United States Environmental Protection Agency

Optimization Review Report
Remedial Process Optimization Study

Calumet Montana Refining, LLC
Great Falls, Cascade County, Montana
EPA Region 8

OPTIMIZATION REVIEW

CALUMET MONTANA REFINING, LLC

GREAT FALLS, CASCADE COUNTY, MONTANA
EPA REGION 8

FINAL REPORT
April 8, 2020

EXECUTIVE SUMMARY

NATIONAL OPTIMIZATION STRATEGY BACKGROUND

The U.S. Environmental Protection Agency's (EPA's) definition of optimization is as follows:

> "*Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation, which may facilitate progress towards site completion. To identify these opportunities, Regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply some other approaches to identify opportunities for greater efficiency and effectiveness.*"[1]

An optimization review for a Resource Conservation and Recovery Act (RCRA) facility considers historical data, available site characterization data for current conditions, criteria for the RCRA Environmental Indicators (EI), the conceptual site model (CSM), any identified goals for the remedy, expected and possible remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within federal, state, and municipal governments. Consistent with this interest, principles of green remediation and environmental footprint reduction are now routinely considered during optimization reviews, when applicable.

This optimization review includes reviewing site documents, interviewing site stakeholders, visiting the site for one day and compiling a report that includes recommendations intended to address the following:

- Data gaps in site characterization
- Data gaps for CSM
- Data gaps for making RCRA EI determinations
- Expected and possible remedy technologies and effectiveness
- Technical improvement
- Cost reduction
- Progress to site closure
- Reuse/revitalization
- Energy and material efficiency

The recommendations are intended to help the site team identify opportunities for improvements in these areas. Analysis of recommendations, beyond that provided in this report, may be needed prior to implementation. All recommendations are based on an independent review and represent the opinions of the optimization review team. The recommendations are not requirements; they are provided for consideration by the EPA Region and other site stakeholders. Also, note that while the recommendations provide some details, they do not replace other, more comprehensive, planning documents such as work plans, sampling plans, and Quality Assurance Project Plans (QAPPs).

[1] EPA, 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

The national optimization strategy includes a system for tracking the outcome of the recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA Office of Land and Emergency Management (OLEM; the Office of Superfund Remediation and Technology Innovation [OSRTI] and Office of Resource Conservation and Recovery [ORCR]).

SITE-SPECIFIC BACKGROUND

The Calumet Montana Refining, LLC (CMR) site is located in Great Falls, Cascade County, Montana within EPA Region 8, and is situated adjacent to the north bank of the Missouri River. The Site is an active petroleum refinery consisting of approximately 87 acres.

A RCRA Facility Assessment (RFA) was completed in 1988 and a Final Description of Current Conditions Report (CCR) was completed in 1998. A draft Remedial Facility Investigation (RFI) report was completed in 2004. Montana Department of Environmental Quality (MDEQ or DEQ) issued a Corrective Action Order on Consent (Order) in 2012 based on previous investigations. A draft RFI work plan was submitted in 2015 to comply with the 2012 Order.

The 2015 draft RFI work plan has not been approved, and stakeholders are currently considering the relative merits of modifying the 2015 submittal or completely replacing the submittal with a new RFI work plan. A complete replacement is being considered, in part, due to releases discovered since 2015, as well as the modified interpretation of geologic and hydrogeologic framework resulting from use of sonic drilling at the Site for the first time during a 2019 investigation in the rail rack areas that resulted in potentially important changes to the CSM. A two-year groundwater monitoring program was implemented in 2019 to provide an improved data set for completing the RFI.

There is no "selected remedy" because the Site is in the investigation phase. A number of interim measures (IMs) have been conducted or initiated during the ongoing RFI period. Since 2015 these IMs have included (but not been limited to) extensive investigation and targeted remediation at the West Rail Rack and East Rail Rack on the main part of the refinery, and at the Truck Loading Area (AOC#16) on the other side (i.e., to the east of) 10th Street NE.

Goals of the optimization review include the following:

- Evaluate the groundwater monitoring system and historical data to determine whether hydrogeology and contamination has been adequately characterized.

- Review the CSM regarding geology, hydrogeology, groundwater flow patterns, contaminant transport, and potential for future migration.

- Evaluate if RCRA Environmental Indicator (EIs) CA 725 (human exposure under control) and CA 750 (migration of groundwater under control) can be met now with an answer[2] of "YE" (indicating under control), and if not, what actions would be recommended to do so.

- Provide general recommendations for groundwater remedies potentially applicable to the Site.

An overarching goal of the optimization review is to help make progress towards RCRA 2020 goals.

[2] The three possible answers for the EI forms are: "YE" indicating under control; "NO" indicating not under control; and "IN" indicating that more information is needed to make a determination.

SUMMARY OF CONCEPTUAL SITE MODEL AND KEY FINDINGS

Source of Contamination and Constituents of Concern

Releases of product at various locations throughout the Site during its operational history are a cause of contamination. There is no explicit list of constituents of concern (COCs) in the quarterly groundwater sampling plan. Quarterly groundwater sampling is currently being conducted at monitoring wells Site-wide with analysis for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), volatile petroleum hydrocarbons (VPHs), extractable petroleum hydrocarbons (EPHs), and metals. The presence of 1,2-dichloroethane (1,2-DCA), which was used as a lead scavenger when gasoline was leaded, indicates that at least some of the groundwater impacts are due to older releases. Releases occurred in 2017 in the West Rail Rack Area and East Rail Rack Area due to unsealed joints in pans that had been recently installed.

Geology and Hydrogeology

Prior to the Rail Investigation Area Interim Measure (RIAIM) field investigation (CMR 2019i) the geology beneath the CMR facility was conceptualized as two primary stratigraphic units, with unconsolidated Pleistocene fluvial and lacustrine deposits (partially replaced by fill over much of the refinery) overlying bedrock. This geologic conceptualization assumed that refusal during direct push, hollow stem auger, and air rotary drilling techniques indicated “top of bedrock”.

During the RIAIM field investigations sonic drilling technology was employed for the first time. The sonic drilling in the rail rack areas indicated that the previously interpreted top of bedrock was, in fact, the top a well lithified dusky red silt and clay unit. The stratigraphic framework was updated for the rail rack areas and includes the following layers with increasing depth from ground surface:

- Approximately 10 ft of fill and/or naturally occurring gravels, sands, silts and clays;
- Weakly to well laminated dusky red silt/clay to depths between 15 and 20 ft below ground surface (bgs); and
- Hard and well laminated silts and clays (i.e., residuum rather than bedrock) interbedded with fine to very fine sand lenses.

This updated CSM differentiates between shallow and deep aquifer zones, separated by the dusky red clay/silt. The dusky red silt/clay is presumably located at greater depth below ground surface to the north where topography is higher. One area where recent drilling did not encounter the dusky red silt and clay was at MW-99, located south of the CMR facility, on the west side of the 10th Street Bridge abutment. At this location the dusky red silt/clay had apparently been dug out as part of previous construction efforts. In reports evaluated for this optimization review, there were some inconsistencies for wells classified as shallow versus deep, and such reclassification had not yet been attempted for all wells.

