ''clear of living quarters''

Air transport

DOT Quantity Limitations Passenger aircraft/rail (49 CFR 173.27)	:	Forbidden
DOT Quantity Limitations Cargo aircraft only (49 CFR 175.75)	:	30 L

SECTION 15: Regulatory information

15.1. US Federal regulations

Tetraethyllead (78-00-2)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory Listed on the United States SARA Section 302	
SARA Section 302 Threshold Planning Quantity (TPQ)	100

15.2. International regulations

Tetraethyllead (78-00-2)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on the Canadian DSL (Domestic Sustances List) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances) Listed on the Japanese ISHL (Industrial Safety and Health Law) Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances) Japanese Poisonous and Deleterious Substances Control Law Japanese Pollutant Release and Transfer Register Law (PRTR Law) Listed on the Canadian IDL (Ingredient Disclosure List) Listed on INSQ (Mexican national Inventory of Chemical Substances)

15.3. US State regulations

TETRAETHYLLEAD(78-00-2)	
U.S. - California - Proposition 65 - Carcinogens List	No
U.S. - California - Proposition 65 - Developmental Toxicity	No
U.S. - California - Proposition 65 - Reproductive Toxicity - Female	No
U.S. - California - Proposition 65 - Reproductive Toxicity - Male	No

Tetraethyllead (78-00-2)				
U.S. - California - Proposition 65 - Carcinogens List	U.S. - California - Proposition 65 - Developmental Toxicity	U.S. - California - Proposition 65 - Reproductive Toxicity - Female	U.S. - California - Proposition 65 - Reproductive Toxicity - Male	No significance risk level (NSRL)
No	No	No	No	

SECTION 16: Other information

Abbreviations and acronyms : Abbreviations: ND: Not Determined, No Data; NA: Not Applicable; LD: Lethal Dose; LC: Lethal Concentration; ATE: Acute Toxicity Estimates; H: hour; °: °C unless otherwise stated; mm: millimeters Hg, torr; PEL: permissible exposure level; TWA: time weighted average; TLV: threshold limit value; TG: Test Guideline; NIOSH: National Institute for Occupational Safety and Health; IARC: International Agency for Research on Cancer; NTP: National Toxicology Program; HMIS: Hazardous Material Information System; CAS No.: Chemcial Abstract Service Registration Number; EC No.: European Commission Registration Number; EC Index No.: European Commission Index Number; OECD: The Organisation for Economic Co-operation and Development.

Full text of H-phrases::

Acute Tox. 2 (Oral)	Acute toxicity (oral) Category 2
Acute Tox. 3 (Dermal)	Acute toxicity (dermal) Category 3
Acute Tox. 4 (Dermal)	Acute toxicity (dermal) Category 4
Aquatic Acute 1	Hazardous to the aquatic environment - Acute Hazard Category 1
Flam. Liq. 4	Flammable liquids Category 4
STOT SE 3	Specific target organ toxicity (single exposure) Category 3
H227	Combustible liquid
H300	Fatal if swallowed
H311	Toxic in contact with skin
H312	Harmful in contact with skin
H335	May cause respiratory irritation
H400	Very toxic to aquatic life

HMIS III Rating

Health : 4 Severe Hazard - Life-threatening, major or permanent damage may result from single or repeated overexposures

Flammability : 3 Serious Hazard

Physical : 1 Slight Hazard

Prepared by safety and environmental affairs.

Date of issue: 04/02/2015 Revision date: 08/28/2015 Version: 2.0

SDS US (GHS HazCom 2012) - Custom

According to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

The information contained in this document has been gathered from reference materials and/or Gelest, Inc. test data and is to the best knowledge and belief of Gelest, Inc. accurate and reliable. Such information is offered solely for your consideration, investigation and verification. It is not suggested or guaranteed that the hazard precautions or procedures described are the only ones which exist. Gelest, Inc. makes no warranties, express or implied, with respect to the use of such information and assumes no responsibility therefore. Information on this safety data sheet is not intended to constitute a basis for product specifications.

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APPENDIX K
SSC Field Checklist

SSC FIELD CHECK LIST

Site Name/Project No.: _____ Designated Person: _____

Walkover Date: _____ PIC/PM: _____

Intrusive Locations Surveyed: _____

(RAMBOLL MANAGED SUBSURFACE CLEARANCE ACTIVITIES)	Yes	No	N/A	Comments
1. The potential for unexploded ordnance (UXO) has been assessed and a UXO survey performed, if applicable.	☐	☐	☐	
2. Public utility markings are present for all utility companies notified. List the companies with public utilities present onsite and cross check with expected utilities and onsite indicators:	☐	☐	☐	
Natural gas/oil/petroleum lines and associated tanks:	☐	☐	☐	
Electric:	☐	☐	☐	
Potable water pipes, hydrants:	☐	☐	☐	
Sewers (storm/process water/sanitary) and/or Manways/Grates/Culverts:	☐	☐	☐	
Public lighting (street and traffic):	☐	☐	☐	
Telephone and Data Lines:	☐	☐	☐	
Other underground utilities:	☐	☐	☐	
3. Private utilities marked and scope discussed with/provided to locator	☐	☐	☐	Subcontractor Name: Contact #:
Alternate intrusive locations chosen in case of refusal or presence of utilities/indicators in Critical Zone	☐	☐	☐	
Describe nonconformity or unexpected conditions found by locator	☐	☐	☐	
4. Site Walkover performed to confirm utility markouts and assess the presence of Visual Indicators. If visual indicators are present, note location in comments/Plot Plan:	☐	☐	☐	
Indication of underground storage tank/piping and dispense islands	☐	☐	☐	
Non-native soils, surface depressions, new/dead vegetation	☐	☐	☐	
Saw cuts, patched surfaces, warning tape or other surficial indicators of below ground work	☐	☐	☐	
Pumps, pump galleries, piping manifolds and/or racks, process equipment, compressors, etc.	☐	☐	☐	
On or below-grade transformers	☐	☐	☐	
Fuel oil lines, tanks, fill ports, observation wells, vent stacks, hydraulic lift systems	☐	☐	☐	
Adjacent/supplemental buildings with no apparent utility feeds (electricity, water, gas)	☐	☐	☐	
Other:	☐	☐	☐	
5. Plot Plan updated to reflect most accurate site SSC information. Describe any onsite additions/changes	☐	☐	☐	
6. Ground Disturbance location(s) and Critical Zones (5ft/1.5m distance in every horizontal direction surrounding disturbance locations) cleared of utilities and visual indicators	☐	☐	☐	Contact PIC/PM and H&S Director if utilities pass through the Critical Zone of a planned ground disturbance location

(RAMBOLL MANAGED SUBSURFACE CLEARANCE ACTIVITIES)	Yes	No	N/A	Comments
A mark has been placed on each intrusive location and radial marks extending to the edge of the Critical Zone	☐	☐	☐	
Intrusive locations and Critical Zones cleared of utilities using sweep and search method or other applicable SSC investigative methods.	☐	☐	☐	
Once evaluated and cleared of utilities, intrusive locations cannot be moved and a Critical Zone must be maintained around the locations	☐	☐	☐	
Alternative intrusive locations used due to obstructions within Critical Zone. Describe abandoned and alternative locations	☐	☐	☐	
7. Pre-start H&S meeting conducted and SSC risk/hazards discussed	☐	☐	☐	
Locate results and intrusive locations/Critical Zones understood by all parties involved	☐	☐	☐	

Form completed by _____ _____ _____
Name Date Signature

APPENDIX L
Emergency Information

TABLE 1A: EMERGENCY RESPONSE TELEPHONE ROSTER		
	OFFICE	**CELL**
PERSONNEL		
Ramboll		
PIC: David Heidlauf	312-288-3823	312-282-1377
PM: Dan Price	314-590-2970	636-577-2357
PM: Aaron Hackman	913-553-5923	317-431-7459
AOC-16 Interim Measure PM: Scott Tarmann	262-901-0093	262-853-9964
Well Installation and Groundwater Monitoring Task Lead: Kit Carson	303-382-5482	630-849-9291
Designated Site Supervisor: Elaine Komm-Enge		406-565-1230
Designated Site Supervisor: Liz Borucki	262-901-3507	262-758-1488
HSC: Beth Richter	312-288-3856	314-630-7364
Corporate H&S Director: Kristen Heitman	312-288-3824	773-879-2235
Contractors		
GPRS Contact: Lisa Lippincott	214-471-9001	
GPRS Contact: Titus Adamson	303-552-8270	
M&D Construction Contact: Josh Picking	406-452-8825	406-781-1898
Cascade Drilling Contact: Ron Rider	253-883-5200	253-293-1910
AOC-16 Interim Measures Construction Contractor Contact: TBD	TBD	TBD
Client/Security		
Site Contact: Joe Dauner	406-454-9887	406-217-3605
Alternate Site Contact: Ray Martinich	406-564-9862	406-564-9769
Safety Superintendent: Paul Carlson	406-564-9945	
Main Security Gate	406-761-4100	
ONSITE EMERGENCY RESPONSE AGENCIES		
Control Room	406-454-9876	
Radio Channel #2		
OFFSITE EMERGENCY RESPONSE AGENCIES		
Hospital: Benefits Health System	911	
Emergency Fire: Great Falls Fire Department	911	
Emergency Police: Great Falls Police Department	911	
County Health Department: City-County Health Department	406-454-6950	

TABLE 1A: EMERGENCY RESPONSE TELEPHONE ROSTER		
	OFFICE	**CELL**
Ambulance Service: Great Falls Emergency Services	406-453-5300	[redacted]
OTHER EMERGENCY ASSISTANCE		
CHEMTREC	800-424-9300	[redacted]
National Response Center (oil and chemical spills)	800-424-8802	[redacted]
Poison Control Center	800-222-1222	[redacted]
Federal Emergency Management Agency	202-646-2500	[redacted]
OFFSITE AGENCIES – NON-EMERGENCY PHONE NUMBERS		
Police: Great Falls Police Department	406-454-0495	[redacted]
Medical Center: Great Falls Clinic	406-454-2171	[redacted]
Hospital: Benefits Health System	406-455-5000	[redacted]
Fire: Great Falls Fire Department	406-727-8070	[redacted]
Ambulance Service: Great Falls Emergency Services	406-453-5300	[redacted]
State Agency: Montana Department of Environmental Quality: Denise Kirkpatrick	406-444-3983	[redacted]

APPENDIX M
Site-specific First Aid Guidance

SITE-SPECIFIC FIRST AID GUIDANCE

Prepared By:
Ramboll EHS Group
333 W. Wacker Drive, Suite 2700
Chicago, Illinois

Implementation Date
January 2016

Revision Date
January 2016

Version Number
2016 Version 2

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1. FIELD PREPARATIONS

The first step in controlling the risks presented by certain plants and animals is thorough field preparations, including but not limited to the following:

- Research local species that are present or active in your area;
- Identify important information to aid in identification and plan for appropriate control mechanisms;
- Document hazards in your field-specific project plan (i.e. HASP or RA) and communicate with field personnel;
- Follow the hierarchy of controls to reduce risks, which we'll discuss later in this lesson; and
- Identify first aid treatments and emergency protocols.

Animals and insects that pose a threat to human safety vary greatly by region and local environment. Furthermore, the level of threat they pose varies greatly by species and situation. Some animals only pose nuisance threats while others can be life threatening. Of those animals that can be harmful to humans, few will outright attack unless they feel threatened or are protecting their young. Therefore it is very important to evaluate each situation where animals can be encountered individually to assess the risk.

2. INSECT BITES AND STINGS

Care will be taken by all site workers to avoid stinging or biting insects such as ticks, spiders, bees, wasps, hornets and yellow jackets. Workers allergic to any particular insect sting or bite should seek medical attention if stung or bitten and may need to carry emergency medicine prescribed by their doctor.

Care should always be taken to avoid these insects and increased vigilance is necessary during high infestation seasons, when opening protective casings of monitoring wells and when walking through areas of heavy vegetation or areas known to be infested.

To minimize the chance of bites/stings:

- Wear appropriate PPE such as light colored clothing so you can see insects, long pants tucked into boots, long sleeves when possible, a hat and gloves if you are cutting brush or need to handle or move vegetation;
- Check your body and clothing for insects, shower after work and wash/dry clothes at as high a temperature as possible;
- Do not swat at insects and do not eat in areas where there are insects; and
- Avoid sweet smelling personal hygiene products and, unless contraindicated by the work being performed (e.g. sampling, data collection), wear USEPA-approved repellants such as those containing DEET.

2.1 SPIDER BITES

Spider bites generally cause only localized reactions such as swelling, pain and redness. However, bites from a Black Widow or Brown Recluse, or if you are allergic to spiders, can cause symptoms that are more serious.

Black Widow Spider

Brown Recluse Spider

2.1.1 First Aid for Spider and Scorpion Bites and Stings

Clean the bite area with soap and water and place a cold pack over the bite area to reduce swelling.

Monitor for allergic reactions. If the victim has more than minor pain or if nausea, vomiting, difficulty breathing, or swallowing occurs medical attention should be sought immediately. CALL 911.

2.2 TICKS

Ticks are common in tropic and temperate regions across the world. They prefer moist areas with dense vegetation/long grass but they can survive in many places including urban parks and gardens.

Ticks are small and easily overlooked. They vary in size, depending on the species, stage of development, gender and whether the tick has recently fed. Ticks do not fly or jump but patiently wait for a mammal to pass by and then climb on. They are most active between spring and autumn.

Ticks feed off of the blood of mammals, birds, amphibians and reptiles. However, they are more likely to feed off of mammals as they mature from nymphs into adulthood and as adults. Ticks find their hosts by detecting animals´ breath and body odors, body heat, moisture and vibrations. Some species can even recognize a shadow.

They wait in a position call "questing," resting on the tips of grasses and shrubs. When the host brushes by the tick, it will climb aboard. Some ticks will attach quickly and others will wander, looking for places like the ear, or other areas where the skin is thinner.

The main hazard associated with ticks is the transmission of disease. The ability of a tick to transmit disease, however, depends on a number of factors:

- The type of tick (only certain species carry transmittable diseases);
- The region of the world the tick inhabits; and
- The duration of time it is attached to a host.

In most cases, tick bites are unlikely to result in a tick-borne illness, especially when removed soon after the bite. For example, the Lyme disease research foundation estimates that only about 2% of all tick bites result in Lyme disease. In addition, in most cases, a tick must be attached for at least 24 hours before disease can be transmitted.

In order to determine the risk of a tick-borne disease, it is important to research the risk prior to starting field activities. Research should include species of tick(s) local to jobsite and diseases the tick species can carry. Some common tick-borne diseases include:

- Bacteria: Lyme disease and Rocky Mountain spotted fever;
- Viruses: Heartland virus and tick-borne encephalitis virus; and

- Parasites: Babesiosis.

Once you are knowledgeable about the hazards and risks presented by ticks at your site you should take as much of the following preventative measures as needed:

- Identify potential tick habitats and avoid them when possible;
- Treat clothes and/or yourself with bug repellent prior to going to the site (check in with PM prior to use);
- Tuck and/or tape pants and long sleeves;
- Wear light colors or Tyvek suits;
- Clear vegetation if possible;
- Perform tick checks periodically throughout the day; and
- Perform a thorough tick check at the end of the day.

It is important to conduct regular tick checks throughout the day and at the end of a work shift, since risk of disease transmission is directly related to the length of time a tick is attached. You may not know you have been bitten as ticks can secrete small amounts of saliva with anesthetic properties. Ticks prefer warm, moist places and may look like a freckle or dirt. Nymphs will be harder to spot!

2.2.1 First Aid for Tick Bites

If you are bitten by a tick:

- Remove tick as soon as possible using tweezers or a tick removing tool.
- Grasp the tick as close to skin as possible in order to grab the head and slowly pull upwards with even pressure. Do not twist or jerk the tick, as mouthparts left behind can cause a local infection
- If you are unable to remove the mouthpart, leave it alone and let the skin heal. DO NOT attempt to remove the tick with heat or "painting" the tick with nail polish or petroleum jelly. You should remove the tick as quickly as possible, do not wait for it to detach.
- Wash the bite area (soap and water or rubbing alcohol) and apply antiseptic. Monitor the bits spot for several weeks.

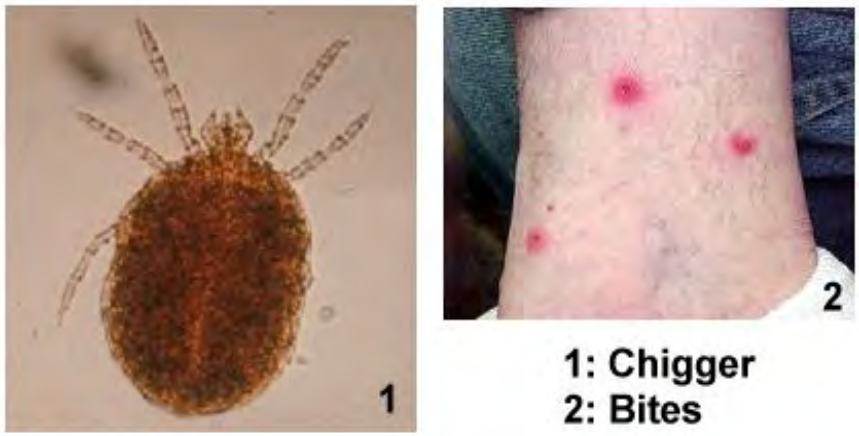
Some regions have tools specific to the removal of ticks. Ask your local HSC if they can get you one.

After you remove a tick, monitor the bite area and yourself for several weeks. If you begin to feel unwell (common symptoms of tick-related illnesses are fever/chills, aches and pains, similar to the flu) or start to develop a red bulls-eye like rash around the bite area, see a doctor immediately.