Potentiometric surface maps illustrate a continuous groundwater table where groundwater flows generally from the north to the south, toward the Missouri River. Sitewide groundwater sampling conducted since January 2019 and during the RIAIM identified some shallow and deep borings and monitoring wells where groundwater was either not detected (dry) or of insufficient volume to collect a groundwater sample. Based on these monitoring results it was posited in recent Site documents that groundwater in both the shallow and deep horizons is discontinuous and predominantly present in relatively permeable lenses above and below the dusky red silt/clay. The optimization review team acknowledges that groundwater monitoring conducted since 2019 confirms dry areas of the shallow and deep horizons, but believes such areas are isolated and inconsistently dry, and that groundwater conditions generally allow for horizontal contaminant transport.

The optimization team estimates that the elevation of the top of the dusky red silt/clay is approximately 10 to 15 ft higher than the river elevation. Therefore, for groundwater to discharge to the river, it would either need to discharge to ground surface on the slope near the river bank as a seep, or it would need to migrate down through the dusky red silt/clay to the deeper aquifer zone which is expected to be hydraulically connected to the river. Given the low permeability of the dusky red silt/clay, vertical seepage into the deep aquifer is likely to be a smaller component of shallow groundwater outflow than the horizontal discharge of shallow groundwater above the dusky red silt/clay as seeps along the steep ground surface adjacent to the Missouri River. Based on calculations performed by the optimization team, total outflow of shallow groundwater outflow at the Site is approximately 2 times the flow of a garden hose and distributed along a potentially large seepage face, which is unlikely to be readily detected.

<u>Contaminant Distribution and Contaminant Fate and Transport</u>

Light non-aqueous phase liquid (LNAPL) is currently recovered in four general areas of the Site: AOC #16; East Rail Rack Area; West Rail Rack Area, and another area referred to as the "Storm Sewer Area". There are some other well locations where sheens are sometimes observed, in some cases outside the four areas discussed above. In general, there have been multiple product releases over time, and it should be expected that LNAPL may be present in additional subsurface locations where there is no monitoring.

Benzene serves as a good indicator for dissolved groundwater impacts because it is relatively mobile, and the extent of other constituents is generally more limited relative to the benzene impacts. Observations based on benzene distribution include the following:

- Benzene concentrations in groundwater are relatively lower in the West Rail Rack Area (typically less than 50 micrograms per liter [µg/L] except at MW-74 where concentrations were observed up to 200 µg/L) compared to the East Rail Rack, AOC #16, and Storm Sewer areas where benzene concentrations exceeding 1,000 µg/L are observed.

- In the East Rail Rack Area, the impacted wells closest to the Missouri River (MW-97 and MW-91) appear to be screened within and below the dusky red silt/clay, and it is not clear if these groundwater impacts are due to horizontal flow in the shallow aquifer zone followed by downward vertical migration near these off-Site wells, or if these wells became impacted due to downward vertical migration on-Site followed by horizontal migration in the deeper zone.

- There are wells further upgradient in the East Rail Rack Area where substantial benzene concentrations are detected in deep wells entirely screened below the dusky red silt/clay (e.g., EB-10D, MW-79D). These observations collectively suggest potential for downward flow and contaminant transport into and through the dusky red silt/clay, and potential for horizontal contaminant migration within the deeper aquifer zone towards the Missouri River. Any such migration in the deeper aquifer is likely to be slow based on low hydraulic conductivity values.

- In the West Rail Rack Area, although temporary wells extended into the deep aquifer zone did not identify dissolved groundwater impacts, there do not appear are no permanent wells screened in that deeper zone for long-term monitoring south (downgradient) of the West Rail Rack.

- In AOC #16, MW-41 had a benzene concentration of 2,100 µg/L in Q2 2019. MW-41 is screened above, within, and below the dusky red silt/clay. It is possible that this well may act as a conduit for downward benzene transport. There are detections of benzene above DEQ standards at well MW-62 located downgradient of MW-41 (e.g., 12 µg/L at MW-62 in August 2019). Well MW-62 appears to be screened within and below the dusky red silt/clay based on review of well logs by the optimization team.

Benzene readily attenuates under aerobic conditions, and it is possible that benzene concentrations could substantially attenuate if aerobic conditions are present between the impacted wells and the Missouri River in the deeper aquifer zone.

Potential Human and Ecological Exposure Pathways

The facility is expected to remain a refinery for the foreseeable future. CMR indicated they are in the process of developing a soil management plan that addresses excavation protocols and training requirements to mitigate potential human exposure to contaminants from these activities. There do not appear to be potential drinking water receptors.

Discharge of impacted groundwater and/or stormwater to the Missouri River is a potential concern from a regulatory standpoint. From a human exposure standpoint, it is highly unlikely that contaminants such as benzene would be detected in the Missouri River, given the very low groundwater flux of impacted groundwater to such a large river. However, MDEQ indicated during the optimization review Site visit (and reconfirmed after the meeting) that MDEQ does not allow for a mixing zone for groundwater into surface water in the context of RCRA corrective action, such that groundwater water must meet DEQ-7 groundwater standards before discharging to surface water.

The office building on the northeast part of the main portion of the refinery is close to monitoring wells impacted by benzene and locations where LNAPL has been observed. There are refinery operations areas located just west of the office building but no groundwater monitoring locations in that vicinity. As such, it seems prudent to assume there could be VI issues in this office building, unless a lack of a completed exposure pathway can otherwise be demonstrated based on engineering factors and considerations.

Status of EI 725 and EI 750

A number of IMs have been implemented, with corresponding improvements to environmental conditions. However, the optimization team believes that the current answer should be "NO" for CA 725 (Current Human Exposures Under Control) and "NO" for CA 750 (Migration of Contaminated Groundwater Under Control) because one or more issues suggests an answer of "NO" for each EI. The recommendations, if implemented, should provide the information to support "YE" answers for CA 725 and CA 750.

RECOMMENDATIONS

Based on a review of Site documents and data, the following recommendations are provided:

- It is recommended that the Site team review boring logs and recharacterize wells according to the hydrogeologic zones that they screen: "shallow" = screened above the dusky red silt/clay; "intermediate" = screened across the dusky red silt/clay; "deep" = screened beneath the dusky red silt/clay. The Site team indicates this work is underway. It is further recommended to develop geologic cross-sections along transects throughout the Site at a vertical scale that allows elevations to be adequately discerned. Such cross-sectional figures would illustrate geologic contacts (e.g. the top and bottom of the dusky red silt/clay), ground surface elevations, screen elevations, groundwater elevations, concentrations of COCs, and the stage of the Missouri River. Geologic cross-sections that include this information will be helpful in validating and/or revising the CSM of groundwater flow and contaminant transport.

- Given the relatively high potential for VI impacts at the office building in the northeast part of the main portion of the refinery, it is recommended that VI mitigation measures be implemented assuming none are currently in place, unless a lack of a completed exposure pathway can otherwise be demonstrated based on engineering factors and considerations.

- It is recommended that MW-41 be abandoned. If benzene concentrations decline at MW-62 after MW-41 is abandoned, then it is likely that the long well screen at MW-41 was the primary cause of deep impacts in that area.

- In the West Rail Rack Area, the lack of a permanent monitoring well in the deep aquifer zone between the recovery trenches and the Missouri River precludes the confirmation that impacted groundwater is not migrating towards the Missouri River in this area. Installation of a permanent deep monitoring well is recommended, screened above the river elevation, approximately 50 ft downgradient of the recovery trench on the municipal WWTP property.

- Upon completion of the two years of quarterly sampling, it is recommended that analytical results be reviewed to determine if future samples need to be analyzed for the current set of 13 metals, with a potential reduction to a smaller group of metals.

- The optimization review team recommends developing a new RFI work plan rather than revising the 2015 draft given the releases discovered since 2015, the extensive amount of new information collected since 2015, the IMs implemented since 2015, and the revised understanding of Site stratigraphy.

- With respect to IMs and remedy approach:

    - LNAPL removal efforts appear to be relatively successful, and it is recommended that these efforts continue.

    - It is recommended that an informal feasibility and cost evaluation be performed for active remedial measures near MW-91 and MW-97, where there appears to be potential for impacted groundwater in the deep aquifer zone to migrate to the Missouri River.

    - If abandoning MW-41 does not eliminate deep aquifer zone concerns in that location, additional remediation for the deep aquifer zone in that area may be appropriate (i.e., (above and beyond the planned shallow remedial activities). In that case (which is not assumed herein), the feasibility and cost evaluation recommended above for the area near MW-97 could be extended to also include deep aquifer remediation in the area near MW-41.

CONTENTS

EXECUTIVE SUMMARY iii
CONTENTS ix
NOTICE AND DISCLAIMER xi
PREFACE xii
LIST OF ACRONYMS AND ABBREVIATIONS xiii
1.0 OBJECTIVES OF THE OPTIMIZATION REVIEW 1
2.0 OPTIMIZATION REVIEW TEAM 2
3.0 SITE BACKGROUND 3
3.1 Site Location and Description 3
3.2 Remedial Action Objectives 8
3.3 Selected Remedy 8
4.0 FINDINGS 9
4.1 Primary and Secondary Sources of Contamination 9
4.2 Constituents of Concern 10
4.3 Topography, Geology, and Stratigraphy 12
4.4 Hydrogeology 14
4.4.1 Groundwater Levels and Hydraulic Gradients 14
4.4.2 Horizontal Hydraulic Conductivity 15
4.4.3 Horizontal Groundwater Flow Velocity 15
4.4.4 Groundwater Flow Balance 16
4.5 Contaminant Distribution and Contaminant Fate and Transport 17
4.6 Remedial System Performance 20
4.7 Potential Human and Ecological Exposure Pathways 21
4.8 Institutional Controls 22
4.9 Groundwater Monitoring 22
4.10 Approximate Annual Costs 23
4.11 Summary of Key Data Gaps or Uncertainties 23
4.12 Summary of Issues Regarding RCRA EIs CA725 and CA750 24
5.0 RECOMMENDATIONS 26
5.1 Review and Expand Revised Geologic Model Site-Wide 26
5.2 VI Mitigation at Office Building West of 10th Street NE 27
5.3 Abandon MW-41 and Add A Deep Monitoring Well in the Same General Area 27
5.4 Add Deep Monitoring Well South of West Rail Rack Recovery Trench 27
5.5 Eliminate Some Metals from Ongoing Monitoring 28

5.6 Develop a New RFI Work Plan 28
5.7 Recommendations regarding remedy Approach 28
5.8 Recommendations regarding CA 725 and CA 750 29

TABLES

Table 1. Optimization Review Team
Table 2. Other Optimization Review Contributors
Table 3. Brief Summary of Site Chronology
Table 4. Sources and Releases in Focus Areas of Optimization Review
Table 5. Contaminants of Concern and Groundwater Standards
Table 6. LNAPL Collection (gallons) March 2018 to October 2019
Table 7. Summary of Recommendations

FIGURES

Figures from Site Document are Included in Appendix B to Appendix F

APPENDICES

Appendix A: References
Appendix B: Figures from *Rail Investigation Area Interim Measure Field Investigation Report* (CMR 2019i)
Appendix C: Figures of Current Wells from *October 2019 Monthly Interim Measures Report* (CMR-Monthly [November 15] 2019)
Appendix D: Select Figures from *AOC-16 Interim Measures Evaluation Report* (CMR 2019e)
Appendix E: Figures from *Storm Sewer Release Investigation and Interim Measures Report* (TriHydro 2017b)
Appendix F: Select Figures from *2nd Quarter 2019 Groundwater Sampling Summary Report* (CMR 2019g)
Appendix G: Discussion of Comments from CMR That Were Not Implemented

NOTICE AND DISCLAIMER

Work described herein, including preparation of this report, was performed by HydroGeoLogic, Inc. (HGL) for the U.S. Environmental Protection Agency (EPA) under Task Order 0066 of EPA contract EP-S7-05-05 with HGL. The report was approved for release as an EPA document, following the Agency's administrative and expert review process.

This optimization review is an independent study funded by EPA that evaluates existing data, discusses the conceptual site model (CSM), and provides recommendations to optimize the current remedial response and associated Site characterization and monitoring, reduce cost, and make progress toward Site remedy, reuse and closure at the Calumet Montana Refining, LLC (CMR) site. Detailed consideration of EPA policy was not part of the scope of work for this review. This report does not impose legally binding requirements, confer legal rights, impose legal obligations, implement any statutory or regulatory provisions, or change or substitute for any statutory or regulatory provisions. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by EPA.

Recommendations are based on an independent evaluation of existing Site information, represent the technical views of the optimization review team, and are intended to help the Site team identify opportunities for improvements in the current remediation strategy and operation and maintenance plan. These recommendations do not constitute requirements for future action; rather, they are provided for consideration by the EPA Region and other Site stakeholders.

While certain recommendations may provide specific details to consider during implementation, these are not meant to supersede other, more comprehensive planning documents such as work plans, sampling plans and Quality Assurance Project Plans (QAPPs), nor are they intended to override or prevent DEQ directions based on Corrective Action Order on Consent #MHWCAO-12-01. Further analysis of recommendations, including review of EPA policy, may be needed before implementation.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization practices to include RCRA facilities from site assessment to site completion as implemented under the oversight by the U.S. Environmental Protection Agency Office of Resource Conservation and Recovery and Office of Land and Emergency Management (OLEM) (formerly Office of Solid Waste and Emergency Response [OSWER])[3]. The project contacts are as follows:

ORGANIZATION	CONTACT	CONTACT INFORMATION
EPA OLEM	Kirby Biggs	EPA OLEM Technology Innovation and Field Services Division 2777 Crystal Drive Arlington, VA 22202 biggs.kirby@epa.gov Telephone: 703-823-3081
HydroGeoLogic, Inc. (Contractor to EPA)	Doug Sutton Mindy Vanderford Rob Greenwald	HydroGeoLogic, Inc. dsutton@hgl.com mvanderford@hgl.com rgreenwald@hgl.com