If you seek or need medical attention, employees are encouraged, when possible, to go to occupational clinics familiar with the hazards and risks that our type of work incurs, as opposed to going to a generic doc-in-the-box or an Emergency Room. In the US, Ramboll's third party medical surveillance partner WorkCare provides an Incident Intervention service that includes a 24 hour help line and information/access to hundreds of clinics around the US. Employees are encouraged to contact WorkCare with their questions/concerns.

2.3 CHIGGERS

Chiggers are tiny, s-legged wingless organisms that grow up to become a type of mite. They are found in tall grass and weeds and their bites cause severe itching.



2.3.1 First Aid for Chiggers

- Reduce discomfort and prevent infection;
- The affected area should be kept clean by washing with soap and water;
- A topical hydrocortisone cream, antihistamine, or local anesthetic may be of value in reducing the itching;
- The wounds should not be scratched, if possible; and
- If signs of infection occur, consult your physician.

2.4 BEES AND WASPS

Bees and wasps belong to the phylum Arthropod family and they are crucially important to the pollination of plants, specifically flowers, fruits and vegetables. A sting from a bee or wasp will cause itching, irritation, redness and/or swelling at the sting site.

A small percentage of people are allergic to stings and a sting can be fatal, caused by a disruption to breathing and circulatory systems called anaphylactic shock. If the sting is followed by severe symptoms, seek medical attention immediately. Allergic people should never be alone for outdoor activities since help may be needed for prompt emergency treatment. Allergic people should have an identification bracelet as well as carry something like an EpiPen for immediate treatment for anaphylactic shock.

2.4.1 First Aid for Bee Stings

- Remove the stinger as quickly as possible-venom continues to enter the skin from the stinger for 45 to 60 seconds following a sting–using a flat dull object, like a credit card. Slid the flat object in the opposite direction of the stinger to remove it from the skin.
- Wash the wound using soap and water.
- Apply ice for swelling and pain.
- A topical hydrocortisone cream, antihistamine, or local anesthetic may be of value in reducing the itching.
- If the sting occurs on the neck or mouth, seek medical attention immediately, swelling in these areas may cause suffocation.

2.5 FIRE ANTS

Fire ants are a variety of stinging ants with over 280 species worldwide. Typically, a colony produces large mounds in open areas and feeds mostly on young plants, seeds and insects. They nest in the soil, often near moist areas such as riverbanks and pond edges. Unlike other ants which bite and then spray acid on the wound, fire ants bite only to get a grip and then sting, injecting toxic alkaloid venom. This results in a painful stinging sensation, similar to what a fire burn feels like.

2.5.1 First Aid for Fire Ant Bites

- Move rapidly away from the nest;
- Quickly remove or kill ants on skin and clothing to prevent further stings;
- Wash the area gently with soap and water to rid the skin of any venom;
- Place cool cloth or ice cloth on sites for 15 minutes and to relieve pain, dab the area with calamine lotion, a topical (cortisone) or oral antihistamine (e.g. Benadryl) to help with swelling;
- Do not scratch the blister because this can lead to infection; and
- Allergic response is rare, but symptoms are difficulty breathing, light headedness and weakness. Immediate medical attention is required.

3. SNAKES

Snakes serve as an important role as predators in the ecosystem and help maintain populations of rodents and other prey.

3.1 FIRST AID FOR VENOMOUS SNAKE BITES

- Wash and immobilize the injured area, keeping it lower than the heart if possible;
- Seek medical attention immediately;
- DO NOT apply ice, cut the wound, or apply a tourniquet;
- Do not cut or suck the bite;
- Remain calm and try not to move the bitten body part;
- Remove jewelry or other items that may be affected by rapid swelling of affected body parts;
- Try to identify the type of snake: note color, size, patterns and markings;
- The bite will be painful and have two distinct puncture wounds;
- If venom is injected there will be burning and swelling; and
- ONLY FOR CORAL SNAKE BITES: apply a mild wrapping on the bite wound.

Water Moccasin
(aka cotton mouth)

Rattlesnake

Coral Snake

Copperhead

4. POISONOUS PLANTS

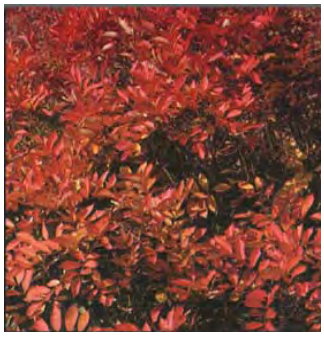
Plants poison on contact, through ingestion, or by absorption or inhalation. They cause painful skin irritations upon contact and can cause internal poisoning when eaten.

4.1 FIRST AID FOR POISONOUS PLANTS

- Wash exposed areas with cold running water as soon as you can;
- When possible, wash your clothing;
- Relieve itching by taking cool showers and applying topical anti-itch medications or hydrocortisone;
- The rash is often arranged in streaks or lines where you brushed against the plant;
- In a few days, the blisters become crusted and take 10 days or longer to heal; and
- If the reaction is severe or worsens, seek medical attention.

POISON IVY

POISON SUMAC



POISON OAK

GIANT HOGWEED

5. HEAT STRESS

Heat stress can be a significant hazard, especially for workers wearing protective clothing.

Depending on the ambient conditions and the work being performed, heat stress can occur very rapidly, within as little as 15 minutes. Site personnel will be instructed in the identification of a heat stress victim, the first-aid treatment procedures for the victim and in the prevention of heat stress incidents.

Workers will be encouraged to immediately report any heat-related problems that they experience or observe in fellow workers. Any worker exhibiting signs of heat stress and exhaustion should be made to rest in a cool location and drink plenty of water. Emergency help by a medical professional is required immediately for anyone exhibiting symptoms of heat stroke, such as red, dry skin, confusion, delirium, or unconsciousness. Heat stroke is a life threatening condition that must be treated by competent medical authority.

ACGIH screening criteria for heat stress exposure in degrees Celsius for an 8 hour workday, five days per week with conventional breaks will be used in determining safe exposure for acclimatized and unacclimatized employees.

ALLOCATION OF WORK IN A WORK/REST CYCLE	ACCLIMATIZED				ACTION LIMIT (UNACCLIMATIZED)			
	LIGHT	MODERATE	HEAVY	VERY HEAVY	LIGHT	MODERATE	HEAVY	VERY HEAVY
75-100%	31.0 (87.8°F)	28.0 (82.4°F)	--	--	28.0 (82.4°F)	25.0 (77°F)	--	--
50-75%	31.0 (87.8°F)	29.0 (84.2°F)	27.5 (81.5°F)	--	28.5 (83.3°F)	26.0 (78.8°F)	24.0 (75.2°F)	--
25-50%	32.0 (89.6°F)	30.0 (86°F)	29.0 (84.2°F)	28.0 (82.4°F)	29.5 (85.1°F)	27.0 (80.6°F)	25.5 (77.9°F)	24.5 (76.1°F)
0-25%	32.5 (90.5°F)	31.5 (88.7°F)	30.5 (86.9°F)	30.0 (86°F)	30.0 (86°F)	29.0 (84.2°F)	28.0 (82.4°F)	27.0 (80.6°F)

5.1 HEAT STRESS PREVENTION

Whenever possible or within the control of ENVIRON, engineering controls should be utilized to protect workers from heat related hazards (e.g. heat shielding such as using awnings or umbrellas). Appropriate work practices can also lessen the chances of heat related hazards. Some of these include:

- Water and/or electrolyte fluids should be about equal to the amount of sweat produced (i.e. drinking 5-7 ounces (150 -200 mL) of water every 15-20 minutes). Ideally, fluids should be at room temperature to allow for quicker absorption. Consider keeping water at room temperature and electrolyte fluids chilled. Do NOT chill both.

- Whenever possible, gradual exposure to heat is preferred to allow the body's internal temperature to actuate to the working conditions.
- Whenever possible, adjust the work schedule to reduce risk of heat stress. For example, postpone nonessential or heavier work to the cooler part of the day and perform work in the shade if portable.
- Rotate personnel to reduce the amount of time spent working in direct sun and heat.
- Increase the number and/or duration of rest breaks and whenever possible, rest break areas should be in a cool area and as close to the work area as is feasible.

Wear appropriate PPE when necessary, such as thermally conditioned clothing, self-contained air conditioning in a backpack and plastic jackets/vests with pockets that can be filled with dry ice or ice. However, based on the type of work being done, where work is being performed, or other required PPE, these options may be prohibited or make the use of this PPE impossible or impractical.

5.2 HEAT RELATED ILLNESSES

5.2.1 Heat Stress

This is the mildest heat-related illness, but prompt action may prevent it from turning into a more severe heat-related illness. Symptoms include irritability, lethargy, significant sweating, headache, or nausea. The following guidance can be used in the identification and treatment of heat related illness.

5.2.2 Heat Stress First Aid

- Take victim to a protected (e.g. shaded, cool) area, remove any excess protective clothing and provide cool fluids;
- If an air-conditioned spot is available, this is an ideal break location; and
- Once the victim shows improvement he/she may resume working, however the work pace and practices (e.g. does fluid intake need to be increased) should be moderated to prevent recurrence of the symptoms.

5.2.3 Heat Exhaustion

Usually begins with muscular weakness, dizziness, nausea and a staggering gait. Symptoms include pale, clammy skin and profuse sweating, vomiting and the bowels may move involuntarily. The pulse is weak and fast, breathing is shallow. Fainting can occur.

5.2.4 Heat Exhaustion First Aid

Immediately remove the victim from the work area to a shady or cool area with good air circulation (avoid drafts or sudden chilling – you do not want the victim to shiver).

- Call a physician or emergency service or transport the victim to medical care;
- Remove all protective outerwear; and
- If the victim is conscious, it may be helpful to give him/her sips of water.

5.2.5 Heat Stroke

Heat stroke is a severe medical condition requiring first aid and emergency treatment by a medical professional as death can occur without appropriate care. Heat Stroke represents the collapse of the body's cooling mechanisms. As a result, body temperatures often rise to between 105°F– 110°F (40.5°C–43.3°C). As the victim progresses toward heat stroke symptoms include hot and usually dry, red and spotted skin, headache, dizziness, nausea, mental confusion, delirium, possible convulsions and loss of consciousness.

5.2.6 Heat Stroke First Aid

- Immediately remove the victim from the work area to a shady or cool area with good air circulation (avoid drafts or sudden chilling – you do not want the victim to shiver).
- Summon emergency medical help to provide onsite treatment and transportation to a medical facility.
- Remove all protective outerwear and loosen personal clothing.
- Apply cool wet towels, ice bags, etc. to the head, armpits and thighs. Sponge off the bare skin with cool water or even place the victim in a tub of cool water.

5.2.7 Skin Hazards

Sunburn and prickly heat are both symptoms of skin irritation/damage produced through exposure to sunlight and operating in hot work environments.

- Protect exposed skin with an appropriate sunscreen. A sunscreen with a sun protection factor (SPF) of 15 or greater is required for work in the sun with reapplication at breaks and lunch.
- Heat rash, also known as prickly heat, can be prevented by the application of a hydrophobic, water repellent barrier cream such as Kerodex 71.

6. COLD STRESS

The four environmental conditions that cause cold-related stress are low temperatures, high/cool winds (wind chill), dampness and cold water. One or any combination of these factors can cause cold-related hazards. Cold stress, including frostbite and hypothermia, can result in severe health effects.

A dangerous situation of rapid heat loss may arise for any individual exposed to high winds and cold temperatures. Major risk factors for cold-related stresses include:

- Wearing inadequate or wet clothing increases the effects of cold on the body.
- Taking certain drugs or medications such as alcohol, nicotine, caffeine and medication that inhibits the body's response to the cold or impairs judgment.
- Having a cold or certain diseases such as diabetes, heart, vascular and thyroid problems, may make a person more susceptible to the winter elements.
- Being male increases a person's risk to cold-related stresses. Men experience far greater death rates due to cold exposure than women, perhaps due to inherent risk-taking activities, body-fat composition, or other physiological differences.
- Becoming exhausted or immobilized, especially due to injury or entrapment, may speed up the effects of cold weather.
- Aging. The elderly are more vulnerable to the effects of harsh winter weather.

TABLE 2. Cooling Power or Wind on Exposed Flesh Expressed as Equivalent Temperature (under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
	Equivalent Chill Temperature (°F)											
calm	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
5	48	37	27	16	6	−5	−15	−26	−36	−47	−57	−68
10	40	28	16	4	−9	−24	−33	−46	−58	−70	−83	−95
15	36	22	9	−5	−18	−32	−45	−58	−72	−85	−99	−112
20	32	18	4	−10	−25	−39	−53	−67	−82	−96	−110	−121
25	30	16	0	−15	−29	−44	−59	−74	−88	−104	−118	−133
30	28	13	−2	−18	−33	−48	−63	−79	−94	−109	−125	−140
35	27	11	−4	−20	−35	−51	−67	−82	−98	−113	−129	−145
40	26	10	−6	−21	−37	−53	−69	−85	−100	−116	−132	−148
(Wind speeds greater than 40 mph have little additional effect.)	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security				INCREASING DANGER Danger from freezing of exposed flesh within one minute.				GREAT DANGER Flesh may freeze within 30 seconds.			
	Trenchfoot and immersion foot may occur at any point on this chart.											

*Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Equivalent chilll temperature requiring dry clothing to maintain core body tempearture above 36°C (96.8°F) per cold stress TLV

6.1 COLD STRESS PREVENTION

Engineering controls should be utilized whenever possible to protect workers from cold related hazards. For example, onsite heat sources, heated shelters, work areas shielded from drafty or windy conditions and the use of thermal insulating material on equipment handles. Effects arising from cold exposure will be minimized by the following control measures:

- Personnel will be trained to recognize cold stress symptoms;
- Field activities will be curtailed or halted if the equivalent chill temperature is below 20°F (7°C);
- As much as possible, work that exposes personnel to the cold will be done during the warmest hours of the day;
- Inactivity in cold conditions will be kept to a minimum;
- Frequent short breaks in warm, dry shelters will be taken; and
- Vehicles will be equipped with supplies in case the vehicle becomes inoperable (e.g. blanket, dry clothing, water, food, a shovel, etc.

TABLE 3. Threshold Limit Values Work/Warm-up Schedule for Four-Hour Shift*

Air Temperature—Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx.)	°F (approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
–26° to –28°	–15° to –19°	(Norm. Breaks) 1		(Norm. Breaks)		75 min	2	55 min	3	40 min	4
–29° to –31°	–20° to –24°	(Norm. Breaks) 1		75 min	2	55 min	3	40 min	4	30 min	5
–32° to –34°	–25° to –29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
–35° to –37°	–30° to –34°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease			
–38° to –39°	–35° to –39°	40 min	4	30 min	5	Non-emergency work should cease					
–40° to –42°	–40° to –44°	30 min	5	Non-emergency work should cease							
–43° & below	–45° & below	Non-emergency work should cease									

Notes for Table 3

1. Schedule applies to moderate to heavy work activity with warm-up breaks of ten (10) minutes in a warm location. For Light-to-Moderate Work (limited physical movement): apply the schedule one step lower. For example, at –35°C (–30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5).
2. The following is suggested as a guide for estimating wind velocity if accurate information is not available:
   5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/m^2; 2) all non-emergency work should have ceased at or before a wind chill of 2250 W/m^2. In general the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.
4. TLVs apply only for workers in dry clothing.

*Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labour.

6.2 COLD-RELATED ILLNESS

6.2.1 Hypothermia

Hypothermia occurs when the body temperature falls to a level where normal muscular and cerebral functions are impaired. Although it usually occurs in freezing air and water temperatures, it can occur in any climate if a person's internal body temperature falls below normal. Symptoms should not be ignored and a supervisor should be notified as soon as hypothermia is suspected.

Initially, symptoms may include shivering, an inability to do complex motor functions, sluggishness and mild confusion as the body temperature drops to around 95 F. As the body temperature falls, speech may become slurred and behavior may be irrational, simple motor functions may be difficult to do and a state of "dazed consciousness" may exist. In severe state (below 90 F or 32 C), heart rate, blood flow and breathing will slow. Unconsciousness and full heart failure can occur.

6.2.2 Hypothermia First Aid

6.2.2.1 On Land

- Call for emergency and then help move the victim (unless other injuries prohibit their being moved) to a warm, dry area and replace wet clothing with warm, dry clothing or a blanket. Move the person carefully because movement can increase the irritability of the heart.
- If the person is conscious and lucid, warm liquids can be provided, but never alcohol or caffeinated drinks. If possible, have them to move their arms and legs to create muscle heat.
- If the person is unconscious or unable to assist, place warm bottles/packs in the person's arm pits, groin, neck and head areas.
- Do not rub the person's body or place them in warm water.

6.2.2.2 In Water

- Call for emergency help and get the victim out of the water. Move them carefully because movement can increase the irritability of the heart.
- If it is you in the water, do not swim unless a floating object or person can be reached quickly as swimming uses the body's heat and reduces survival time by about 50%.
- If you are in the water, conserve body heat by folding arms across the chest, keeping thighs together, bending knees and crossing ankles, if another person is in the water with you, huddle together.
- If you are in the water, do not remove clothing-button, buckle, zip and tighten collars, cuffs, shoes and hoods as the water trapped next to the body provides a layer of insulation that may slow the loss of heat.

6.2.3 Frostbite

Frostbite occurs when the skin literally freezes and deep frostbite can affect deeper tissues such as tendons and muscles. Frostbite usually occurs when temperatures drop below 30°F (1°C), but wind chill effects can cause frostbite at above-freezing temperatures. The ears, fingers, toes, cheeks and nose are the most commonly affected body parts. Initially, symptoms include an uncomfortable

sensation of coldness. Tingling, stinging or an aching feeling of the exposed area is followed by numbness. Frostbitten areas appear white and cold to the touch and with deeper frostbite, the area becomes numb, painless and hard and can turn black.

6.2.4 Frostbite First Aid

- Seek medical attention as soon as possible and treat any existing hypothermia first;
- Warm liquid can be provided, but not alcohol or caffeinated drinks such as tea and coffee;
- Do not rub the affected areas, but cover them with dry, sterile gauze or soft, clean bandages; and
- Do not try rewarming the affected area if you have not been specifically trained to do so and/or if there is a chance the affected area will get cold again.

7. SMALL CHEMICAL SPILLS

Chemical hazards present in environmental samples or in the environment being sampled are NOT the only "chemicals of concern". Toxic chemicals may also be brought onto a site as part of the sampling event in the form of sample preservatives. In general, sample preservation is required for most water samples. Two practices exist for adding a preservative: 1) addition of the preservative to the samples in the field; and 2) addition of the preservative to the sampling containers prior to sending the samplers into the field. In either case, EXTREME caution MUST be exercised when adding a preservative to a sample vial or using vials which already contain a preservative since these preservatives will vary in concentration and type. Some examples of the type of preservatives which may be encountered include sodium thiosulfate to remove chlorine, hydrochloric acid or ammonium chloride to stabilize pH and reduce biological activity or sodium bisulfate.

7.1 CHEMICAL FIRST AID (BODY)

In the event that you suspect that you have been exposed to a chemical, whether or not you were wearing PPE, you should:

- Remove yourself or the victim from the accident area.
- Remove any contaminated clothing.
- Wash the injured area to dilute or remove the substance, using large volumes of water.
- Wash for at least 20 minutes, taking care not to allow runoff to contact unaffected parts of your body.
- Gently brush away any solid materials, again avoiding unaffected body surfaces.
- Especially wash away any chemical in your eye. Sometimes the best way to get large amounts of water to your eye is to step into the shower.

7.2 CHEMICAL FIRST AID (EYE)

For all chemical injuries to the eye, the first thing you should do is immediately irrigate the eye copiously. Ideally, specific eye irrigating solutions should be used for this, but if none are available regular tap water will do just fine.

- Begin washing your eye before taking any other action and continue for at least 10 minutes. The longer a chemical is in your eye, the more damage will occur. Diluting the substance and washing away any particles that may have been in the chemical are extremely important.
- Ideally, in a work setting, you would be placed in an emergency eyewash or shower station and your eye washed with sterile isotonic saline solution. If sterile saline is not available, use cold tap water.
- All acid or alkali eye burns require immediate treatment and evaluation by a doctor. You should be taken immediately to the closest emergency department. If you suspect a serious injury may have occurred or are otherwise not able to make the trip to the emergency room quickly, then you should call an ambulance to shorten transport time. Take the SDS on the chemical you were exposed to with you to the hospital.

Any time you experience pain, tearing, redness, irritation, or vision loss, go to a hospital's emergency department for immediate evaluation, even if you believe the chemical is only a mild irritant.

APPENDIX N
Standard Practice Instruction 19 – Incident Reporting

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STANDARD PRACTICE INSTRUCTION 19

INCIDENT REPORTING

RAMBOLL

STANDARD PRACTICE INSTRUCTION 19

IMPLEMENTATION DATE: January 2017

REVISION DATE: January 2020

SUBJECT: Incident Reporting

GENERAL: Ramboll will ensure that the conduct of all Ramboll employees and contractors will exhibit a professionalism in performing their duties effectively and efficiently. The Purpose of this Standard Practice Instruction (SPI) is to establish a uniform and comprehensive process for prompt investigation of fatalities, injuries & illnesses, property damage, near misses, unsafe acts or conditions, and other Environmental, Health and Safety incidents. This SPI is intended to provide information, mitigate any consequences and initiate corrective and preventative actions.

RESPONSIBILITY: The Directors of Health and Safety (the "Directors) and Human Resources are solely responsible for all facets of this program and has full authority to make necessary decisions to ensure success of the program. The Directors of Health and Safety and Human Resources are the sole persons authorized to amend these instructions.

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ATTACHMENTS

Attachment A: Incident Reporting Form

Attachment B: Injury and Illness Recordkeeping_US

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ACRONYMS AND ABBREVIATIONS

dB	Decibels
Directors	Directors of Health and Safety
Form	Template Incident Reporting Form
HSC	Health and Safety Coordinators
MSD	Musculoskeletal Disorder
MSDs	Musculoskeletal Disorders
PIC	Principle-in-Charge
SPI	Standard Practice Instruction
STS	Standard Threshold Shift

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1. OBJECTIVE

To provide the minimum requirements for the investigation, reporting and recording of accidents/incidents which result in the potential or actual injury/illness to a person, or damage to any property, in order to insure compliance with federal, state, and local laws; client contract provisions, insurance policy requirements and to prevent recurrence. All incidents shall be investigated, reported and recorded pursuant to the requirements of this section.

The following EHS incidents will be reported and investigated:

- All employee injuries and illnesses to include first aid, restricted duty, lost time injuries or illnesses, and deaths.
- Environmental incidents and exposures, such as spills or other unplanned releases to the environment or nonconformance to operating procedures.
- All evacuations.
- Any Property damage.
- "Near miss" incidents which could have resulted in serious injury, accident, environmental impact or significant loss of facilities.
- Unsafe acts or conditions that may threaten the health and safety or workers or cause property damage.
- Public/third party liability - Incidents that involve injury, illness or property damage to any non-Ramboll employee (e.g., contractors) arising out of, or in connection with the company's operations, products, or premises.
- All vehicle accidents and incidents that occur while a vehicle is being used for project work regardless of vehicle ownership (i.e., personal, rented/for-hire, and/or fleet vehicles). And regardless of whether the Ramboll employee was operating the vehicle at the time of the accident/incident (e.g., parked and unattended).

2. INCIDENT REPORTING

All of the incidents types outlined above MUST be verbally communicated by the affected employee or an Ramboll employee witnessing the incident to either the local HSC, PM, or PIC immediately following the incident. This contacted person will then ensure that the other core project members, plus the Director of H&S, and the Managing Principal are informed either in person or via phone, e-mail, or text messaging, regardless of time of day. The PIC will notify the client of the incident as appropriate in a timely fashion. For incidents involving in-patient hospitalization and/or the death of any employee, the applicable regulatory agency will be notified by the Director of Health and Safety or designated representative.

If an employee is injured on site, and immediate medical treatment beyond first aid is needed, the accompanying Ramboll person is instructed to call 911 and/or the designated emergency phone number and accompany the injured employee to the medical treatment facility. Reporting of the incident should be completed as soon as possible following the

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event, once personnel, equipment and property are appropriately secured, following reporting protocol.

Notification to the regional HR representative and/or the Director of HR MUST also be made for accidents/incidents involving any employee fatality, injury and/or illness that happened while on company time including doctor/hospital visits which may or may not involve restricted work and/or lost time.

The template Incident Reporting Form (Form) is contained in Attachment A of this SPI. As soon as possible after the incident but no later than 72 hours after the event, Page One of the Form is to be completed by the employee and a witness that was involved in the incident and/or observed the incident. The Form will be completed and sent the core project members (i.e., the local HSC, PM, or PIC), the Director of H&S, and the Managing Principal for preliminary root cause analysis. The root cause analysis will not be deemed complete until input from the Director of H&S and the Managing Principal (and others as necessary) has been obtained. Similarly, the implementation of any corrective/preventive actions will NOT be implemented until input from the Director of H&S and the Managing Principal (and others as necessary) has been obtained.

The results of the accident investigation and the protective/corrective actions will be communicated to all Health and Safety Coordinators (HSC) during the monthly HSC conference call and documented in the minutes of the HSC conference call. This will aid in informing Ramboll employees of any changes, additions, and/or modifications to existing policies and/or procedures, as applicable.

2.1 Unsafe Acts or Conditions

It is every Ramboll employee's responsibility to monitor against unsafe acts and conditions. If you see something that appears to be a hazardous or unsafe occurring in your work area, please bring it to the attention of the Project Manager, Office Manager or other appropriate personnel for immediate action. Some acts or conditions may require reporting to a higher level. In these cases, complete Page One of the Form, and forward it to your local HSC or directly to the Global HS Director.

3. INCIDENT INVESTIGATION

The Investigation Team will be provided with training related to their level of responsibilities in the investigation process but as a minimum all team members will be provided with initial training for conducting Incident investigations that will include the procedures, methods, and techniques as provided by Ramboll's insurance carrier. Appropriate tools, equipment, supplies and forms shall be made available for incident investigators and included in the project planning. Page Two of the Form is to be used to investigate the incident and identify the root cause(s) of the incident. At a minimum, this investigation should involve the Principal-in-Charge, the on-site Manager (if different than the Project Manager) and the Project Manager (if different than the on-site Manager) of the injured employee, and the local Health and Safety Coordinator (HSC). This team should conduct the following:

3.1 Determine WHAT happened.

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The scene of the incident must be immediately secured so as to not damage or destroy evidence that may be necessary during the investigation. The responsible on-site Manager will employ reasonable judgment to determine if production line needs to be halted during an investigation.

WHO?

- Get the names of everyone present at the incident. Have the injured employee and all witnesses independently complete if a production line needs to be halted during an investigation.

WHAT?

- Itemize the equipment, materials, and environmental factors involved at the time of the incident. Be specific and provide sufficient detail. Check materials and equipment involved for defects and react accordingly. For example, damaged equipment (however minor) should be immediately taken out of service and inspected as appropriate.

- A camera should be available to assist in this recording.

WHERE?

- Describe the exact location of the incident. Refer to pertinent identifying physical landmarks. In some cases, this may come down to taking measurements in increments of inches and/or feet.

WHEN?

- Record the exact time, date and other important factors such as shift change or stage of work cycle that relate to the incident.

HOW?

- List the sequence of events, before, during, and after the incident occurred.

WHY?

- Determine the contributing factors and the root cause of the incident. The "5 Why Process" is the tool utilized to accomplish this task.

3.2 Determine The Root Cause:

The format of a Five Why Analysis follows a structure question and answer sequence. The leader of the investigation team asks the first in a series of questions:

<u>Director of H&S will be the Lead Investigator and ask:</u>

- *"Why did the incident occur?"*
- Then, a member of the investigation team with expertise and knowledge to formulate and answer responds.
- The process continues with a member of the investigation team phrasing the next question by asking why the outcome presented in the previous answer occurred:

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Investigation Team Member:

- *"Why did that happen?"*
- A qualified investigation team member provides the answer.
- The "Five Why" Analysis process continues with this question and answer format until the answer provides is unacceptable and cannot be justified. Once this occurs, the root cause is identified.

CAUTIONS:

- Ask "Why" as many times as necessary during the investigation to derive the root cause (The title "5 Why" refers to the investigative process, not to the specific number of questions to be asked).
- Human error or employee fault is never the correct root cause. There is always a physical and/or a cultural reason for the occurrence of the incident.
- There can be multiple root causes to an incident.

3.3 Determining the Corrective Actions:

Once the real root cause and all contribution factors are identified, the next step is to use the Hierarchy of Health and Safety Controls to identify appropriate corrective action. The single most important outcome that results from an incident is the implementation of an effective, high-level safety most important outcome that results from an incident is the implementation of an affective, high-level safety control that eliminates the possibility of the incident reoccurring. Just as we use the "Five Why" analysis to identify the cause of a health and safety incident, similarly we use the Hierarchy of Health and Safety Controls to identify appropriate corrective action.

The Hierarchy of Health and Safety Controls has five levels of possible alternatives and corrective actions. They are listed in the preferred order of priority:

A. Elimination Or Substitution – (Preferred type of corrective action)
   - Eliminates the reliance on supervisor and employee behavior for effectiveness.
   - 100% reliability.
   - Eliminates long term cost.

B. Engineering Controls – (Second priority corrective action)
   - Minimizes inspection, maintenance, training, and employee behavior for effectiveness.
   - Minimizes long-term costs associated with inspection and maintenance.

C. Warning – (Third priority corrective action)
   - Relies heavily on supervisor and employee behavior for effectiveness.
   - Minimal costs to maintain warnings.

D. Training And Procedures / Administrative Controls – (Fourth priority corrective action)

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- Relies heavily on supervisor and employee behavior for effectiveness.
- Significant recurring costs due to required supervision and training.

E. Personal Protective Equipment – (Least preferred type of corrective action)

- Relies heavily on supervisor and employee behavior, inspection, maintenance, and training for effectiveness.
- Significant recurring costs due to required supervision, and maintenance.

Whenever a "Five Why" Analysis is moving in the direction of an unsafe condition or unsafe practice that can be eliminated or controlled, the "real" root cause is about to be identified.

The top two levels in the Hierarchy of Health and Safety Controls are the most effective controls in preventing the reoccurrence of a similar incident because they do not rely on human behavior or human effort to eliminate or control an unsafe condition. Page Three of the Form should be used to document the Corrective Actions and Preventive measures and establish implementation/completion dates.

Employees shall cooperate with the investigation team personnel and any concurrent client investigation when participation is requested and with management approval.

4. DEFINITIONS

Competent Person - A person who can demonstrate sufficient professional or technical training, knowledge, actual experience and authority to:

- Perform his or her assigned duties at the level of responsibility allocated to him or her.
- Understand any potential hazards related to the work or equipment.
- Detect any technical defects or omissions in the work or equipment, recognize any implications for health and safety caused by those defects or omissions and specify a remediating action to mitigate those implications.

Consequence - The outcome of an event.

Contractor - An individual or company under a contractual relationship to supply Ramboll with goods and/or services. A contractual relationship covers:

- All individuals contracted directly or sub-contracted.
- All employees of companies contracted directly or sub-contracted

Corrective Actions - Actions intended to prevent, or reduce the probability of, the identified systemic root cause(s) of the incident investigated.

Critical Factors - Events or conditions, which if eliminated, would have prevented the incident's occurrence or significantly reduced its severity.

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Day Away from Work Case - A work-related injury or illness which has either of the following consequences:

- The member of the workforce could not have worked on any day after the injury or illness, irrespective of whether there was scheduled work.
- The member of the workforce comes to work even when a physician or other licensed health care professional recommends that the individual stays at home.

Employee - People directly employed by Ramboll.

Event - Occurrence of a particular set of circumstances.

Establishment – An Establishment is a single physical location where business is conducted or where services or industrial operations are performed.

First Aid – First Aid means only the following:

- Using a non-prescription medication at nonprescription strength (for medications available in both prescriptions and non-prescriptions form, a recommendation by a physician or other licensed health care treatment for record keeping purposes);
- Administering tetanus immunizations (other immunization, such as Hepatitis B vaccine or rabies vaccine, are considered medical treatment);
- Cleaning, flushing or soaking wounds on the surface of the skin;
- Using wound coverings such as bandages, Band-Aid™, gauze pads, etc.; or using butterfly bandages or Steri-Strips™ (other wound closing devices such as sutures, staples, etc., are considered medical treatment);
- Using hot or cold therapy;
- Using any non-rigid means of support, such as elastic bandages, wraps, non-rigid back belts, etc. (devices with rigid stays or other systems designed to immobilize parts of the body are considered medical treatment for record keeping purposes);
- Using temporary immobilization devices while transporting an accident victim (e.g., splints, slings, neck collars, back boards, etc.).
- Drilling of a fingernail or toenail to relieve pressure, or draining fluid from a blister;
- Using eye patches;
- Removing foreign bodies from the eye using only irrigation or a cotton swab;
- Removing splinters or foreign material from areas other than the eye by irrigation, tweezers, cotton swabs or other simple means;
- Using finger guards;
- Using massages (physical therapy or chiropractic treatment are considered medical treatment for record keeping purposes); or
- Drinking fluids for relief of heat stress.

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Note: When determining whether a prescription medicine was used the normal practice is to apply the definitions used in the country where the incident occurred. However, when making this classification it should be remembered that the intent is to distinguish those more severe situations that require a medical practitioner to use strong antibiotics and painkillers from those that only require simple first aid.

Five Why Analysis - Question-asking method used to explore the cause/effect relationships underlying a particular problem. Ultimately, the goal of applying the "Five Why" method is to determine a root cause of a defect or problem.

Global Finding - A finding that are believed to be at risk for reoccurrence at other sites.

Incident – An unplanned sequence of events accompanied by undesirable consequences.

Incident Owner - The owner of the incident/accident will be the designated site Manager/Office who were responsible for the day-to-day operations of the project /office and supervision of project employees when and where the incident/accident occurred.

Injury or illness – When an injury or illness is an abnormal condition or disorder. Injuries that is the consequence of an instantaneous event and includes cases such as, but not limited to, a cut, fracture, sprain, or amputations. Illnesses include both acute and chronic illnesses, such as, but not limited to, a skin disease, respiratory disorder, or poisoning. Back problems are always considered injuries. Conditions such as sunburn, welder's flash, friction blisters or repetitive motion-induced conditions are illnesses.

Legal and Regulatory Requirements - Applicable obligations established by recognized legislation, regulation, administrative order or notice, permit, consent decree or any other similar instrument, and any legally binding commitment where failure to comply by is unlawful and enforceable by a court of law in the relevant jurisdiction.

Lost Work Day – When an injury or illness involves one or more days away from work, you must record the injury or illness. Begin counting day away on the day after the injury occurred or the illness began.

Major Incident - An incident/accident, including any security incident, involving any of the following:

- A fatality associated with any company operation;
- Serious injuries or health effects requiring the rendering of professional medical care;
- Significant adverse reactions from authorities, the media, non-governmental organizations or the general public.