[3] EPA, 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

LIST OF ACRONYMS AND ABBREVIATIONS

μg/L	micrograms per liter
amsl	above mean sea level
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
AS	air sparging
AS/SVE	air sparging/soil vapor extraction
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylene
C5, C6, etc.	number of carbon atoms
CA 725	RCRA Corrective Action EI for "Current Human Exposures Under Control"
CA750	RCRA Corrective Action EI for "Migration of Contaminated Groundwater Under Control"
CCR	Current Conditions Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMR	Calumet Montana Refining, LLC
COC	contaminant of concern
CSM	conceptual site model
1,2-DCA	1,2-dichloroethane
DEQ	Montana Department of Environmental Quality
DEQ-7	Circular DEQ-7, Montana Numeric Water Quality Standards
EI	Environmental Indicator
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
FS	Feasibility Study
ft	feet
ft/d	feet per day
ft^3/d	cubic feet per day
ft/ft	feet per foot
ft/yr	feet per year
gal	gallons
gpd	gallons per day
gpm	gallons per minute
HGL	HydroGeoLogic, Inc.
HQ	EPA Headquarters
i	gradient
IC	institutional control
IM	interim measure
K	hydraulic conductivity
LCA	Lead Consolidated Area
LIF	Laser-Induced Fluorescence
LNAPL	light non-aqueous phase liquid
MDEQ	Montana Department of Environmental Quality
MTBE	methyl tert-butyl ether
n	porosity

NFA	No Further Action
O&M	operation and maintenance
OLEM	Office of Land and Emergency Management
ORCR	Office of Resource Conservation and Recovery
Order	Corrective Action Order on Consent issued by MDEQ in 2012
OSWER	Office of Solid Waste and Emergency Response
Q2 2019	second quarter 2019
Q3 2019	third quarter 2019
PCP	Pentachlorophenol
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RIAIM	Rail Investigation Area Interim Measure
RPM	Remedial Project Manager
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
UVOST	Ultraviolet Optical Screening Tool
v	velocity
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons
WWTP	wastewater treatment plant

1.0 OBJECTIVES OF THE OPTIMIZATION REVIEW

For more than a decade, the Office of Land and Emergency Management (OLEM) has provided technical support to the U.S. Environmental Protection Agency (EPA) regional offices by using independent (third party) optimization reviews, typically (but not always) at Superfund sites. The Office of Resource Conservation and Recovery (ORCR) has contracted with the Superfund program's optimization expertise to help advance the progress of Resource Conservation and Recovery Act (RCRA) facilities identified as having complex technical 'barriers' to cleanup progress. The Calumet Montana Refining, LLC (CMR) site (EPA ID# MTD000475194) ("the Site") is managed under the RCRA framework and was nominated for an optimization review by the EPA Region 8 RCRA program managers and Optimization Coordinators. The focus of this optimization review is to: 1) evaluate historical data; 2) provide recommendations to optimize the current remedial response and associated Site characterization and monitoring; and 3) provide recommendations to facilitate progress regarding RCRA Corrective Action Environmental Indicators (EIs) for "Current Human Exposures Under Control" (CA 725) and "Migration of Contaminated Groundwater Under Control" (CA 750). An additional goal of this optimization review is to facilitate coordination of optimization efforts between RCRA and Superfund programs.

This optimization review used existing environmental data to interpret the conceptual site model (CSM), identify potential data gaps, and recommend groundwater monitoring improvements and potential site-wide remedy alternatives. The optimization review team evaluated the quality of the existing data before using the data for these purposes. The evaluation for data quality included a brief review of data collection and management methods (where practical, the Site Quality Assurance Project Plan [QAPP] is considered), the consistency of the data with other Site data, and the potential use of the data in the optimization review. Data that were of suspect quality were either not used as part of the optimization review or were used with the quality concerns noted. Where appropriate, this report provides recommendations made to improve data quality.

2.0 OPTIMIZATION REVIEW TEAM

The optimization review team, which collaborated with representatives of EPA Headquarters (HQ), EPA Region 8, and Montana Department of Environmental Quality (MDEQ) consists of the independent, third-party participants listed in Table 1.

TABLE 1. Optimization Review Team

NAME	ORGANIZATION	TELEPHONE	EMAIL
Rob Greenwald[1,2]	HydroGeoLogic, Inc.	732-239-6407	rgreenwald@hgl.com
James Ross[1]	HydroGeoLogic, Inc.	330-467-0453	jlross@hgl.com
Mindy Vanderford[2]	HydroGeoLogic, Inc.	713-865-2223	mvanderford@hgl.com

[1] Attended optimization meeting in Great Falls, Montana on October 1, 2019
[2] Participated in kickoff call on August 27, 2019

Individuals that contributed to the optimization review process, including participation in the kickoff call on August 27, 2019 and/or a meeting in Great Falls, Montana on October 1, 2019, are listed on Table 2.

TABLE 2. Other Optimization Review Contributors

NAME	ORGANIZATION	TITLE/ROLE
Kirby Biggs[2,3]	EPA HQ	Optimization Coordinator
Henry Schuver[2,3]	EPA HQ	RCRA
Mike Adam[1,3]	EPA HQ	EPA Optimization Project Lead
Tara Hubner[3]	EPA Region 8	RPM
Denise Kirkpatrick[1,3]	MDEQ	RPM
Joe Dauner[1,3]	CMR	Environmental Manager
Wayne Leiker[1]	CMR	Plant Manager
Ron Colwell[1]	CMR	Operations Manager
David Heidlauf[1,3]	Ramboll (Contractor to CMR)	Hydrogeologist
Elaine Komm-Enge[1,3]	Ramboll (Contractor to CMR)	On-Site Environmental Consultant
Dan Price[1]	Ramboll (Contractor to CMR)	Geologist

RPM = Remedial Project Manager.
Notes:
[1] Attended optimization meeting in Great Falls, Montana on October 1, 2019 in person
[2] Attended optimization meeting in Great Falls, Montana on October 1, 2019 via phone
[3] Participated in kickoff call on August 27, 2019

Documents reviewed for the optimization effort are listed in Appendix A.

3.0 SITE BACKGROUND

3.1 SITE LOCATION AND DESCRIPTION

The Site is located in Great Falls, Cascade County, Montana within EPA Region 8, and is situated adjacent to the north bank of the Missouri River (Figure 1 in Appendix B). The Site is an active petroleum refinery consisting of approximately 87 acres. The refinery produces gasoline, middle distillates, and asphalt. Industrial operations began at the Site in 1922 and have continued to the present time.

The refinery has previously operated under several corporate entities including American Refining Company, Montana Refining Company (Holly Oil Corporation), and Connacher Oil and Gas Limited of Canada. Calumet Specialty Products Partners, LP has owned the refinery since 2012 (CMR 2019i) and Calumet Montana Refining, LLC is the entity responsible for environmental investigation and remediation of the Site.

Figure 2 in Appendix B illustrates the Site location. The Site is bounded by Smelter Avenue to the north. A bridge over the Missouri River feeds into 10th Street NE which separates the refinery, with the main portion of the refinery located west of 10th Street NE, and the Truck Loading Rack located east of 10th Street NE. There a walking trail called the River's Edge Trail between the southern boundary of the refinery and the Missouri River. A municipal wastewater treatment plant (WWTP) is located south of the far western portion of the refinery, between the refinery fence and the walking trail (i.e., south and southwest of the West Rail Rack – see Figure 2 in Appendix B). East of 10th Street NE there are several features between the refinery property and the river in addition to the walking trail, including a paved county road and a right-of-way for a nonoperational railroad that is part of a Superfund site.

Other features or landmarks illustrated on Figure 2 in Appendix B include the following:

- The East Rail Rack and West Rail Rack, which are both located in the southern part of the refinery; both have been the focus of recent environmental investigation.
- The Process Area, Tank Farm, Southwest Tank Farm, and Northwest Tank Farm which are components of current refinery operations.
- An office building in the eastern part of the main portion of the refinery, just west of 10th Street NE.
- The refinery WWTP (south of the East Rail Rack).

Topography slopes gently across the refinery to the south or southwest towards the Missouri River, with a steep drop of approximately 20 feet (ft) adjacent to the river. No streams or ditches are present on the refinery property, but there is a surface water impoundment at Area of Concern (AOC) #25 just east of the Southwest Tank Farm (Figure 2 in Appendix B) that resulted from soil excavation conducted as an interim action in 2010 and 2011.

Storm water across the refinery collects in shallow depressions and evaporates, or it is captured by a combined process and storm water sewer system which discharges to the refinery WWTP. There are subsurface pipelines within the main portion of the refinery and a set of product pipelines connecting the refinery and Truck Loading Rack. Some of the subsurface pipelines are associated with refinery processes, the majority are associated with combined storm and process water, and some are more regional in nature (e.g., a Smelter Avenue stormwater pipe runs south to the Missouri River through the main portion of the refinery[4] but is not intended to address refinery stormwater).

A RCRA Facility Assessment (RFA) was completed in 1988 and a Final Description of Current Conditions Report (CCR) was completed in 1998. A draft Remedial Facility Investigation (RFI) report was completed in 2004. MDEQ issued a Corrective Action Order on Consent (Order) in 2012 based on previous investigations. The order identified a number of Solid Waste Management Units (SWMUs) and AOCs (Figure 3 in Appendix B). SWMUs are areas where solid wastes were historically placed, and AOCs are areas where a release of a hazardous waste or hazardous constituent occurred (or is suspected) which may present an unacceptable risk to human health and the environment. A draft RFI work plan (TRC 2015) was submitted in 2015 to comply with the 2012 Order. The 2015 draft RFI work plan has not been approved, and stakeholders are currently considering the relative merits of modifying the 2015 submittal or completely replacing the submittal with a new RFI work plan. A complete replacement is being considered, in part, due to releases discovered since 2015, as well as the modified interpretation of geologic and hydrogeologic framework resulting from use of sonic drilling at the Site for the first time during a 2019 investigation in the rail rack areas that resulted in potentially important changes to the CSM.

A two-year groundwater monitoring program (CMR 2017a) was implemented in 2019 to provide an improved data set for completing the RFI. The current monitoring well network is illustrated on Figure 1-1 in Appendix C for the Truck Loading Rack Area (AOC #16) and on Figure 1-2 in Appendix C for the main portion of the refinery.

A number of interim measures (IMs) have been conducted or initiated during the ongoing RFI period. These IMs have included the following:

- In response to hydrocarbon seeps identified in 1995 on the north bank of the Missouri River immediately south of the Truck Loading Rack Area (AOC #16), containment boom was placed in the river and two light non-aqueous phase liquid (LNAPL) recovery trenches were implemented (Montana Refining Company 1998) . The recovery trenches operated until 2004 when operation was terminated due to decreased recovery.

- At AOC #25, solid waste (believed to be mostly construction debris) that had been placed in a historically ponded area was removed as an IM in 2010 to 2011 (TRC 2015). A risk assessment was recently submitted for AOC #25 to assist in evaluating alternatives for additional remediation in that area.

- Contaminated soil was removed at multiple AOC/SWMU locations from 2013 to 2015 because refinery expansion at that time resulted in the removal of tanks and piping which made these areas accessible for contaminated soil excavation (CMR 2017; CMR 2019i). Soil that was hazardous for benzene and/or lead was disposed off-Site. These areas were renamed as the Lead Consolidated Area (LCA) because of lead observed in these areas. The LCA is generally coincident with the southwest quadrant of the Process Area indicated on Figure 2 in Appendix B.

[4] Smelter Avenue stormwater pipe enters the main portion of the refinery from the north near MW-85, runs south near MW-84 and MW-83, and discharges to the Missouri River between MW-71 and MW-72, see Figure 1-2 in Appendix C for locations. This storm sewer is also illustrated on Figure 1 in Appendix E.

- In 2016 an IM investigation was performed near the Truck Loading Rack Area (AOC #16), east of 10th Street NE, in response to a complaint of hydrocarbon odors in a house just to the east. The investigation determined that LNAPL in the subsurface (from historic releases) intersected a sanitary sewer line for the Black Eagle Sewer District that ran through the area, and the sewer provided a potential conduit for vapor transport (TriHydro 2016). MDEQ stated during the October 1, 2019 Site visit that the Black Eagle sanitary sewer line was rerouted further south in December 2016, the abandoned line was flow-filled, and concrete was added at the location of a manhole to prevent migration of contaminants along the outside of the sewer line. The abandoned Black Eagle sewer line is illustrated on Figure 2 in Appendix D, and LNAPL extent is suggested by the highest readings from Laser-Induced Fluorescence (LIF)/Ultraviolet Optical Screening Tool (UVOST®) illustrated on Figures 3a and 3b in Appendix D.

- In response to findings of subsurface LNAPL in the Truck Loading Rack Area identified during the 2016 AOC #16 investigation into the Black Eagle sewer line, LNAPL recovery was again initiated as an IM in the Truck Loading Rack Area. LNAPL has been actively collected at AOC #16 since 2016 via a skimmer pump at MW-53 (TriHydro 2017a), and via absorbent socks at MW-41, MW-63, and MW-64 (locations on Figure 1-1 in Appendix C) (CMR 2019e). In June 2019 CMR presented to MDEQ an evaluation of potential interim remedies to control the LNAPL source at AOC#16 and ameliorate dissolved constituent concentrations in groundwater beneath and downgradient of AOC#16. The interim remedy preferred by CMR (Figure 6 in Appendix D) includes LNAPL skimming and biosparging in the LNAPL source area, and air sparging/soil vapor extraction (AS/SVE) in the dissolved plume downgradient of the source area but upgradient of the Missouri River. This proposed IM was approved by MDEQ in June 2019[5].

- IM activities related to a "storm sewer release" were initiated after a sheen was observed on the Missouri River south of the main portion of the refinery in July 2017. The storm sewer collects stormwater from north of the refinery and runs south through the refinery to a culvert feeding a ditch that enters the Missouri River within approximately 25 ft (Figure 1 in Appendix E). The initial IM response included booms in the river, cleaning and inspecting the storm sewer, and temporarily plugging the storm sewer (routing the storm sewer flows to the refinery WWTP). An IM investigation indicated the presence of LNAPL adjacent to the storm sewer (Figure 4 in Appendix E) that apparently entered the storm sewer in the subsurface, ultimately resulting in the observed sheen at the river. Initially a temporary sump was implemented to collect total fluids (including LNAPL) from that source area, and subsequently sumps SS-Sump-N and SS-Sump-S (Figure 1-2 in Appendix C) were installed to collect LNAPL starting in early 2018, with discharge to the refinery WWTP. The storm sewer was lined in the apparent source area in late 2018 to eliminate subsurface inflow to the storm sewer in that area, and the sheen did not return after the storm sewer was returned to service. CMR indicated that, based on a follow-up in-line camera warranty inspection of the 2018 storm sewer lining work, a portion of the lined sewer was determined to be compromised because of manufacturer product defects, and accordingly a 185-foot long portion of the compromised storm sewer was relined on August 26, 2019.