Medical Treatment – Medical treatment means the management and care of a patient to combat disease or disorder for which the medical services can only be provided by a medical professional (e.g., wounds requiring stiches). Medical treatment does not include:

- Visits to a physician or other licensed health care professional solely for observation or counseling;

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- The conduct of diagnostic procedures, such as x-rays and blood test, including the administration of prescription medications used solely for diagnostic purposes (e.g., eye drops to dilate pupils); or
- "First aid" as defined above, even if the first aid was provided by a medical professional.

Musculoskeletal Disorder (MSD) – Musculoskeletal disorders (MSDs) are disorders for the muscles, nerves, tendons, ligaments, joints, cartilage and spinal discs. MSDs do not include disorders caused by slips, trips, falls, motor vehicle accidents, or other similar accidents. Examples of MSDs include: Carpal tunnel syndrome, Rotator cuff syndrome, De Quervain's disease, Trigger finger, Tarsal tunnel syndrome, Sciatica, Epicondylitis, Tendinitis, Raynaud's phenomenon, Carpet layers knee, Herniated spinals disc, and Low back pain.

Near Miss – A near miss or "minor" incident is an unplanned event that did not result in a significant injury, illness or damage.

Occupational Health and Safety – Conditions and factors that affect the well – being of employees, temporary workers, contractor personnel, visitors and any other person in the workplace.

Physician or Other Licensed Health Care Professional – A physician or other licensed health care professional is an individual whose legally permitted scope of practice (i.e. license, registration, or certification) allows him or her to independently perform, or be delegated the responsibility to perform, the activities described by this regulation.

Privacy Case – The following injuries or illnesses are the only privacy concern cases:

- An injury or illness to an intimate body part or the reproductive system;
- An injury or illness resulting from a sexual assault;
- Mental illnesses;
- HIV infection, hepatitis, or tuberculosis;
- Needlestick injuries and cuts from sharp objects that are contaminated with another person's blood or other potentially infectious material; and
- Other illnesses, if the employee independently and voluntary requests that his or her name not be entered on the log. MSDs are not considered privacy concern cases.

Recordable Occupational Injury/Illness - If a case meets any of the listed criteria in either the general or specific, it must be considered recordable. General cases are:

- Death
- Days away from work.
- Restricted work or transfer to another job.
- Medical treatment beyond first aid.
- Loss of consciousness.

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- A significant work-related injury or illness diagnosed by a physician or other licensed health professional, such as:
  - Cancer
  - Chronic irreversible disease.
  - Fractured or cracked bone.
  - Punctured eardrum.

Specific cases are:

- Needle sticks and cuts from sharp objects contaminated with another person's blood or other potentially infectious material.
- Medical removal under Government standards.
- Occupational hearing loss (current hearing test must show 10dBA shift from current baseline and total cumulative hearing loss must be 25dBA or move above audiometric zero).

Restricted Work – Restricted work occurs when, as the result of a work – related injury or illness:

- You keep the employee from performing one or more of the routine functions of his or her job, or from working the full workday that he or she would otherwise have been schedule to work;
- A physician or other licensed health care professional recommends that the employee not perform one or more of the routine functions of his or her job, or not work the full workday that he or she would otherwise have been schedule to work.

Root Cause - The most basic cause(s) that can be reasonably identified, which management has control to fix, and for which effective corrective actions for preventing recurrence can be generated.

Root Cause Analysis (RCA) - A formal process designed to determine the systemic root causes in an incident or accident, and develop effective solutions to those systemic root causes to eliminate (or reduce the probability of) a recurrence.

Routine Functions – For record keeping purposes, an employee's routine function are those work activities the employee regularly performs at least once per week.

Security Incident - Assault, threat, burglary, civil unrest, criminal property damage, drug/alcohol possession/abuse, robbery, breach of security of information, terrorist/guerrilla activity and/or theft.

Standard Threshold Shift – A Standard Threshold Shift, or STS, is defined as a change in hearing threshold, relative to the most recent audiogram for that employee, of an average of 25 decibels (dB) or more at 2000, 3000 and 4000 hertz in one or both ears.

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Unsafe Act - An unsafe act is the performance of a task or other activity that is conducted in a manner that may threaten the health and safety of workers but does not. Examples include lack or improper use of PPE, failure to LOTO, horseplay, and bypass or removal of safety devices where a negative outcome does not occur (e.g., an injury).

Unsafe Condition - An unsafe condition is a condition in the work place that can cause property damage or injury but does not. Examples include use of defective tools, equipment or supplies, inadequate support or guards, poor housekeeping, and excessive noise where a negative outcome does not occur.

5. REVISION SUMMARY

Version	Author	Description of Change	Date
8.0	Mark Watka	Expanded definitions, clarified reporting process.	04 2015
9.0	K. Heitman	Updated formatting	01 2016
10	K. Heitman	Added Injury and Illness Recordkeeping (FKA SPI 01) as Appendix A	01 2017

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ATTACHMENT A
INCIDENT REPORTING FORM

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RAMBOLL ENVIRON

INCIDENT REPORTING FORM

Purpose: This form is to be completed for all accidents, incidents, near misses, and/or unsafe acts and/or conditions (including Ramboll contractors and/or leased/owned property).

Instructions: Please Print. Fill in all blanks. If the question is not applicable to the incident, write "N/A" in that blank. When completed, return this form your Principal-in-Charge for further completion and corrective action.

Employee Name	**Employee Classification & Title**	**Employee Number**	**Company Start Date**
Office Location	**Principal In Charge**	**Project Manager**	**HSC**
Project Number:	**Project Name:**		
Incident Name:	**Time/Date of Incident**	**Location of Incident:**	
Task being performed:			
Results of Incident (circle): Lost Time First Aid Near Miss Medical Treatment Restricted Work Property Damage **Type of Incident (circle):** Injury Near Miss Unsafe Act/Condition Other:			
Nature of Injuries/Body Parts Affected:	**Treatment:** ☐ In-house ☐ Hospital/Clinic	**Work Status:** ☐ Returned ☐ Did Not Return to work	
Equipment/Materials Damaged and Location:		**Nature of Damage:**	**Estimated Cost of Damages:**
Were you using required safety equipment, if so describe:		**Name(s) of Witness:**	

Describe how the Incident happened (Attach photos and/or diagrams as necessary).

Describe What Caused the Incident?

What could have prevented this Incident?

The information I have provided either in my own writing or verbally for the purpose of this form is true and correct. I understand that providing false or misleading information or omission of information on this report or any other form relating to this claim of injury/accident may result in termination of my employment.

Signature of Affected Person: _____ **Date:** _____

Signature of Witness: _____ **Date:** _____

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Root Cause Analysis for Incident Name:

Basic Rules for Incident Investigation

- Interview witnesses & employees at the scene
- Conduct interviews in private – Interview one witness at a time
- Get signed statements from all involved
- Take photos or make a sketch of the incident scene
- What hazards are present – what unsafe acts contributed to incident
- Attach test results/other documentation from responsible parties

Describe Incident Facts & Events:

Root Cause Analysis
Check ALL that apply to this incident; state name of responsible party to best of knowledge

Unsafe Acts		Unsafe Conditions	
Improper work technique		Poor Workstation design	
Safety rule violation		Unsafe Operation Method	
Improper PPE or PPE not used		Improper Maintenance	
Operating without authority		Lack of direct supervision	
Failure to warn or secure		Insufficient Training	
Operating at improper speeds		Lack of experience	
By-passing safety devices		Insufficient knowledge of job	
Protective equipment not in use		Slippery conditions	
Improper loading or placement		Excessive noise	
Improper lifting		Inadequate guarding of hazards	
Servicing machinery in motion		Defective tools/equipment	
Horseplay		Poor housekeeping	
Drug or alcohol use		Insufficient lighting	
Other:		Other:	

Describe Summary of Root Cause:

Unsafe Acts performed by employee, if any, require a documented verbal warning or written warning and re-training before the employee resumes work.

Incident Report Reviewed and Root Cause Analysis prepared by:

H&S Director: _____ Date: _____

Principal-in-Charge: _____ Date: _____

Project Manager: _____ Date: _____

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HSC: _____ Date: _____

Corrective Action and Preventative Measures for Incident Name:

Describe Corrective Action(s) and Preventive Measures

Preventive measure(s) implemented	**Implemented By Whom**	**Completion Date (Est.)**	**Confirmation Date**

Completion of Accident Corrective Action:

H&S Director: _____ Date: _____

Principal-in-Charge: _____ Date: _____

Project Manager: _____ Date: _____

HSC: _____ Date: _____

Affected Person: _____ Date: _____

Retain a copy in the employee's file; Office file and provide a copy to Mark Watka, CIH –H&S Director-Global Operations.

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ATTACHMENT B
INJURY AND ILLNESS RECORDKEEPING_US

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INJURY AND ILLNESS RECORDKEEPING

1. GENERAL RECORDKEEPING REQUIREMENTS

This section provides for recordkeeping, and reporting by Ramboll as necessary or appropriate for developing information regarding the causes and prevention of occupational accidents and illnesses, and for maintaining a program of collection, compilation, and analysis of occupational safety and health statistics on a calendar year basis. Records of fatalities, injuries, and illnesses must recorded for each type of fatality, injury and/or illness that:

A. Is work-related; and

B. Is a new case; and

C. Meets one or more of the general recording criteria.

2. Log of Injuries and Illnesses (OSHA 300)

The log will be used for classifying occupational injuries and illnesses, and for noting the extent of each case. The log shows when the occupational injury or illness occurred, to whom, the regular job of the injured or ill person at the time of the injury or illness exposure the department in which the person was employed, the kind of injury or illness, how much time was lost, whether the case resulted in a fatality, etc. Ramboll shall:

2.1 Maintain a log and summary of all recordable occupational injuries and illnesses by calendar year.

2.1.1 The form will be updated to include newly discovered cases and to reflect changes, which occur in recorded cases after the end of the calendar year. Although all OSHA injury and illness records will be retained, only the log must be updated. If, during the 5-year retention period, there is a change in the extent or outcome of an injury or illness, which affects an entry on a previous year's log, then the first entry will be lined out and a corrected entry made on that log. New entries for previously unrecorded cases that are discovered will also be documented. Log totals will also be modified to reflect these changes.

2.2 Enter each recordable injury and illness on the log and summary as early as practicable but no later than 7 days after receiving information that a recordable injury or illness has occurred. For this purpose OSHA Form No. 300 or an equivalent, which is as readable and comprehensible to a person not familiar with

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it will be used. Computerized versions are acceptable so long as they contain the same information as the OSHA version.

2.3 At each office, there will be available a copy of the log, which reflects separately the injury and illness experience of that office.

2.4 Circumstances when an employee's name should be omitted from the OSHA Form 300. The words "privacy case" will be inserted instead of the persons name.

2.4.1 Injury or illness to an intimate part of the body.

2.4.2 Injury or illness resulting from a sexual assault.

2.4.3 A mental illness.

2.4.4 A case of HIV infection, hepatitis, or tuberculosis.

2.4.5 A needlestick or "sharps" cut from potentially contaminated blood.

2.4.6 Other illness where the employee requests omissions of their name.

2.4.7 A case of HIV infection, hepatitis, or tuberculosis.

3. ILLNESS AND INJURY REPORT (OSHA 301)

In addition to the log of occupational injuries and illnesses (OSHA 300) Ramboll shall maintain the OSHA 301 (illness and injury report). The record shall be completed in the detail prescribed in the accompanying instructions provided by the Occupational Safety and Health Administration. Computerized versions are acceptable so long as they contain the same information as the OSHA version.

3.1 Fatality Reporting or Multiple Hospitalization. The site controlling employer or designee will be responsible for filing a report if no more than two employees of a single employer were hospitalized but, collectively, three or more workers were hospitalized as in-patients. Ramboll will report the following to the nearest OSHA office within 8 hours of a work related fatality.

- The Establishment Name;
- The Location of the Incident;
- The Time of the Incident;
- The Number of Fatalities or Hospitalized Employees;
- The Names of Any Injured Employees;
- Contact Person and His or Her Phone Number; and
- A Brief Description of the Incident.

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4. SUMMARY OF ILLNESSES AND INJURIES (OSHA 300A)

Ramboll shall post an annual summary of occupational injuries and illnesses for each facility under our control on February 1st for 3 months (Feb 1 – Apr 30). The summary shall contain information from the previous year. This summary shall consist of a copy of the year's totals from the form OSHA No. 300 and the following information from that form:

4.1 Calendar year covered.

4.2 Company Name and establishment address.

4.3 Certification signature, title, and date by a company executive.

4.4 A form OSHA No. 300A shall be used in presenting the summary. If no injuries or illnesses occurred in the year, zeros will be entered on the totals line, and the form posted.

4.5 Ramboll shall post a copy of the establishment's summary in each facility. This portion shall be in a designated located so that all employees have the ability to review the summary.

5. RECORDS RETENTION

Records maintained by Ramboll will be retained for the following time periods following the end of the year to which they relate.

5.1 Log occupational injuries and illnesses (OSHA 300 or equivalent) shall be retained for at least 5 years.

5.2 Supplementary records (OSHA 301 or equivalent) shall be retained for at least 3 years.

5.3 Employee exposure and medical records for company employees shall be retained for 30 years.

5.4 Noise exposure measurement records shall be retained for 25 years.

5.5 Audiometric test records shall be retained for the duration of the affected employee's employment.

6. ACCESS TO RECORDS

Ramboll shall provide, upon request, records provided, for inspection and copying by any representative of the Secretary of Labor for the purpose of carrying out the provisions of the OSHA act, and by representatives of the Secretary of Health, Education, and Welfare, or by any representative of a State accorded jurisdiction for occupational safety and health inspections or for statistical compilation.

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7. CHANGE OF OWNERSHIP

Should Ramboll change ownership, Ramboll shall notify the buyers of the requirement to preserve those records, if any, of the prior ownership, which are required to be kept.

8. PETITIONS FOR RECORDKEEPING EXCEPTIONS

Should Ramboll wish to maintain records in a manner different from that required, Ramboll will submit a petition containing the information specified by the Regional Commissioner of the Bureau of Labor Statistics in our region.

9. EMPLOYEES NOT IN FIXED ESTABLISHMENTS

On site records requirements for company employees engaged in physically dispersed operations that do not report to any fixed company establishment, but are subject to common supervision will be satisfied by:

9.1 Transmitting a copy of the records to the worksite upon request.

9.2 Transmitting a copy to the requesting government office upon request.

9.3 Providing copies in accordance with regulatory requirements.

9.4 To be completed within 4 hours of the request.

10. STATISTICAL PROGRAM

Ramboll will comply with all requirements to maintain, provide, and use statistical summaries. Upon receipt of an Occupational Injuries and Illnesses Survey Form,Ramboll shall promptly complete the form in accordance with the instructions contained therein, and return it in accordance with the instructions.

11. RECORDABILITY AND CLASSIFICATION

11.1 Case analysis. The following decision logic will be followed:

11.1.1 Determine whether a case occurred (death, injury, illness).

11.1.2 Establish that the case was work related.

11.1.3 Work related means: Cases resulting from an event or exposure in the work environment. An event or exposure in the work environment either caused or contributed to the resulting condition or; an event or exposure in the work environment significantly aggravated a pre-existing injury or illness.

In addition to the physical location, equipment or materials used in the course of an employee's work are also considered part of the employee's work environment.

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11.2 Establishing that the case was not work related.

11.2.1 The case will be considered not work related when an employee is off duty on our premises as a member of the general public and not as an employee.

11.2.2 The case will be considered not work related when an employee has symptoms that merely surface on company premises, but are the result of a nonwork-related event or exposure off the premises.

11.3 Determining if the case is an illness or injury.

11.3.1 Illness cases. Illnesses usually result from a long term exposure, or cases where the illness does not develop as the result of an instantaneous event. This concept of illness includes acute illnesses, which result from exposures of relatively short duration.

11.3.2 Injury cases. Injuries are only required to be recorded when they require medical attention (other than first aid). Injuries are usually caused by instantaneous events in the work environment. Cases resulting from anything other than instantaneous events are considered illnesses. This concept of illness includes acute illnesses, which result from exposures of relatively short duration.

11.4 Recordable case. If the case is an injury, decide if it is recordable. The following criteria will be used as a basis for recordability. Injuries or illnesses resulting in, or requiring:

11.4.1 Death

11.4.2 Loss of consciousness,

11.4.3 Days away from work,

11.4.4 Restricted work activity;

11.4.5 Job transfer;

11.4.6 Medical treatment beyond first aid;

11.4.7 Related injury or illness that is diagnosed by a physician or other licensed health care professional (PLHCP);

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11.4.8 Work- related case involving cancer,

11.4.9 Chronic irreversible disease

11.4.10 Fractured or cracked bone

11.4.11 Punctured eardrum.

11.4.12 Any needlestick injury or cut from a sharp object that is contaminated with another person's blood or other potentially infectious material.

11.4.13 Tuberculosis infection as evidenced by a positive skin test or diagnosis by a PLHCP after exposure to a known case of active tuberculosis.

11.4.14 Any case requiring an employee to be medically removed under the requirements of an OSHA health standard.

11.4.15 Positive skin test or diagnosis by a PLHCP after exposure to a known case of active tuberculosis.

11.4.16 Medical treatment includes managing and caring for a patient for the purpose of combating disease or disorder.

11.4.17 Any other condition required regulatory requirements.

11.5 Illness case. Generally, occupationally induced illness should be recorded as a separate entry on the OSHA 300 (or equivalent) log. However, certain illnesses, such as silicosis, may have prolonged effects, which recur over time. The recurrence of these symptoms will not be recorded as new cases on the OSHA forms. The recurrence of symptoms of previous illness may require adjustments of entries on the log for previously recorded illnesses to reflect possible change in the extent or outcome of the particular case. Where it is unclear where an entry should be made, the Director of Health and Safety and/or the Director of Human Resources will be contacted to offer advice for proper annotation.