- Product releases were discovered at the West Rail Rack and East Rail Rack in June 2017, resulting in IM activity. CMR indicated at the optimization review Site visit that these releases resulted from unsealed joints in pans that had been recently installed at the rail rack areas. The

[5] CMR comment #2 on the draft optimization review report (see Appendix G) discussed additional information learned during pilot testing in AOC#16. The report referenced in the CMR comments was dated January 9, 2020 and was completed after the optimization review team completed its technical evaluation; that report and associated data could not be reviewed or considered in this optimization report.

initial discovery of the release occurred after a sheen was observed on the Missouri River south of the City WWTP. The sheen was determined to result from a stormwater culvert near the boundary between CMR property and the City WWTP (CMR 2018c). Subsequently, similar types of releases (from the same cause) were discovered at the East Rail Rack[6]. Surface LNAPL seeps were present near both rail racks. The sheen was controlled with booms and stormwater was managed to avoid further sheens on the river. A series of IM investigations were performed in both loading rack areas from June 2017 through 2019 including soil borings, LIF/UVOST® to help delineate LNAPL, and installation of monitoring wells. IM activities for LNAPL recovery in these areas have included the following:

- West Rail Rack Area – An initial LNAPL recovery trench was implemented in June 2017 on City property just south of the CMR fence, with one sump. Based on additional LNAPL seeps further east, a second portion of trench was added in September 2017 with a second sump (CMR 2019i). The combined trench system is illustrated on Figure 7 in Appendix B. Final sumps with recovery pumps were added to this trench system in July 2018 (locations CSW and CSE on Figure 1-2 in Appendix C), and LNAPL recovery from those sumps has been reported since August 2018. Additionally, six potential LNAPL recovery wells (MW-73 to MW-78 – see Figure 1-2 in Attachment C) were installed in December 2017, and LNAPL recovery via pumps is actively preformed at three of those wells (MW-73, MW-75, and MW-76). Recovery socks have also been deployed at MW-74.

- East Rail Rack Area: Four potential LNAPL recovery wells were installed in December 2017 (MW-79 to MW-82 – see Figure 1-2 in Appendix C for locations) but recovery pumps were not installed due to lack of significant LNAPL accumulation (CMR 2019i). LNAPL sorbent socks have been deployed in monitoring wells MW-14R, MW-19R, MW-48, MW-70, and MW-97 (CMR 2019i).

Although a number of IMs have been implemented, with corresponding improvements to environmental conditions, the current status is “NO” for RCRA Corrective Action EIs CA725 (Current Human Exposures Under Control) and CA 750 (Migration of Contaminated Groundwater Under Control”). This is discussed in Section 4.12.

A better understanding of potential LNAPL distribution resulted from investigations performing using LIF/UVOST® at AOC-16 (2016, 2018), the East Rail Rack Area (2017), the West Rail Rack Area (2017), and the storm sewer area (2017). This was followed by installation of additional monitoring wells in those areas to further assess mobility and recoverability of LNAPL and evaluate technologies to address source control, groundwater contamination (both LNAPL and dissolved phase) and soil contamination in these areas. Monitor well installation in 2019 included a switch to sonic drilling, which resulted in new findings and potential changes to the CSM (see Section 4.3).

Site chronology is briefly summarized in Table 3.

---

[6] Other historical releases have also occurred in the vicinity of both East and West Loading Rack Areas (CMR, 2019i). However, it seems likely that the LNAPL seepage issues in 2017 were primarily the result of recent releases due to the unsealed pans.

TABLE 3. Brief Summary of Site Chronology

Date	Action
1922	Refinery begins operation as American Refining Company.
1988	RFA.
1995	Hydrocarbons observed Missouri River immediately south of the Truck Loading Rack Area (AOC #16).
1995-2004	Recovery trench downgradient from AOC #16 recovers LNAPL.
1998	CCR completed.
2000	Product observed in SWMU #15, resulting in installation of an interceptor trench.
2004	Draft RFI Report.
2010-2011	Soil removed as IM at AOC #25.
2012	CMR acquired the refinery property; Order issued by MDEQ.
2013-2015	Refinery expansion (included addition of West Rail Rack); Excavation of contaminated soil as an IM in the LCA that was accessible during refinery expansion.
2015	Draft RFI Work Plan (not yet approved).
2016	Black Eagle Sewer Line investigation at AOC #16 and IM to relocate sewer; IM for LNAPL recovery begins at AOC #16.
2016-2018	LNAPL investigation using LIF at AOC #16.
2017	LNAPL releases discovered at West and East Rail Rack Area, IM investigations using LIF commence in both areas; LNAPL recovery begins as IM in West Rail Rack Area.
2017-2018	Sheen on Missouri River discovered due to subsurface inflow to storm sewer running south through the main portion of the refinery; LNAPL recovery sumps and lining of storm sewer in that source area implemented as IMs.
2019	Rail Investigation Area IM Investigation first utilizes sonic drilling (resulting in potential updates to CSM); AOC #25 Risk Assessment; Two-year monitoring program initiated; Proposal for additional IM in AOC #16 (LNAPL skimming and biosparging in the LNAPL source area, and AS/SVE in the dissolved plume downgradient of the source area) was submitted by CMR and approved by MDEQ.
2020	AOC-16 Pilot Test Evaluation and 2019 Annual Groundwater Sampling Report (both of these reports were completed after the optimization review team completed its technical evaluation, so these reports and associated data could not be reviewed or considered in this optimization report).

Goals of the optimization review include the following:

- Evaluate the groundwater monitoring system and historical data to determine whether hydrogeology and contamination has been adequately characterized.
- Review the CSM regarding geology, hydrogeology, groundwater flow patterns, contaminant transport, and potential for future migration.
- Evaluate if RCRA EI CA 725 (human exposure under control) and CA 750 (migration of groundwater under control) can be met now with an answer[7] of “YE” (indicating under control),

[7] The three possible answers for the EI forms are: “YE” indicating under control; “NO” indicating not under control; and “IN” indicating that more information is needed to make a determination.

and if not, what actions would be recommended to do so.

- Provide general recommendations for groundwater remedies potentially applicable to the Site.

An overarching goal of the optimization review is to help make progress towards RCRA 2020 goals.

3.2 Remedial Action Objectives

There are no specific remedial action objectives (RAOs) because the Site is in the investigation phase. However, there are RAOs identified for ongoing IMs in the Rail Rack Areas and in AOC#16.

- For the Rail Rack Areas, LNAPL collection as an IM has been ongoing, and the RAO for the LNAPL collection is presumably to remove as much LNAPL as possible while investigations continue.

- For the groundwater beneath AOC #16, RAOs for the recently selected/approved IM include the following:

    - In the LNAPL source area, recover free phase LNAPL mass present in the area south of AOC-16 to stabilize the LNAPL plume;

    - Address LNAPL within the soil matrix to stabilize the dissolved phase plume; and

    - Downgradient of the LNAPL area reduce dissolved phase impacts to stabilize the dissolved phase plume (prevent offsite migration).

It is assumed the RAOs associated with a final Site remedy will generally be to prevent human exposures to contaminated media (soil, groundwater, vapors), to remove LNAPL to the extent practicable, and to prevent offsite migration of contamination to the Missouri River via groundwater as well as any other potential migration pathways to the Missouri River (e.g., via storm sewers).

3.3 Selected Remedy

There is no “selected remedy” because the Site is in the investigation phase. Interim measures were listed in Section 3.1 and are discussed further in Section 4.