11.5.1 Cases not resulting in death or lost workdays. These cases consist of the relatively less serious injuries and illnesses, which satisfy the criteria for recordability but do not result in death or require the affected employee to have days away from work or days of restricted work activity beyond the date of injury or onset of illness.

12. ANNUAL OSHA INJURY AND ILLNESS SURVEYS

OSHA has the authority to collect establishment-specific data on different work places. These surveys require employers to report information to OSHA that is contained in records that employers are required to create and maintain pursuant to 29 CFR 1904, and the number of workers they employed and hours their employees worked during designated periods.

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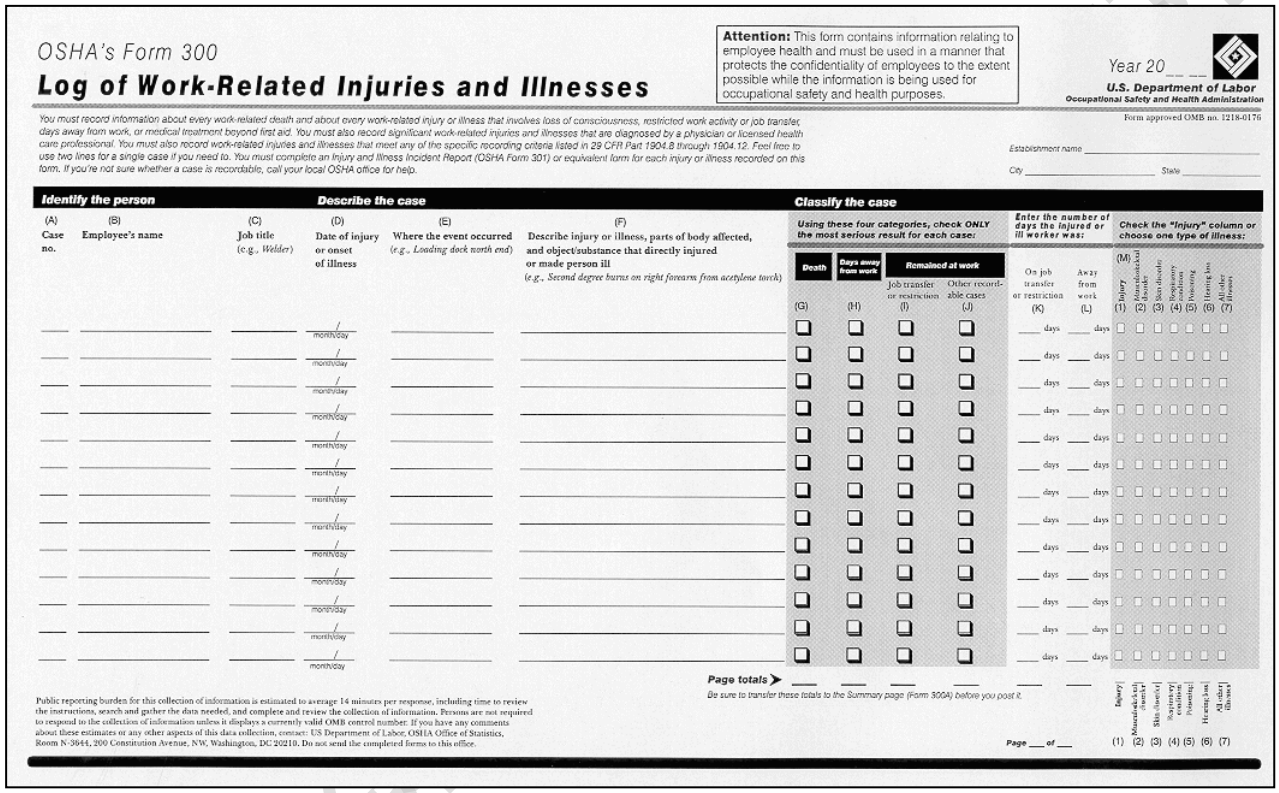
12.1 Ramboll will, upon receipt of OSHA's Annual Survey Form, report to OSHA or OSHA's designee the number of workers we employed and number of hours worked by the employees for periods designated in the survey form and such information as may request from records.

12.2 Survey reports will be sent to OSHA by mail or other means described in the Survey Form within the time stated in the Survey Form.



OSHA's Form 300

Log of Work-Related Injuries and Illnesses

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

You must record information about every work-related death and about every work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid. You must also record significant work-related injuries and illnesses that are diagnosed by a physician or licensed health care professional. You must also record work-related injuries and illnesses that meet any of the specific recording criteria listed in 29 CFR Part 1904.8 through 1904.12. Feel free to use two lines for a single case if you need to. You must complete an Injury and Illness Incident Report (OSHA Form 301) or equivalent form for each injury or illness recorded on this form. If you're not sure whether a case is recordable, call your local OSHA office for help.

Establishment name _____

City _____ State _____

Identify the person			Describe the case			Classify the case														
						Using these four categories, check ONLY the most serious result for each case:				Enter the number of days the injured or ill worker was:		Check the "Injury" column or choose one type of illness:								
(A) Case no.	(B) Employee's name	(C) Job title (e.g., *Welder*)	(D) Date of injury or onset of illness	(E) Where the event occurred (e.g., *Loading dock north end*)	(F) Describe injury or illness, parts of body affected, and object/substance that directly injured or made person ill (e.g., *Second degree burns on right forearm from acetylene torch*)	Death (G)	Days away from work (H)	Remained at work: Job transfer or restriction (I)	Remained at work: Other recordable cases (J)	On job transfer or restriction (K)	Away from work (L)	(M) Injury (1)	Skin disorder (2)	Respiratory condition (3)	Poisoning (4)	Hearing loss (5)	All other illness (6)	(7)
___	_____	_____	__/__ month/day	_____	_____	☐	☐	☐	☐	___ days	___ days	☐	☐	☐	☐	☐	☐	☐
___	_____	_____	__/__ month/day	_____	_____	☐	☐	☐	☐	___ days	___ days	☐	☐	☐	☐	☐	☐	☐
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					Page totals ➤	___	___	___	___	___	___							

Be sure to transfer these totals to the Summary page (Form 300A) before you post it.

Public reporting burden for this collection of information is estimated to average 14 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistics, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

Page ___ of ___

OSHA 300

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OSHA's Form 301

Injury and Illness Incident Report

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

This *Injury and Illness Incident Report* is one of the first forms you must fill out when a recordable work-related injury or illness has occurred. Together with the *Log of Work-Related Injuries and Illnesses* and the accompanying *Summary,* these forms help the employer and OSHA develop a picture of the extent and severity of work-related incidents.

Within 7 calendar days after you receive information that a recordable work-related injury or illness has occurred, you must fill out this form or an equivalent. Some state workers' compensation, insurance, or other reports may be acceptable substitutes. To be considered an equivalent form, any substitute must contain all the information asked for on this form.

According to Public Law 91-596 and 29 CFR 1904, OSHA's recordkeeping rule, you must keep this form on file for 5 years following the year to which it pertains.

If you need additional copies of this form, you may photocopy and use as many as you need.

Completed by _____

Title _____

Phone (_____) _____-_____ Date ___/ ___/ ___

Information about the employee

1) Full name _____

2) Street _____

City _____ State _____ ZIP _____

3) Date of birth ____ / ____ / ____

4) Date hired ____ / ____ / ____

5) ☐ Male
☐ Female

Information about the physician or other health care professional

6) Name of physician or other health care professional _____

7) If treatment was given away from the worksite, where was it given?

Facility _____

Street _____

City _____ State _____ ZIP _____

8) Was employee treated in an emergency room?
☐ Yes
☐ No

9) Was employee hospitalized overnight as an in-patient?
☐ Yes
☐ No

Information about the case

10) Case number from the *Log* _____ *(Transfer the case number from the Log after you record the case.)*

11) Date of injury or illness ____ / ____ / ____

12) Time employee began work _____ AM / PM

13) Time of event _____ AM / PM ☐ Check if time cannot be determined

14) ***What was the employee doing just before the incident occurred?*** Describe the activity, as well as the tools, equipment, or material the employee was using. Be specific. *Examples:* "climbing a ladder while carrying roofing materials"; "spraying chlorine from hand sprayer"; "daily computer key-entry."

15) ***What happened?*** Tell us how the injury occurred. *Examples:* "When ladder slipped on wet floor, worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; "Worker developed soreness in wrist over time."

16) ***What was the injury or illness?*** Tell us the part of the body that was affected and how it was affected; be more specific than "hurt," "pain," or sore." *Examples:* "strained back"; "chemical burn, hand"; "carpal tunnel syndrome."

17) ***What object or substance directly harmed the employee?*** *Examples:* "concrete floor"; "chlorine"; "radial arm saw." *If this question does not apply to the incident, leave it blank.*

18) ***If the employee died, when did death occur?*** Date of death ____ / ____ / ____

Public reporting burden for this collection of information is estimated to average 22 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Persons are not required to respond to the collection of information unless it displays a current valid OMB control number. If you have any comments about this estimate or any other aspects of this data collection, including suggestions for reducing this burden, contact: US Department of Labor, OSHA Office of Statistics, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

OSHA 301

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OSHA's Form 300A

Summary of Work-Related Injuries and Illnesses

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

All establishments covered by Part 1904 must complete this Summary page, even if no work-related injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete and accurate before completing this summary.

Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the Log. If you had no cases, write "0."

Employees, former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR Part 1904.35, in OSHA's recordkeeping rule, for further details on the access provisions for these forms.

Number of Cases

Total number of deaths	Total number of cases with days away from work	Total number of cases with job transfer or restriction	Total number of other recordable cases
_____	_____	_____	_____
(G)	(H)	(I)	(J)

Number of Days

Total number of days of job transfer or restriction	Total number of days away from work
_____	_____
(K)	(L)

Injury and Illness Types

Total number of . . . (M)

(1) Injuries _____
(2) Musculoskeletal disorders _____
(3) Skin disorders _____
(4) Respiratory conditions _____
(5) Poisonings _____
(6) Hearing loss cases _____
(7) All other illnesses _____

Establishment information

Your establishment name _____

Street _____

City _____ State _____ ZIP _____

Industry description (*e.g., Manufacture of motor truck trailers*)

_____

Standard Industrial Classification (SIC), if known (*e.g., SIC 3715*)

___ ___ ___ ___

Employment information

(If you don't have these figures, see the Worksheet on the back of this page to estimate.)

Annual average number of employees _____

Total hours worked by all employees last year _____

Sign here

Knowingly falsifying this document may result in a fine.

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

Company executive _____ Title _____

( ) - _____ / / _____
Phone Date

Post this Summary page from February 1 to April 30 of the year following the year covered by the form.

Public reporting burden for this collection of information is estimated to average 50 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistics, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

OSHA 300A

UNCONTROLLED

APPENDIX O
HASP Addendum

CMR SUPPLEMENTAL DOCUMENTS

SUPPLEMENTAL DOCUMENT 1

CMR Subcontractor Safety Manual

Calumet MONTANA REFINING, LLC

Contractor Safety Manual

CALUMET
Montana Refining, LLC

GUIDELINES AS TO THE COMPANY'S RELATIONSHIP WITH INDEPENDENT CONTRACTORS AND THE CONTRACTOR'S EMPLOYEES

Rev. 6/18

Advanced Litho Printing LLC
Great Falls, Montana

CALUMET MONTANA REFINING
SAFETY MANUAL

I. Introduction-Plant Policy

Calumet Montana Refining, LLC. (CMR) is committed to providing a safe and healthful workplace environment for its employees and contractors.

CMR is committed to the following hierarchy of values:

- Personal and Process Safety
- Environmental Compliance
- Asset Protection
- Profitability

Related values include Continuous Improvement and Open Communication of Concerns.

Calumet Montana Refining, LLC expects you to comply with all requirements and regulations set forth by the Occupational Safety and Health Administration (OSHA). In some instances, the company may establish work practices that exceed those required by OSHA. It is our company's policy that our employees be trained in their assigned work, safe work practices, and in the hazards associated with the chemicals and processes of our company.

Our safety policy encourages positive recognition of employees' and contractors safe work behaviors while providing discipline to employees and contractors who fail to abide by established safe work procedures. Employees and contractors are encouraged to make management aware of unsafe conditions and to suggest methods or procedures to improve the safety of the worker. Calumet Montana Refining, LLC, shall also act on each unsafe condition and safety improvement suggestion brought to their attention.

We want our workplace to be one that employees and management will be proud of. When the safety program breaks down resulting in an incident steps will be taken to provide the best care and treatment for injured employees. A review of the incident will take place to establish procedures or modify existing ones to assure that such incidents will not happen again.

It is our belief and position that with the cooperation of management, employees, and staff that Calumet Montana Refining can be and shall be a safe workplace. The company's top management is committed to this idea and will make every effort to support this objective.

II. Calumet Cardinal Rules

Calumet's Cardinal Rules:

Protecting the safety and health of employees, contractors and visitors is a shared responsibility of everyone that works at Calumet Specialty or one of its subsidiaries. We hold Safety, both Occupational and Process Safety, as our Top Priority, followed by Environmental Protection, followed by Production. If it isn't Safe, We Don't Do It.

The following Cardinal Rules are intended to communicate clear expectations in areas that are critical to occupational safety, process safety, and environmental protection. One hundred percent (100%) compliance with these Cardinal Rules is a basic expectation of all Calumet employees, contractors and visitors. Deliberate violations of these Cardinal Rules cannot and will not be tolerated.

Failure to follow any of these Cardinal Rules will result in an investigation into the circumstances, followed by appropriate actions, which may include disciplinary action.

1. Personal protective equipment, including H2S monitors, must be worn when required by a Calumet procedure or Safe Work Permit.
2. Injuries, incidents, releases, fires, vehicular and property damage must be promptly reported.
3. Operating and maintenance procedures and Safe Work Permit requirements must be followed, unless there is a supervisory notification and concurrence, with mitigating measures. Propose changes to improve procedures, rather than taking shortcuts.
4. Safe Work Permits, issued in accordance with site-specific procedures, are always required for the following types of activities:
   a. Isolation of energy sources ('Lockout-Tagout-Try')
   b. Entering a Confined Space
   c. Hot work such as cutting and welding
   d. Line breaking
   e. Electrical system maintenance and repair
   f. Work at heights requiring fall protection systems

   Compliance with the specific requirements of the individual Safe Work Permit is required. Safe Work Permits may be required for additional activities based on site-specific programs.
5. Removing, disabling, tampering, silencing, or bypassing alarms, safety devices or guards must never be done unless allowed by written procedures or with written managerial approval. Operators are empowered and expected to shut units down when needed to avoid exceedance of Safe Operating Limits.
6. Safety systems must be functional and enabled prior to startup and equipment in working order prior to use. Any other condition requires management review, approval and mitigating measures.
7. Weapons, substance abuse, smoking outside of designated areas, and workplace violence are never acceptable.

III. Safety and Loss Prevention Policy

The safety and health of all employees of Great Falls Refinery is of primary importance. Safety is a requisite to all of our operations.

Management recognizes that all injuries and all losses are preventable – and all employees must work toward this goal.

Management is responsible for the safety of employees and for prevention of losses. This is a line responsibility and it extends from the plant manager to, and including, first line foremen. Management has the responsibility to provide the necessary training of employees and to provide safeguarding of all operating exposures.

Each employee has the responsibility to receive, understand and use the training as provided by Management. In the performance of his assigned work, an employee is expected to do his work safely and follow correct operating procedures. This is a condition of employment. Any employee who violates safety rules and practices may be subject to disciplinary action.

Prevention of personal injuries, both on and off the job, and prevention of losses from adverse happenings is good business practice for both the employees and the Company. It reduces pain, suffering and loss by the employee and promotes efficiency and economy for the Company.

IV. General Safety Rules

- **Minimum Personal Protective Equipment (PPE) Required for work in the Refinery:**
  Hard Hat (With Safety Goggles)
  Safety Glasses
  Fire Resistant clothing (FRC's)
  Safety Toe Boots
  Personal H2S Detector
  Hearing Protection
- Horseplay will not be permitted on the job
- Report any unsafe acts or conditions to your supervisor immediately
- Only explosion-proof flash lights and cameras supplied or approved by the Company are permitted in the plant. Firearms are not permitted at any time.

- Theft of company equipment or property may be handled with immediate termination.
- Housekeeping is the responsibility of all contractors. The ground and work areas should be clean, all tools clean and in their proper place and all doors and exits clear.
- A steam whistle is blown as the emergency signal, this whistle is blown every day at 12:00 noon and 12:30 pm. If the whistle is blown at any other time it is considered an emergency whistle.
- Windsocks are used at chemical plants where there is a potential for releases. Also to indicate the direction and strength of the wind. Identify the wind direction prior to beginning work for egress direction.
- Barricade and road closure signs shall be observed. Removal of such items shall be limited to authorized individuals.
- Use of cell phones inside the refinery is prohibited.
- All camera use must be authorized by management using the camera use permit and all pictures must be reviewed by CMR before removal or transmittal off site.
- Fall protection (Safety harness with self retracting lanyard (yo-yo) is required when working over six feet above grade unless a standard railing is provided.
- The Alkylation Unit is a hydrofluoric acid regulated area and is marked with an orange line painted on the ground around the unit, an orange chain and cones strung around the perimeter with signs stating "Danger Hydrofluoric Acid". NO person, or persons, can enter this unit without special Alky training, Alky Safe Work Permit and PPE.
- Acetylene and oxygen cylinder valves, welding machines, compressors, etc., must be shut off when workers leave the job. Acetylene and oxygen hoses must be removed from inside confined spaces when not in use.
- Portable lighting and electrical equipment should be maintained in good condition and will be subject to inspection by the safety department. Cords shall be provided with a three prong grounding connection or the equipment double insulated. GFCI protected or low voltage equipment is required in confined spaces. Use may require a Hot Work permit. Check with operator in charge before use.

- The presence of illegal drugs or alcohol is prohibited. The company reserves the right to search (including drug test) personnel and vehicles on company premises.
- Contractor is responsible for providing respiratory protective equipment and training necessary for their employees. Contract employees which may be subject to using respiratory protection shall be clean shaven in the seal area.
- Work stoppage (operator control, safety infractions, unsafe conditions, etc.)

Vehicle Controls:

- Subject to inspection and search entering and exiting Speed limit 5 mph in units; 10 mph in tank farm.
- Restriction on entering units or fire walls. Contact the operator in charge of the area before entering
- Parking requirements:
  1. Engine off (keys left in ignition especially during an emergency evacuation do not drive out, leave keys in ignition). Emergency personnel will move as necessary.
  2. Park or in gear
  3. Chocking of wheels
  4. Emergency brake set
- The driver must always be in attendance while motor is running.
- When refueling, engine driven equipment must be turned off and grounded or bonded to the fuel truck.
- Vehicles and materials shall not be positioned such that they block any roadways or emergency access without prior management approval.
- Personnel riding in the bed of trucks must be seated while the vehicle is in motion. Down inside box, not on side.
- Driving into tank dikes is prohibited without approval on permit.
- Forklift training certifications required before operating.
- ***Any contractor's vehicle used inside the plant must have a permit displayed in the windshield where it can readily be seen.***

AWP Pre-Task Requirements:

- Third party training / certification of all equipment operators and spotters – Copies of certification must be forwarded to CMR prior to work.
- CMR safety procedures are followed at **ALL TIMES**.
- Pre-task analysis / JHA are required and approved by a Manager during day shift and Shift Supervisor with manager notification on nights for each AWP use.
- Minimum of one full-time **certified** spotter while JLG is operated within the CMR refinery.
- 2 spotters are required when vehicle is moved in reverse.
- Safe Work Permit is required for **ALL** Aerial Work Platform use.

Excavation

- Contractor must supply CMR with any training certifications or records for the operation of any motorized excavation equipment.
- Contractor must follow the standards and procedures associated with excavating as described in 29 CFR 1926.650-652(confined space, sloping/shoring, evacuation procedures, locating procedures, soil classification, hot work, PPE, dikes and berms, and barricades and road closures). Work shall be planned to minimize the time that the excavation is left open.
- Environmental Department approval is required prior to any soil excavation, placement, or waste generation to verify proper handling and paperwork. All spills are to be reported immediately to CMR.

Bathrooms

- Portable bathrooms are located throughout the Refinery
- A bathroom is located in the emulsion area, next to the SE gate.
- The basement bathroom in the Operations Building is for CMR personnel ONLY.

Smoking & E-Cigarette Use

Restricted to designated areas at each building.

1. North side of new maintenance shop.
2. South West side of Control Room.
3. In personal vehicles outside refinery fences.

- No smoking anywhere along front side of refinery offices facing 10th street.
- All cigarette butts need to be put out & disposed of properly.
- Single action lighters prohibited, Strike anywhere matches prohibited.
- Smoking is prohibited in company vehicles.

V. Air, Water, Steam and Nitrogen Hoses

- High pressure air hoses are not to be used for blowing dust/debris off clothing.
- Air hose connections must be pinned prior and during use including whip checks at the joints
- Do not drive on unprotected hoses.
- Secure (tie-off) hoses in process sewers so that the hose will not come out of the drain.
- Hoses at CMR are color coded and hoses shall be selected based on the table below:

SERVICE	HOSE COLOR	FITTING COLOR
Plant Air	Yellow	Blue
Water	Yellow	Green
Steam & Condensate	Red	N/A
Hydrocarbons & water containing hydrocarbons (<350°F)	Red	N/A
Hydrocarbons & water containing hydrocarbons (<150°F)	Blue	N/A
Bulk Nitrogen (DO NOT use on nitrogen bottles)	Green w/ purple metal band on ends	Purple
Chemicals including Acids and Caustics (< 175°F)	Blue	N/A

VI. First Aid

- Contractor is responsible for providing first aid or other medical care for injured contract employees. Copies of the contractors accident report and investigation must be provided to the safety department.
- First aid station / kits with proper supplies are maintained in the front office, laboratory, CMR control room, safety office, Westgate, and the operations building.
- First Aid kits are used for minor cuts, scrapes and burns.
- All injuries minor or serious are to be reported to your supervisor, CMR operations, and CMR safety immediately.

Cuts, Scratches and Bruises

A minor cut or scratch may not at first be serious. However, if not properly treated, infection may bring serious complication. Obtain first aid treatment at once. If, later, the wound does not heal properly, further medical treatment will be provided.

VII. Reporting Injuries

- If an incident is identified as an emergency or suspected emergency report by radio, telephone or face-to-face to the control room operator.

  The control room may be reached by the following methods:
  - Channel 1 on any refinery radio
  - (406) 454-9876
  - Reporting to the control room on the south side of the operations building
- After initial emergency notifications, take the following reporting actions:
  - Report near miss and incidents to your company supervisor
  - Notify CMR Safety immediately.
- Company supervisors have the responsibility to complete all required forms and make notifications following the initial incident reporting.

VIII. Emergency Evacuation

Emergency Signals are as follows:
In the event of an emergency the refinery whistle will be used to indicate what area of the refinery is being evacuated as identified below.

CODE	MEANING
Long single whistle blast	Refinery Wide Evacuation
Single (1) whistle blast	Emergency in Zone 1
Double (2) whistle blast	Emergency in Zone 2
Triple (3) whistle blast	Emergency in Zone 3

If an emergency occurs in another area, the whistle may be sounded as described above to alert personnel to the second emergency.

- In emergency, leave unit and reassemble at location assigned. Walk - do not drive
- Primary Muster point in the East Employee Parking lot across 10th Street NE
- Secondary Muster Point is at the West Entrance Gate #1
- Which assembly muster point you go to depends on wind direction and your location within the refinery.

IX. Toxic Gases and Chemicals

Toxic Gases

In the refinery a number of potentially harmful gases are used or produced. Among these are hydrogen sulfide, hydrocarbon vapors, carbon monoxide, ammonia and other. The best protection from these materials is to avoid exposure or use the prescribed respiratory protection.

Chemicals

Many of the chemicals and reagents used daily in the refinery can cause injury if not properly handled. If an employee is exposed to or comes in contact with a chemical product stop work and proceed to a safety shower. Use the safety shower or eyewash for 15 minutes and follow any additional action identified on the SDS

- Safety Data Sheets (SDS) are required on any chemicals used by contractors during work in the facility. SDS's must be cleared via the CMR Chemical Approval procedure.
- CMR SDSs are available 24 hrs a day on MSDS Online. They will tell you what the hazards of the product are, safety precautions, First Aid measures, and how to recognize symptoms of overexposure.
- SDS are available from Operations, the Lab, & Safety
- Report any chemical exposures to both the Operations and Safety Departments

Potential Fire, Explosion, Toxic Release Hazard:

- Depending on the unit or area of the plant where work is being done, known hazards that can potentially affect employees will be discussed before work commences and need to be listed on permits.
- Any employee that is unsure of, or thinks job site or area is unsafe, do not start work. Bring issues to the CMR Safety Department immediately for further discussion.
- If there are ANY issues that arise in course of work, concerning your safety or safety of others, contact the operations shift supervisor for that zone immediately.

X. Fire

Types of Fires

- If you find a fire immediately report it on radio ch. 1.
  (You are not obligated to fight a fire)

Incipient Fire:

A fire which is in the initial or beginning stage that can be controlled or extinguished by a portable fire extinguisher, snuffing steam, deluge system, or small hose systems without the need for protective clothing or breathing apparatus.

Examples Include:

- Fire on a small quantity of ordinary combustibles
- Residual hydrocarbon Fire
- Iron Sulfide Fire
- Small pool of hydrocarbon burning

Fully Involved:

Fire, heat and smoke around a fire or in a structure are such that access to the source of the fire must wait until the area can be cooled and secondary fires extinguished.

Examples Include:

- The fire is too hot to approach
- Active leak & fire
- Multiple fires
- Adjacent structures are involved or damaged
- Smoke or vapor clouds
- Do not attempt to extinguish a fire on an active leak.

Fire Alarm system

For Offices or Buildings-

- All office buildings have manually activated fire alarms mounted throughout the building. In the case of a fire, pull the nearest fire alarm (or tell a co-worker to pull it) and call 911.
- Immediately evacuate the building and report to a prearranged meeting location
- Do not try to put out the fire with an extinguisher, unless you have been trained and are expected to use an extinguisher
- Wait for the "all clear" signal before you re-enter the building

Fire Extinguishers/ Fire Hydrants

Maintenance, periodic inspections and instructions on the use of fire extinguishers and firefighting equipment are the responsibility of the Safety Department.

Types of Fire Extinguishers:

Class A- Ordinary combustibles

Class B- Petroleum Based products such as gasoline, diesel, etc.

Class C- Electrical based fires such as circuit overload

Class D- Metal fires such as magnesium or other shavings.

There are two types of fire extinguishers found in the Refinery:

1. Dry Chemical- (for BC class fires) pressurized and cartridge type, these are distributed throughout the refinery in all the units and in most buildings.
2. Halotron- (For ABC class fires) Installed in the control rooms, MCC buildings and in the laboratories.
    - All extinguishers have name plates that give full instructions for use.
    - Yearly training is provided to all employees on the use of fire extinguishers.
    - Notify the Safety Department or your supervisor *immediately* following the use of any extinguisher so it can be recharged or replaced.
    - Do not use a fire hydrant downwind or in close proximity of a fire.
    - When cooling a fire do not attempt to extinguish a fire that is part of an active leak. Extinguishing a fire that is part of an active leak can lead to vapor clouds that may cause chemical exposures or ignite and cause additional secondary damage.

Fire Hazards

1. Accumulation of combustible material such as oil soaked and paint covered cloths, rags, waste, etc., is not allowed. Such material must be placed in metal containers with approved type lids. This material must be frequently collected and properly disposed of.
2. Tanks, oil drums, etc., which have contained gaseous liquids (such as gasoline, oils, paints, etc.), shall not have heat applied either by fire or welding torch until they have been cleaned and made safe. If there is any doubt, check with the supervisor. An "empty" drum is more dangerous than a filled one.
3. Before a fire of any description can be lighted on plant property, except in furnaces, heaters, etc., it will be necessary to obtain permission from the supervisor.

Management has taken all practical means to provide a safe Refinery free from fires and explosions and considers the protection of each employee to be a great responsibility. The active assistance of every person in the Refinery is necessary if we are to prevent fires. It is the duty of each employee to know the operation and use of Refinery firefighting and emergency equipment. From time to time, instructions will be given on the use of this equipment in safety meetings, fire drills, etc

Solvents

The prevention of fire is of utmost importance and like accidents, fires do not just happen, they are caused. The practice of good housekeeping greatly minimizes the possibility of fires because it deprives them of a place to start. When doing work that requires the use of solvents special attention should be given to the following:

1. Gasoline m u s t not be used for cleaning purposes.
   Gasoline is to be used as a motor fuel only. Use a high flash solvent or other approved cleaning solvent for tools and parts. Use a non-flammable safety solvent for cleaning electrical or instrument parts. Always provide adequate ventilation.
2. All flammable liquids (oils, paints, varnishes, cleaners, etc.) should be stored in approved locations. These locations should be such that, if a fire did occur, its spread would be limited.

XI. Permit to Work Program

- Permits are required when performing work on, in or near process and utility units, pipe racks and tank farms, including buildings, fabrication areas and shop buildings adjacent to or within process unit battery limits. All areas inside of tank berms/dikes are considered electrically classified and must be permitted.
- Permit duration shall not exceed 12 hours.
- Permits expire at operations shift change.
- Only the Safety Department can issue confined space and excavation permits.

- It is not permissible to enter tanks, tank cars, vessels, furnaces, electrical manholes, sewer manholes or other confined spaced without appropriate confined space approval.
- A hot work permit is required to drive automotive equipment into operating units, such as trucks, forklifts, and man lifts.
- There are five (5) types of permits at CMR:

Safe Work Permit- Work that does not include an ignition source. Any job requiring hand or non-powered equipment, painting, installing or removal of insulation, steel erection, scaffold work, opening of plant vessels, towers, drums exchangers, coolers, filters, heaters and tanks, installing electrical lockouts, opening of piping by breaking flanges and unions and installing blinds/ blanks, etc.

Hot Work Permit- Work that requires the use of an open flame, spark producing tools, electrical motor drive tools (I.e. non-intrinsically safe equipment).

Confined Space Permit- Entry for any reason into a tank, vessel, hopper, pit, tanker truck, rail car, silo, or other enclosed space with limited access and/or egress, or a space not designed or intended for human occupancy, and has one or more of the following characteristics:

- Contains or has a known potential to contain a hazardous atmosphere.
- Contains a material with the potential for engulfment of an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls, or a floor which slopes downward and tapers to a smaller cross-section, or
- Contains any other recognized serious safety or health hazard.

Excavation Permit- work that requires excavation work by equipment. Approvals for excavation work include environmental, maintenance, safety and operations departments.

HF Safe Work Permit- No person, or persons, other than regularly assigned Zone 1 operators, are permitted to enter the Alky unit without prior approval and a completed HF Safe Work Permit. All work in the Alky unit must be approved by the chief operator.

- Safe work permits may be obtained by following the process outlined below:
  - Obtain a blank copy of a permit to work
  - Complete the white headlining using as much detail as possible about the planned work, examples of completed heading sections include:
    - Operating Unit or Area: Zone 2 MHC Compressor Deck
    - Specific Equipment or Location: HC Off-Gas B Compressor (41-C03B)
    - Specific Details of Work: Offline compressor tuning, lubrication, & cleaning
  - Note the time you will pick up the permit in the top right corner
  - Turn in a completed permit request to the Operations Superintendent, Assistant Superintendent, or Shift Supervisor by 4:30 p.m. the day prior to the planned work
  - Report to the control room to pick up your permit at the time you indicated
    - Work with Operations to complete the section of the permit incorporating hazards and controls for both the unit and your work
  - Leave the original copy with operations in the permit box or control room as instructed
  - Perform job site briefing of the permit with all employees and have all employees sign the back
  - Upon completion of work complete the Permit Closure section and return the permit to Operations

XII. Lock, Tag, Try (lockout/tagout)

- Lockout-Tagout (LOTO) requires that hazardous power sources be "isolated and rendered inoperative" before any repair procedure is started.
- LOTO shall be used to ensure that machines, processes, or equipment are isolated from all potentially hazardous energy, de-energized, and locked or tagged out before personnel perform any servicing or maintenance activities where the unexpected energizing, start-up or release of stored energy could cause injury.
- When contractors are involved in working on refinery equipment they must be informed of the lock/tag/try procedure by a supervisor and must follow the same procedure as maintenance with the understanding that operations is in main control with, 'first lock on and last lock off".
- Combination locks are prohibited.
- Locks are assigned to CMR employees according to the following color code:
    - Blue= Zone 1 Operations
    - Purple= Zone 2 Operations
    - Orange= Zone 3 Operations
    - Green= Maintenance
    - Red= Instrument & Electricians
    - Brass= Other CMR Departments.
- Isolation tags are standardized and provided by the company with a sufficient breaking strength to withstand high winds and cold temperatures.
- Only the affected employee (maintenance) installing a lockout lock and tag may remove their lock and tag.
- Each isolation point must be verified as part of the "try" portion of the energy isolation.
- Contractors may not use Abus brand locks.

I. Personal Protective Equipment (PPE)

- Proper clothing must be won on the job. Loose or fraying clothing, dangling sleeves, long neckties, etc., create a hazard as they can easily get caught in moving machinery. Personal protective equipment is required as follows.
- Contractors are required to provide all required PPE to their employees at no cost.
- Contractors may not use CMR supplied disposable PPE.

Hard Hats

- Hard hats must be worn by all contractors while in the refinery with the exception of the control room, lab, office buildings, maintenance shop, warehouse office, alky change room and inside vehicles.
- Hard hats must be in good condition at all times, not painted or overly stickered and cannot be worn backwards.
- Periodically check hard hats for cracking or brittleness and have it replaced at least once every 5 years.

Foot Protection

- All employees entering or working in the refinery are required to wear protective toe footwear according to OSHA 1910.136 (a).
- Safety footwear must be clearly marked with **ASTM F2412-11; or ASTM F2413-11** and made of materials that are abrasion and chemical resistant with safety toes and non-slip soles in addition to ensuring the safety footwear is all leather, over the ankle and include a defined heel.
- Any athletic style footwear such as tennis shoes, footwear with ventilation holes, sandals, and steel toed footwear when the steel is exposed is *prohibited*.

Clothing

- Full length pants and long sleeve shirts must be worn in the refinery at all times.
- FR clothing is always your outer layer of clothing.
- Worn or damaged FR clothing must be replaced immediately and not worn as protection while in the refinery.

Hearing Conversation

- Hearing protection must have a minimum Noise Reduction Rating (NNR) of 25 dB
- Hearing protection is required throughout the refinery according to the following map.