4.0 FINDINGS

4.1 PRIMARY AND SECONDARY SOURCES OF CONTAMINATION

Releases of product at various locations throughout the Site during its operational history are a cause of contamination. There are multiple SWMUs and AOCs at the CMR Site that are identified in Figure 3 of Appendix B. This optimization review primarily focuses sources of contamination that impact the following portions of the Site where recent investigations have been performed and/or where ongoing IMs are being conducted:

- West Rail Rack Area
- East Rail Rack Area
- Truck Loading Rack Area (AOC #16)
- Storm Sewer Release Area
- Old Ponded Area (AOC #25)

Table 4 summarizes SWMUs and AOCs associated with these portions of the Site, as well as specific releases in each of these areas that were identified in the CCR (Montana Refining Company 1998) and the Rail Investigation Area Interim Measure (RIAIM) Investigation Report (CMR 2019i). Descriptions of relatively recent (2017) releases in the West Rail Rack Area and East Rail Rack Area, due to unsealed joints in pans that had been recently installed, were presented in Section 3.1. Table 4 only includes documented releases dating back to approximately 1992, and it is presumed that other releases may have occurred throughout the operational history of the refinery.

TABLE 4. Sources and Releases in Focus Areas of Optimization Review

Site Area	SWMUs and AOCs	Documented Releases
West Rail Rack Area	SWMU #8 – Aeration Pond (NFA) SWMU #9 – Oxidation Pond (NFA) SWMU #27 – Lead Pit SWMU #30 – Tank 112 Dump Site (NFA) AOC #26 – Contaminated Area South of Landfarm AOC #28 – Tank 48 Spill Area AOC #33 – Rail Line Expansion Area	**SWMU #9** - 2001: 1,500 gal of asphalt - 2013: 1,400 gal of gasoline **AOC #33** - 2017: Unknown quantity of unknown product
East Rail Rack Area	SWMU #1 – Diversion Pond SWMU #2 – Overflow Sump SWMU #3 – Wastewater Surge Tank SWMU #4 – API Separator SWMU #5 – Dissolved Air Floating Unit SWMU #6 – DAF Cone Bottom Tank SWMU #11 – Past Leaded Sludge Oxidation Area SWMU #20 – Refinery Sewer System AOC #10 – TEL Building AOC #12 – Staining Around Tanks 17, 52, 53, 54 AOC #13 – Stained Area East of Former EPA Well DH-1	**SWMU #1** - 1998: Unknown quantity of wastewater **SWMU #4** - 1994: 40 gal of slop oil and water - 1995: Approx 2,100 gal of waste oil - 1995: 30 gal of slop oil - 1996: 10 gal of gas oil **SWMU #5** - 1994: 1,000 gal of wastewater **SWMU #20** - 8,400 gal of gas oil and water **AOC #12** - 1992 – 4,350 gal of gasoline

Site Area	SWMUs and AOCs	Documented Releases
	AOC #17 – Asphalt and Heavy Oil Loading Rack AOC #21 – Emulsion Mill Area AOC #22 – Tank 50 Stained Area AOC #23 – Tank 115 and 117 AOC #24 – Rail Loading Area AOC #32 – Tank 48 Spill Area	- 1994 – 1,932 gal of gasoline - 1994 – 90 gal of #5 fuel oil - 1995 – 20 gal of gas oil - 1995: 6,846 gal of gasoline - 1996 – 15 gal of gasoline - 1997: 1,920 gal of gasoline - 1998: 12,600 gal of gasoline - 2000: 5,250 gal of gasoline - 2001: 5,712 gal of gasoline - 2013: unknown quantity / unknown product - 2014: 14,000 gal of caustic **AOC #24** - 1992 – 40 gal of 85/100* - 1996 – 100 gal of asphalt - 1996 – 25 to 40 gal of 85/100* - 1998 – 5 gal sodium hydrosulfide - 1998 – 400 gal of asphalt - 2017: 1,620 gal of unknown product - 2017: unknown quantity / unknown product
Truck Loading Rack Area	AOC #16 – Gasoline and Light Oil Loading Rack	- 1995: unknown quantity of petroleum - 2001: 10,000 to 20,000 gal of gasoline from underground pipe - 2003: unknown quantity / unknown product from loading lines - 2011: unknown quantity of diesel #2 from a pipe leak
Storm Sewer Release Area	No specific AOC number, but CMR identified a "new AOC" via a letter to MDEQ on August 9, 2017	LNAPL in the Missouri River was discovered in July 2017, later determined to be entering a storm sewer in the subsurface on refinery property, but specific dates and quantity of the original releases to the subsurface that ultimately entered into the storm sewer are not known
Old Ponded Area	AOC #25 – Old Ponded Area	No specific releases occurred at AOC #25, and the pond is only documented as having been backfilled by construction debris and soil

*NFA= No Further Action; gal = gallons; *Not clear "85/100" represents.*

4.2 CONSTITUENTS OF CONCERN

There is no explicit list of constituents of concern (COCs) in the quarterly groundwater sampling plan (CMR 2019a). Quarterly groundwater sampling is currently being conducted at monitoring wells Site-wide with analysis for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), volatile petroleum hydrocarbons (VPHs), extractable petroleum hydrocarbons (EPHs), and metals. Table 5 summarizes the constituents that have exceeded applicable groundwater standards at or near the SWMUs and AOCs listed in the Table 4, based on the three rounds of quarterly sampling conducted in 2019 (CMR 2019d, g, j) Groundwater standards included on Table 5 include the following:

- 2017 DEQ-7 (MDEQ 2017) groundwater standard identified in the monitoring plan;

- 2019 DEQ-7 (MDEQ 2019) groundwater standard (updated by MDEQ subsequent to the submission of the monitoring plan and first two rounds of quarterly sampling); and

- 2018 DEQ Tier 1 Risk Based Screening Level (RBSL).

Methyl tert-butyl ether (MTBE), and 1,2-dichloroethane (1,2-DCA) are historical gasoline additives. MTBE is a more recent additive, whereas 1,2-DCA was used as a lead scavenger when gasoline was leaded, so detections of 1,2-DCA in groundwater indicate that at least some of the groundwater impacts are due to older releases. Pentachlorophenol (PCP) is a wood preservative but prior to 1984 was also widely used as a biocide. The DEQ-7 groundwater standards for constituents in Table 5 did not change between 2017 and 2019.

TABLE 5. Contaminants of Concern[8] and Groundwater Standards

Category	Contaminant	2017 DEQ-7 Groundwater Quality Standard (µg/L)	2019 DEQ-7 Groundwater Quality Standard (µg/L)	2018 DEQ Tier 1 RBSL (µg/L)
VOC	Benzene	5	5	5
	1,2-DCA	4	4	
	Ethylbenzene	700	700	700
	MTBE	30	30	30
	Toluene	1,000	1,000	1,000
	Total Xylenes	10,000	10,000	10,000
SVOC	Naphthalene	100	100	100
	2-methylnaphthalene			36
	2,4-dimethylphenol	100	100	
	PCP	1	1	
VPH	C5-C8 Aliphatics			650
	C9-C12 Aliphatics			1,400
	C9-C10 Aromatics			1,100
EPH	C11-C22 Aromatics			1,100
Metals	Arsenic	10	10	
	Barium	1,000	1,000	
	Selenium	50	50	

µg/L = micrograms per liter; EPH and VPH analysis includes different ranges (for number of carbon atoms) of aliphatic and aromatic hydrocarbon compounds

Table 5 only contains contaminants that exceeded applicable groundwater standards during quarterly sampling conducted in 2019. A few additional constituents were detected above applicable standards at one or more locations during interim measures investigations (e.g., cadmium) but not during the three quarterly monitoring events, suggesting distribution of these constituents above standards in groundwater is limited.