Respiratory Protection

When working in the Calumet refinery there is or may be a potential to be exposed to chemicals at or above the Exposure Limit. As a result contractors who perform work in process areas must maintain a current respiratory medical clearance and fit testing for the following type of respirators;

- ½ mask Air Purifying Respirator
- Full face Air Purifying Respirator
- Full face respirator for Supplied Air or Self-contained Breather Apparatus (SCBA)

Generally Accepted Hair for Respirators:

If it should become necessary to work in places where contaminants in the atmosphere will interfere with normal breathing, there are several types of protective respiratory equipment provided to cope with such conditions. These are:

1. Dust Filtering Respirators (P-100)
   This respirator must be worn for all operations where there is an excessive amount of dust in the air. Examples are handling chemicals, lime, soda ash, water treating chemicals, and others. Filters must be changed when breathing becomes difficult.

2. Combination Cartridges
   Combination cartridges must be used when exposures to acid gases, hydrocarbons, heavy smoke, or ammonia exceed the exposure limit but not the IDLH level. These cartridges must be replaced daily and have a "shelf-life" that must also be observed. Combination cartridges are not suitable protection against oxygen deficiency.

3. Supplied Air Respirators
   If IDLH or unknown exposure conditions are encountered a Air Purifying Respirator cannot be used. A Supplied Air Respirator must be used. Airline respirators may be used for extended duration work and Self-Contained Breathing Apparatus (SCBAs) must be used when chemical concentrations are unknown.

Gloves

- Gloves should be worn when handling pipe, lumber, wire line, or other rough materials and equipment. It is the responsibility of the contractor to furnish protective gloves for specialized work.

Safety Glasses

- Safety Glasses are required in all locations of the plant with the exception of the operations offices, control rooms and restrooms.
- It is the employee's responsibility to have and wear them at all times when in the plant.
  If prescription eye wear is required, it is the contractor's responsibility to purchase. All safety glasses shall meet the requirements of ANSI Z87.1

XIII. Elevated Work

Ladder Safety

- Use only ladders, which are in good condition.
- All ladders must be secured at the top and all straight ladders should extend a minimum of 3 feet above the point to which a person must climb.
- Metal ladders or ladders with metal reinforcement shall not be used where any electrical hazards exist

- Ladder usage shall be restricted to the purpose for which the ladder is designed and only one person shall be on the ladder at any one time.
- The ladder shall be placed on a firm level base or surface with the feet parallel to the surface it rests against. DO NOT use ladders on ice or slippery surfaces.
- Carrying tools, equipment etc. while climbing a ladder is prohibited.
- Step ladders are not to be used as a straight section, they should be fully opened with all four legs securely positioned.

Scaffold

- The area beneath scaffolds shall be barricaded or placarded to protect personnel walking or working underneath.
- All scaffolding used in the plant must meet OSHA requirements.
- All scaffold boards must be 2” minimum thickness and in good condition
- DO NOT paint scaffold boards, paint may obscure defective boards.
- Lower and secure swing scaffolds at the end of each shift.
- Work shall not be permitted on scaffold during storms or high winds.
- Make sure all connections are firm before using.
- Scaffold footings when on gravel or dirt must be on a minimum pad 2” thick x 10” x 10”.

XIV. Lifting

Serious injury can result from lifting incorrectly or attempting to lift a load that is too heavy. If the object to be moved is heavy or of an awkward size, ask for help or arrange to have it moved by mechanical means.

When lifting, the worker should first assume a semi- squatting position with secure footing and face the object to be lifted with back erect and raise the load by straightening the legs. This method will bring leg muscles into use and take the strain off the back.

When an object is in a position that you cannot use the semi-squatting position, consideration must be given to use of mechanical equipment or assurance of secure footing, keeping the body

erect, and not turning while lifting. Keeping these points in mind will minimize the possibility of injury. The same consideration to stance and footing should be given to lowering as was given in lifting. The purpose again is to make the leg muscles, not the back muscles, do the work.

When two or more men are carrying an object, only one man should give instructions. The men should decide what route they are going to take and should understand clearly how the object is to be handled. Keep in step as nearly as possible and have signals for changing directions, stopping, and lowering the load.

XV. Running Machinery

Guards should not be removed from running machinery. Upon completion of any job on which guards have been removed, guards should be replaced before machinery is started. New machinery requiring guards should not be put into operation unless guards, whether temporary or permanent, are provided. Temporary or permanent guards on new installations should be approved by the Safety Inspector before machinery is started.

XVI. Blinds

When blinding off equipment, be sure that the blinds installed meet the thickness requirements as shown below:

Fantail Blinds Thickness Requirements
Pressure Rating

Pipe Size	150#	300#	400#	500#
2”	1/8”	1/8”	3/16”	3/16”
3”	1/8”	3/16”	1/4”	5/16”
4”	3/16”	1/4”	1/4”	5/16”
6”	1/4”	5/16”	3/8”	1/2”
8”	5/16”	7/16”	1/2”	5/8”
10”	3/8”	9/16”	5/8”	3/4”
12”	1/2”	11/16”	3/4”	15/16”

XVII. Operating Lines and Equipment Clearances

A clearance from the Operating Department is required before it is permissible to open operating lines or equipment. The supervisor may be called for consultation. After the Operating Department has given this clearance and the Supervisor or designated craftsman in charge of the working crew agree that the conditions are safe, the job may be performed. Either of the above parties may elect to withdraw the permit from a safety point of view in the event the conditions of the original clearance change. This procedure applies to opening equipment for such purposes as installing or removing blinds, maintenance, adding connections, etc. In the event hot work is required, a safety check and permit is required in addition to the above. In all cases the bolts in any flanged connection on the side away from the worker should be loosened first and no bolts completely removed. The operation of valves by contractors is not authorized.

The Operating Department is responsible for starting and stopping electrically operated equipment. If repair work is required on electrical or electrical powered equipment or electric switch gear this equipment must be isolated, disconnected, or locked-out as required by person working on the equipment.

XVIII. Barricade Tape

- RED DANGER or DO NOT CROSS TAPE is to be used when keeping workers out of an area or unit.
  - This Barricade cannot be crossed without approval from the person/persons that have the area barricaded off. This must be a visual or verbal clearance prior to crossing the tape.
- Yellow caution tape needs to be used when you are providing a caution to fellow workers or workers traveling through the affected area where there is overhead work such as crane work, lifting tools, etc.
- Yellow and Magenta Tape or Rope marks the boundary for radiation work. This barricade may never be crossed by non-radiation workers.

- Caution tape being used for barricade tape needs to be removed and picked up at the end of each shift, unless the caution remains present.
- All barricades need to be tagged with a name, a contact, date, and what the caution is for, and located on all 4 sides of the area.

XIX. Employee Training & Medical Qualification

- Contractors are responsible for knowing, training their employees to, and complying with the OSHA regulations associated with their work scope.
- Contractors are also required to know the requirements of CMR safety policies and procedures and training their employees to the requirements of those procedures.
    - Copies of CMR policies or procedures will be made available upon requests made to the CMR Safety Department
    - Alternate contractor procedures may be used if those meet or exceed CMR requirements and the contractor supplies a copy of the proposed alternate procedure to CMR Safety for review and bridging prior to use.
- Contractors are responsible for knowing the medical qualifications associated with their work and providing empoyees who are medically qualified to perform their planned scope of work.

I have read the Contractor Safety Manual provided by Calumet Montana Refining, LLC. and I understand its meaning and purpose.

Name (Print) _____

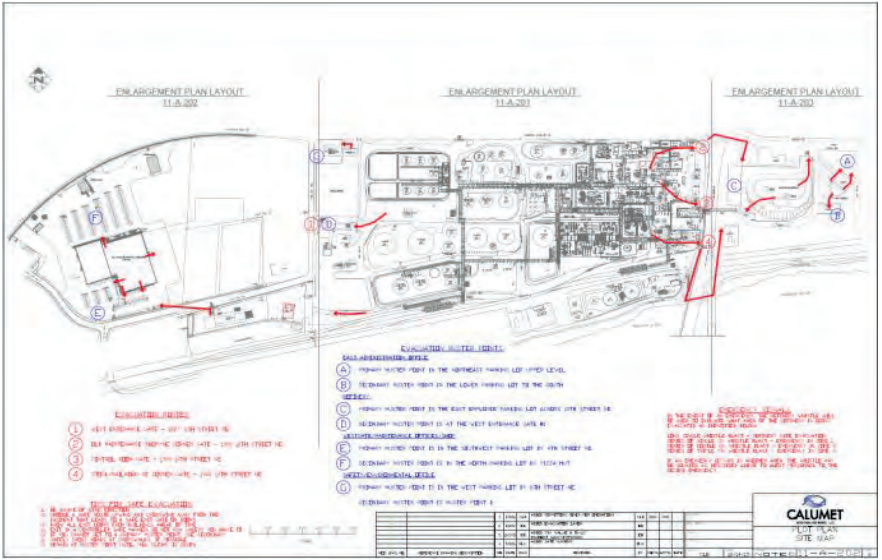
Signature _____

Date: _____

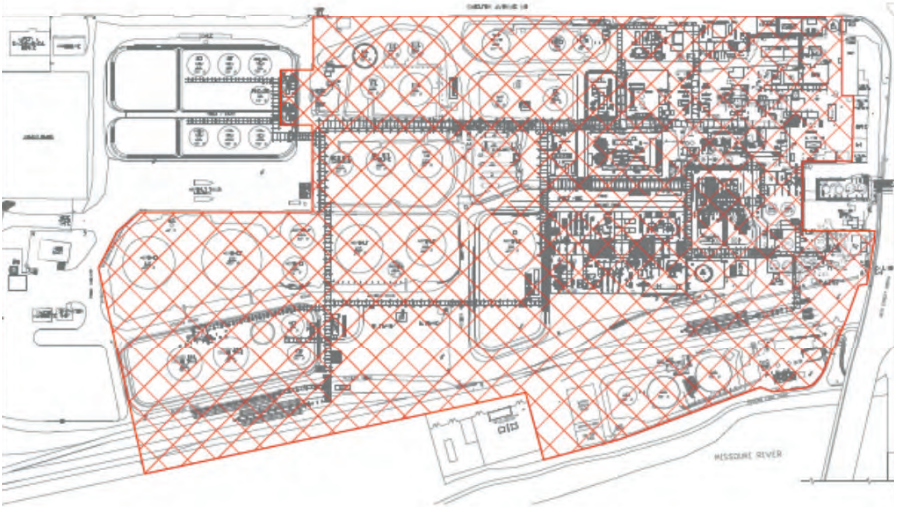
This form is the same as 04 Contractor Safety Manual (little blue book) signature sheet fillable. Please use that form to sign as acknowledgment.

Copies of CMR Safety Policy Procedures are available upon request.

Emergency Evacuation Routes



Hearing Protection Required Areas



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SUPPLEMENTARY DOCUMENT 2

CMR Chemical Approval Form

Appendix B Chemical Request Form (Pg 1 of 2)

Part A -- Originator completes this section. Attach two (X2) SDS of Chemical being requested.

1	**Originator**'s Name		**Originator**'s Company		
2	Chemical TRADE Name		Manufacturer		
	What will the chemical be used for?		Chemical Storage Location		
3	Unit Name/Unit No. where chemical will be used		Equipment/vessel name and number (if applicable)		
	Unit Name/Unit No. where chemical will be used		Equipment/vessel name and number (if applicable)		
4	Is the chemical replacing an existing ▶	☐ No ☐ Yes ▶	Trade Name	Manufacturer	Product Code Number
5	What will be the usage status of this new chemical? ▶	☐ Temporary ☐ Permanent	Is this a process chemical? ☐ No ☐ Yes ▶	MOC No.	
6	When will Chemical arrive ▶		Projected Inventory		
7	Transfer Method (Check only one) ☐ Closed ☐ Open ☐ Manual	**Closed** = No exposure potential, example - pumping into closed process. **Open** = Moderate exposure potential, example .- pumping into open hatch **Manual** = High exposure potential, example - dumping 5 gallon pails			
8	**Originator**'s Signature X		Date	Forward form to Environmental Manager upon completion of Part A	
	Originator's Manager Signature X		Date		

Part B -- Environmental Completes

1	Special Disposal Requirements ☐ No ☐ Yes ▶	Explain		
2	Release/Spill Trigger Reporting ☐ No ☐ Yes ▶	Explain		
3	Is this an Extremely Hazardous Substance (EHS) or contain an EHS? ☐ No ☐ Yes ▶	Explain		
4	Other Remarks			
5	Reviewed by X	Date	Forward to Safety Manager upon completion	

Part C -- Safety Department Completes

1	Reviewed by X	Date		
2	Approved for use ☐ Yes ☐ No ▶	Explain		
	Training Required ☐ Yes ☐ No	PPE Procedure Updated ☐ Yes ☐ NA		
	Comments			

The Originator is responsible for the completion of the Chemical Request Form; obtaining all necessary signatures, providing 2 copies of the SDS, ensuring all information is given to the training department and training is completed, initiating an MOC if necessary and providing 2 finalized copies of the Chemical Request Form to both the Purchasing Manager and the PSM Coordinator.

Appendix B **Chemical Request Form (Pg 2 of 2)**

For all Manager Approvals, sign below. If the chemical is not approved please refer to section 5.5.6 for instructions.

Maintenance Manager _____ Date _____

Operations Manager _____ Date_____

Logistics Manager_____ Date_____

Engineering Manager_____ Date_____

Purchasing Manager_____ Date_____

Warehouse _____ Date_____

Storage Location of Chemcial_____

Environmental Manager_____ Date_____

(Final Signature) Safety Manager_____ Date_____

The Originator is responsible for the completion of the Chemical Request Form; obtaining all necessary signatures, providing 2 copies of the SDS, ensuring all information is given to the training department and training is completed, initiating an MOC if necessary and providing 2 finalized copies of the Chemical Request Form to both the Purchasing Manager and the PSM Coordinator.

SUPPLEMENTARY DOCUMENT 3

CMR Radio Channel List

CALUMET

Montana Refining, LLC

RADIO CHANNELS

1.....ALL CALL
2.....OPERATIONS-ZONE 1
3.....OPERATIONS-ZONE 1 Scan
4.....OPERATIONS-ZONE 2
5.....OPERATIONS-ZONE 2 Scan
6.....STOCK DEPT.-ZONE 3
7.....STOCK DEPT.-ZONE 3 Scan
8.....MAINTENANCE
9.....MAINTENANCE - Scan
10.....SAFETY
11.....SAFETY - Scan
12.....CONTRACTORS
13.....CONTRACTORS - Scan
14.....T/A 1
15.....T/A 2 - Scan
16.....SCARLET

*** Zones 1, 2, 3 Base Stations can activate "All Call"**

**** Orange Taped Antennae portable radios can activate "All Call"**

When using ALL CALL Channel (1) repeat message 3 times with short pauses between each repeat of message Keep radio keyed during CALL ALL

SUPPLEMENTARY DOCUMENT 4

CMR Excavation Approval Form

Attachment 1- Excavation Approval Form

Excavation Company Performing Work:	Requestor Name:	
Excavation Project Leader:	Competent Person for Excavation:	
Purpose, Details, and Schedule for Excavation Project (attach additional pages as needed):		
Locations Authorized (if partial approval, state reasoning and stipulations):		
Special Soil Handling Required? Yes or No (include details below and attach supplemental information):		
Special Safety Requirements? Yes or No (include details below and attach supplemental information):		
Authorized Work Dates:		
Calumet Montana Refining, LLC (CMR) Authorizations for Excavation Project		
Environmental	Name:	Signature/Date:
Maintenance Electrical and Piping/Sewer/Firewater	Name(s):	Signature(s)/Date(s):
Engineering	Name:	Signature/Date:
Safety	Name:	Signature/Date:
Requestor Signature: *You must review all supplemental information and requirements before signing. Signing below indicates that you understand and will ensure your project team abides by the stipulations prescribed by CMR representatives above.*		
Company:	Name of Requestor:	Signature/Date:

KEEP A COPY *of this Excavation Approval Form and all the supplemental information including a copy of the Montana 811 ticket at the jobsite while conducting excavation.*

INCLUDE A MAP *showing each excavation location with dimensions.*

GIVE A COPY *of the map to the work area zone operations center for posting*

ATTACH A COPY *of the map to the work permit and turn the map in with the finalized work permit at the end of each shift.*

Excavation Project Leader Closure Certification:

Signed at completion of excavation project and turned in with final work permit

Department:	Name:	Signature/Date:

SUPPLEMENTARY DOCUMENT 5
CMR Waste Labeling Procedures

WASTE LABELING PROCEDURE

CALUMET MONTANA REFINING, GREAT FALLS, MT

PURPOSE **1**

APPLICATION **1**

OVERVIEW **1**

REFERENCES **2**

RESPONSIBILITIES **2**

SIMPLIFIED WASTE CONTAINER AND STORAGE AREA REQUIREMENTS **3**

01 SIMPLIFIED GUIDANCE FOR WASTE CONTAINER MANAGEMENT 3

02 SIMPLIFIED GUIDANCE WASTE STORAGE AREA MANAGEMENT 4

WASTE LABELING PROCEDURE **4**

WASTE LABELING REQUIREMENTS 5

LIST OF ATTACHMENTS

ATTACHMENT 1 – DEFINITIONS

ATTACHMENT 2 – APPROVED WASTE LABELS AND INSTRUCTIONS FOR USE

ATTACHMENT 3 – WASTE MANAGEMENT DECISION DIAGRAM

PURPOSE

The purpose of this procedure is to describe the Calumet Montana Refining, LLC (CMR) policy for labeling waste (non-hazardous, hazardous, universal, used oil, solvents/wipes, etc.) during storage and disposal; as defined in the Attachment 1 - Definitions. This procedure ensures that the CMR complies with the Montana AMR Chapter 50 and Federal 40 CFR 172 and 262.30.

APPLICATION

This procedure applies to CMR employees and contract employees and provides guidance for properly labeling waste for storage and off-site disposal.

OVERVIEW

The intention of this procedure is to provide a guidance for labeling waste generated and stored at CMR. Every waste container requires a completed Waste Label (Attachment 2). The Waste Management Decision Diagram included in Attachment 3 is a visual tool that shows each label required for a wide variety of potential waste streams generated at CMR.

REFERENCES

Montana Department of Environmental Quality (MDEQ)

- Administrative Rules of Montana (ARM) Chapter 50 – Solid Waste Management

US Environmental Protection Agency (EPA)

- 40 CFR 172 Subpart E, DOT requirements
- 40 CFR 262.30

Department of Labor, Occupational Health and Safety Administration (OSHA), 29 CFR 1910 Occupational Safety and Health Standards

- 1910.1200 Hazard Communication

National Fire Protection Association (NFPA)

- NFPA 704, Standard for Chemical Hazard Labels

Calumet Montana Refining Procedures

- Aerosol Cans
- CMR Waste Management Program
- Empty Container Management
- Hazardous Waste Satellite Accumulation Area
- Liquid Hazardous and Nonhazardous Waste
- Metal, Asphalt and Concrete
- Nonhazardous Solid Waste Management
- Parts Washer Fluid
- Refrigerant
- Solvents and Solvent Wipes
- Universal Waste – Batteries, Lamps and Mercury-Containing Equipment
- Used Oil and Spent Oil Filters

RESPONSIBILITIES

1. CMR Environmental Department

   Staff signatories are responsible for the following:

   - Ensure all personnel follow the requirements of this procedure and provide clarification as needed.
   - Make waste determinations using pertinent information and provide direction for labeling to refinery staff and/or refinery contractors according to waste determination.
   - Provide guidance and best management practices to refinery staff and refinery contractors to ensure proper waste management in accordance with CMR procedures and state and federal regulations.

2. Shift Supervisors, Operations Supervisors, and Zone Operators

   Shift Supervisors, Operations Supervisors, and Zone Operators are responsible for the following:

   - Review and understand this procedure and ensure all personnel follow the requirements of this procedure.
   - Communicate with CMR Environmental Department prior to generating waste, if possible.
   - Ask the Environmental Department for additional waste management guidance such as details regarding proper waste labeling and storage, as needed.
   - When requested, provide CMR Environmental Department with details regarding the waste generation process such as chemicals and products added during the process of generating the waste.

3. CMR Employees and CMR Contractors

   CMR Employees and CMR Contractors are responsible for the following:

   - Review and understand this procedure.
   - Communicate with CMR Environmental Department prior to generating waste, if possible.
   - Ask the Environmental Department for additional waste management guidance such as details regarding proper waste labeling and storage, as needed.
   - When requested, provide CMR Environmental Department with details regarding the waste generation process such as chemicals and products added during the process of generating the waste.

SIMPLIFIED WASTE CONTAINER AND STORAGE AREA REQUIREMENTS

This document details the proper labeling of waste generated at the CMR facility. Waste is considered as any substance - liquid, solid, semi-solid, or gaseous - that is no longer of use. EPA and MDEQ regulate the generation, storage and disposal of industrial waste under the Resource Conservation and Recovery Act (RCRA) to protect individuals and the environment.

To provide context for waste labeling, the following subsections provide a simplified overview of requirements for waste containers, and waste storage areas. Please refer to the Hazardous Waste Satellite Accumulation Area procedure and CMR Waste Management Program document for a complete description of requirements and specific guidance.

01 SIMPLIFIED GUIDANCE FOR WASTE CONTAINERS

Containers should be labeled as soon as waste is put into them and must be kept closed when not actively adding or removing waste.

Containers holding waste shall have the following characteristics:

- Non-leaking and in good condition
  - Containers must not be cracked, broken, or chemically damaged
- Closed
  - Lids must be non-leaking, tight fitting, and completely closed when not adding or removing material.

- Compatible with waste
  - Chemical compatibility and container suitability should be considered for each waste generated.
- Department of Transportation (DOT)-certified if transport from the site is required; regardless of hazardous or nonhazardous designation
  - Container reuse is encouraged if the container is DOT-approved, in good condition, and the previous contents is not incompatible with the new waste.
- Not overfilled
  - Drums shall not exceed 600 lbs total weight.
  - Containers shall only be filled to a level that the container design specifications allow
- Do not allow wastes to comingle
  - Different wastes shall not be accumulated together or mixed in the same container; unless the CMR Environmental Department provides formal order to do so.

02 SIMPLIFIED GUIDANCE WASTE STORAGE AREAS

The designated waste storage areas shall have the following characteristics:

- Have posted signage in accordance with current state and federal waste regulations.
- Allow for incompatible waste to be stored separately.
  - e.g. Ignitable shall not be stored next to reactive wastes. Acids shall not be stored next to substances that contain chlorine such as chlorinated solvents.
- All waste containers and container labels shall be visible and accessible for inspection and in case of emergency.
- All containers and storage areas must be kept clean and orderly.
- Hazardous waste can ONLY be stored in two areas: Satellite Accumulation Area (SAA), or the 90-day Central Storage Area (90-day Pad).

WASTE LABELING PROCEDURE

1. A label shall be applied to every waste container at the point of generation.
2. The proper label shall be selected by the CMR Environmental Department based on the waste determination.[1]
3. Only approved waste labels shown in Attachment 2 shall be used. Detailed guidance for how to use the approved waste labels is provided in Attachment 2.
4. General visual guidance for waste label selection is provided in Attachment 3.
5. Basic labeling tips are provided in the following flow chart.

[1] The term "waste designation" is defined in Attachment 1 – Definitions.

WASTE LABELING REQUIREMENTS

Each waste/ waste conatiner requires labeling.

- See the Approved Waste Labels and Instructions For Use in Attachment 2.
- See the Waste Management Decision Diagram included in Attachment 3.

Obtain the proper label.

- Contact the CMR Environmental Department for guidance regarding label selection.
- Only approved labels are acceptable for use.

Labeling is required as soon as waste is placed into a container (at the point of generation).

- If containers are found without labels, immediately notify the CMR Environmental Department and include the location, container type, and markings, and a photo if possible.

For hazardous waste stored at waste storage areas:

- At a Satellite Accumulation Area: once a hazardous waste container is full, the waste container must be moved to the 90-day pad and the date must be added to the label.
- At the 90-day Pad: all waste containers shall have a label appropriate for the contents and include the required information.

Reused waste containers must have all other labels defaced as part of the cleaning process to avoid identity confusion.

- "Empty" labels can be used after a container is emptied and cleaned.
- If a container holds only the original contents, the hazardous waste label should be placed so that the original label is not covered, if feasible.

Attachment 1- Definitions

90-day pad:
Central accumulation storage area for full containers of hazardous waste or containers awaiting transport from the site. The containers must be transported for offsite disposal within 90-days.

Aerosols:
Aerosol cans containing paint, lubricants, glues, pesticides are considered hazardous waste. Empty cans are excluded from regulation as hazardous waste.

Construction and Demolition Waste:
Waste building materials, packaging, and rubble resulting from construction, remodeling, repair and demolition operations on pavements, houses, commercial buildings, and other structures, once municipal, household, commercial and industrial waste have been removed.

Contaminated Soil:
Waste soil, rocks, dirt, or earth that has been made impure by contact, commingling, or consolidation with organic compounds such as petroleum hydrocarbons.

Electronic Waste:
Electronic waste, or e-waste, describes electrical or electronic devices. Used electronics that are destined for refurbishment, reuse, resale, salvage recycling through material recovery or disposal are also considered e-waste.

Empty Container(s):
The hazardous waste container is empty if:

All waste has been removed that can be removed by pouring, pumping or by suction; and,

No more than 1 inch of residue remains on the bottom or 3% by weight of total capacity.

Generation:
The act or process of producing waste materials. Generation also pertains to the time when a product or material is deemed no longer useful or unusable and is then considered as waste.

Hydrocarbon Stained Soil:
Soil contaminated with petroleum products or by-products and characterized as RCRA nonhazardous. Soil is NOT considered hydrocarbon stained soil if it is impacted by listed waste or removed from a designated solid waste management unit (SWMU) that is associated with listed waste (i.e former land treatment unit SWMU 34). Every batch of waste soil must be sampled and analyzed for RCRA hazardous waste constituents and applicable characteristics. If the analytical results are below the Maximum Concentration of Contaminants for the Toxicity Characteristic and do not possess hazardous characteristics, the soil can be classified as hydrocarbon stained soil.

Liquid Waste:
Any waste material that is determined to contain free liquid (water, oil, etc.) as defined by Method 9095 (Paint Filter Liquids Test).

Polychlorinated Biphenyls (PCB) Wastes:
Polychlorinated Biphenyls (PCB) wastes are materials made with polychlorinated biphenyls items subject to

regulation under 40 CFR Part 761. Historically, PCBs were commonly used in electrical equipment such as capacitors and transformers and can still be found in older equipment that has yet to be updated.

Qualified Individual:
A person representing the contracting company or refinery department performing the excavation work whom shall review the Excavation Approval Form documents and sign the Excavation Approval Form ensuring that they understand and will ensure their project team abides by any and all stipulations prescribed by the four CMR departments.

Regulated Hazardous Waste:
Solid waste that is a hazardous waste, as defined in 40 CFR 261.3.

Satellite Accumulation Area (SAA):
Area at or near point of waste generation where hazardous waste initially accumulates and that is under the control of the operator of the process generating the waste. Once the volume of an SSA reaches the maximum allowable volume of 55 gallons of hazardous waste or 1 pound of acutely hazardous waste, the waste must be dated and moved to the 90-day pad within 3 days.

Solvent wipes and oil rags:
Solvents wipes and oil rags used to cleanup oil-contaminated and/or solvent-contaminated material and/or spills. Oil and solvent contaminated wipes and rags are managed together at CMR to avoid any potential confusion regarding if a rag was contaminated with oil or solvent, or both oil and solvent.

Universal Waste:
Universal waste includes batteries, lamps, light bulbs, light tubes, and mercury-containing equipment.

Used Antifreeze:
Spent antifreeze is regulated as a hazardous waste because it may contain ethylene glycol, lead or other hazardous chemicals. Recycled antifreeze is not considered as hazardous waste. Used refrigerant from refinery cooling units is managed by CMR's cooling unit maintenance contractor.

Used Oil:
Any petroleum or synthetic oil that has been used and as a result is contaminated by physical or chemical properties. Used oil filters shall be managed in accordance with the CMR Used Oil and Used Oil Filters procedure. Used filters shall be hot drained and liquids captured in used oil accumulation containers. Used oil accumulated at CMR is picked up by a vendor for reuse, repurposing, and/or energy recovery.

Waste Determination

Prior to disposal of any waste, the generator must perform a waste determination. A waste determination is a decision made by a qualified individual with knowledge of federal and state waste regulations that identifies the following:

- A waste and/or waste stream as hazardous, or nonhazardous;
- Related federal or state specific waste codes that apply to the waste or waste stream;
- Handling requirements;
- Labeling requirements; and
- Other waste specifications that outline waste management requirements.

Wastes at CMR fall into numerous categories depending on the point of generation, characteristics, and physical properties. At any time if you are unsure of the waste type, contact the CMR Environmental Department.

Attachment 2- Approved Waste Labels and Instructions for Use

The following labels must be used for each type of waste:

WASTE DETERMINATION IN PROGRESS OR WHEN HAZARDS AND/OR WASTE CODES ARE NOT YET CONFIRMED

Use a "Hazardous Waste Determination In Progress" label when it is unknown whether a waste will be hazardous or nonhazardous.

For example, when CMR Environmental Department is awaiting laboratory analytical results or when material data such as SDSs are being reviewed.

Include the following information:

- A description of the material (not just "stained soil, or caustic, include details such as diesel stained soil from xx tank dike, or NaHS stained soil from the east truck rack).
- Accumulation start date (the day the container was placed at the 90-day pad.

Use a "Hazardous Waste" label when CMR Environmental Department indicates that the waste will be hazardous due to a RCRA listing or other reason but is waiting for laboratory reuslts or waste profiling.

For example, waste from the Waste Water Treatment Plant can be RCRA F037, F038, K048, and/or K050 listed waste.

Include the following information:

- Accumulation start date;
- Description of the contents; and
- Associated hazard indication on the top of the label (i.e. ignitable, toxic, corrosive, or reactive).

If you need guidance on which hazards apply, please reach out to the CMR Environmental Department.

EMPTY CONTAINERS

Use an "Empty" container label when an empty container previously held a chemical or waste.

Use of empty container labels can help prevent adverse chemical reactions between incompatible waste when a product container that is in good condition is reused to contain waste.

Under contents, list the material that the container previously held.

Including other information is optional.

If you are unsure if it is safe to reuse a product container such as tote, contact the CMR Environmental Department for guidance or do not reuse the container.

HAZARDOUS WASTE

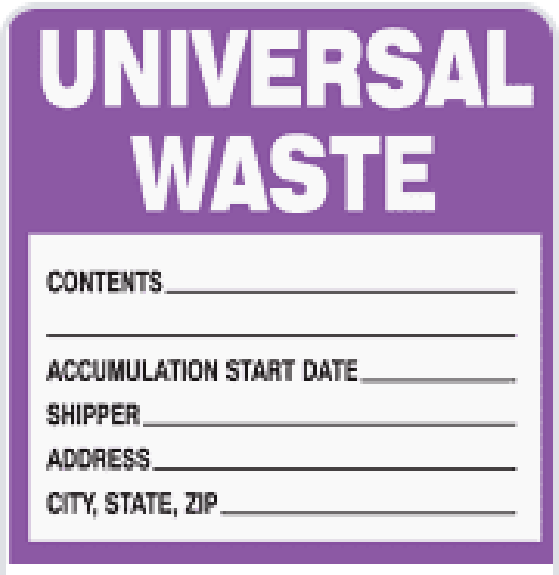
Use a "Hazardous Waste" label after the CMR Environmental Department makes a final determination that the waste is hazardous.

Include the following information:

- Accumulation start date
- Description of the contents
- Associated hazard indication on the top of the label (i.e. ignitable, toxic, corrosive, or reactive)

If you need guidance on which hazards apply, please reach out to the CMR Environmental Department.

UNIVERSAL WASTE



Use a "Universal Waste" label for spent batteries, lamps, light bulbs, light tubes, and mercury-containing equipment.

Include the following information:

- Description of contents
- Accumulation Start date (Remember the start date for universal waste is the day the first item/volume/piece of universal waste is placed in the container

Notify the CMR Environmental Department if you notice a universal waste container is nearing its 365-day time limit.

USED OIL

Used oil containers must be labeled with the words "Used Oil".

"Used Oil" labels for containers accumulating used oil are available in the CMR Environmental Department.

Used oil is recovered for reuse, repurposing, or energy recovery and is therefore not considered a hazardous waste; as long as it is not mixed with any other liquids; particularly no fuel, or antifreeze and limit water content.

See the CMR Used Oil and Spent Oil Filters Procedure for more information regarding sampling and managing used oil.

The accumulation container must be in secondary containment, container must be kept closed except when actively adding and removing material, and area must be kept clean and tidy.

USED ANTIFREEZE

Used antifreeze must be labeled with the words “Used Antifreeze”.

Note: Used antifreeze is not the same as used refrigerant. Cooling units and used refrigerant from cooling units are managed by a vendor.

Used antifreeze that is filtered and processed for reuse is not considered a hazardous waste.

Used antifreeze shall not be combined with other liquids.

Nonhazardous Waste

Use a “Nonhazarous Waste” label once a waste is determined to be nonhazardous using laboratory analytical results, SDS(s), or generator knowledge. Only a representative or person under the direction of the CMR Environmental Department shall place nonhazardous waste labels on waste containers.

A description of the contents must be included on the label. The date and sample ID number are helpful pieces of information that are optional.

Attention: No containers shall be labeled with a nonhazardous without confirming with and obtaining direct applroval from the CMR Environmental Department that the waste is nonhazradous.

If the waste is nonhazardous “hydrocarbon stained soil” then the words “to be managed as hydrocarbon stained soil” shall be written on the nonhazardous label.

SATELLITE ACCUMULATION AREAS (LABELS/ SIGNS)

All satellite accumulation areas (SAA) that accumulate hazardous waste must be marked with signage.

A MAXIMUM of 55-gallons for hazardous waste or 1 lb for acutely hazardous waste can be accumulated at a single SAA.

Note: There are no restrictions for how many SAAs are located adjacent to eachother. However, each SAA must be labeled separately to be considered separate. A segregated secondary containment for adjacent SAAs must be used for incompatabile wastes and should be considered for all adjacent SAAs, when feasible.

The SAA label can be posted in an "area" where accumulation occurs in multiple containers, or it can be place directly on a container. [2]

In addition to an SAA sign, each accumulation container shall be labeled with a hazardous waste label that includes a description of the contents, and an indication of the hazard (i.e. ignitable, toxic, corrosive, or reactive). For guidance, contact the CMR Environmental Department.

The date shall be added to the label once 55-gallons of hazardous waste or 1 lb of acutely hazardous waste has been accumulated at the SAA.

The container must be moved to the 90-day pad within 3 days of reaching the maximum allowable accumulation volume and applying the date.

[2] For a complete description of the requirements for an SAA including signage, please refer to the CMR Hazardous Waste Satellite Accumulation Area procedure.

Attachment 3- Waste Management Decision Diagram