[8] This list of COCs is specific to this optimization review and it is possible the forthcoming RFI will identify a broader list of COCs.

4.3 TOPOGRAPHY, GEOLOGY, AND STRATIGRAPHY

The topography of the Site slopes gradually from the northern Site boundary to the southern Site boundary:

- East of 10th Street NE the ground surface elevation decreases from 3,372 ft above mean sea level (ft amsl) at MW-54 in the north portion of AOC-16 to 3,337 ft amsl at MW-62 near North River Road.
- West of 10th Street NE the ground surface elevation decreases from 3,361 ft amsl at MW-85 northwest of the Northwest Tank Farm to 3,336 ft amsl at MW-98 along the southern Site property boundary (south of the refinery WWTP).

Between the southern boundary of the Site property and the Missouri River, the ground surface drops much more sharply than between the northern and southern property boundaries:

- East of 10th Street NE the ground surface elevation decreases from 3,337 ft amsl at MW-62 to 3,311 ft amsl at sandpoint well MW-43 on the bank of the Missouri River.
- West of 10th Street NE the change in topography is similar to that east of 10th Street NE (no sandpoint wells are located west of 10th Street NE).

Prior to the RIAIM field investigation (CMR 2019i) the geology beneath the CMR facility was conceptualized as two primary stratigraphic units, with unconsolidated Pleistocene fluvial and lacustrine deposits (partially replaced by fill over much of the refinery) overlying consolidated Kootenai Formation bedrock consisting of interbedded claystones and sandstones in the northern half of the refinery and shales in the southern half of the refinery. This geologic conceptualization assumed that refusal during direct push, hollow stem auger, and air rotary drilling techniques indicated “top of bedrock”.

During the most recent RIAIM field investigations sonic drilling technology was employed for the first time, in the West Rail Rack and East Rail Rack areas. The sonic drilling in the rail rack areas indicated that the previously interpreted top of bedrock was, in fact, the top a well lithified dusky red silt and clay unit. Per figure 20 in Appendix B, the stratigraphic framework has been updated for the rail rack areas and includes the following layers with increasing depth from ground surface:

- Approximately 10 ft of fill and/or naturally occurring gravels, sands, silts and clays;
- Weakly to well laminated dusky red silt/clay to depths between 15 and 20 ft below ground surface (bgs); and
- Hard and well laminated silts and clays (i.e., residuum rather than bedrock) interbedded with fine to very fine sand lenses.

In the RIAIM Investigation Report (CMR 2019i), the CSM differentiates between shallow and deep aquifer zones, separated by the dusky red clay/silt. The dusky red silt/clay is presumably located at greater depth below ground surface to the north where topography is higher. One area where recent drilling did not encounter the dusky red silt and clay was at MW-99, located south of the CMR facility, on the west side of the 10th Street Bridge abutment. At this location the dusky red silt/clay had apparently been dug out as part of previous construction efforts and replaced with backfill to a depth of nearly 20 ft bgs, below which was a cemented sand.

The optimization review team notes the following complications in reviewing the descriptions of stratigraphy and associated well depth designations in Site documents:

- Well logs from the recent investigations identify the dusky red silt/clay for newly drilled locations, but for older drilled locations the well logs simply identify “refusal” or “shale” or “bedrock”. It is not apparent that auger refusal or “shale” or “bedrock” on older boring logs always identifies the top of the dusky red silt/clay, as opposed to other relatively hard units.
- Recent Site documents in some cases refer to “shallow” and “deep” wells but these classifications are not entirely clear or consistent. For example, in the RIAIM Investigation Report (CMR 2019i) it states that “groundwater in the deeper zone beneath the dusky red silt…” implying that deep wells are those screened below the dusky red silt/clay. However, the nine monitoring wells identified as “deep wells” within that report (all in the in the East Rail Rack Area) are not all screened below the dusky red silt/clay, based on cursory review of well logs by the optimization review team[9]:
    - MW-68 and MW-72 are called “deep wells” but appear to be screened above and within the dusky red silt/clay (the water table appears to be within the dusky red clay or just above the top of it). CMR noted that these wells have subsequently been reclassified as shallow wells (see Comment #8 in Appendix G).
    - MW-91, MW-97, and MW-98 are called “deep wells” but appear to be screened partially in dusky red silt/clay and partially below it.
    - MW-79D and MW-81D appear to fully meet the definition of “deep well” stated in the report (i.e., screened below the dusky red silt/clay).
    - MW-99 and MW-11 are also screened at depths consistent with being below the dusky red silt/clay, but the dusky red silt/clay is not present (MW-99) or not apparent (MW-11) on the well logs.
- The fence diagrams included in the RIAIM Investigation Report (CMR 2019i) (see Figures 9, 12, 13, and 17 in Appendix B) do not include specific elevations and are not at an orientation or vertical scale that allows for a comprehensive and detailed comparison of ground surface elevation, stratigraphic contacts elevations, screen intervals, water levels, and groundwater quality data.

Extending the geologic model recently developed for the rail rack areas to the rest of the Site would require reinterpretation of previous boring logs (to the extent possible) to define top and bottom of the dusky red silt/clay, where those contacts are believed to exist. Based on the cursory review performed by the optimization review team, the top of the dusky red silt/clay is approximately at elevation 3325 ft amsl in the East Rail Rack Area and approximately at elevation 3320 ft amsl in the West Rail Rack Area (perhaps partially dug out and backfilled in the West Rail Rack Area). In the Truck Loading Rack Area the interpretation is limited to older borings based on refusal depth, and older Site documents indicate the refusal depth slopes towards the river in the Truck Loading Rack Area, but it is not certain that the refusal depth corresponds to the top of the dusky red silt/clay[10].

---

[9] CMR comment #8 on the draft optimization review report (see Appendix G) indicate a 2019 Annual report (submitted in February 2020) includes a reevaluation of “shallow” and “deep” wells in relation to the dusky red silt/clay. That report was completed after the optimization review team completed its technical evaluation, so that report and associated data could not be reviewed or considered in this optimization report.

[10] CMR comment #9 recent work, including an AOC#16 Pilot Study Report submitted in January 2020, includes a reevaluation of “shallow” and “deep” wells in relation to the dusky red silt/clay. That report was completed after the optimization review team completed its technical evaluation, so that report and associated data could not be reviewed or considered in this optimization report.

4.4 HYDROGEOLOGY

4.4.1 Groundwater Levels and Hydraulic Gradients

The potentiometric surface presented in the second quarter 2019 (Q2 2019) groundwater sampling report (CMR 2019g) (see Figure 3 in Appendix F) illustrates a continuous groundwater table where groundwater flows generally from the north to the south (toward the Missouri River)[11]. Whereas this representation of shallow groundwater implies a continuous shallow groundwater table, Sitewide groundwater sampling conducted since January 2019 and during the RIAIM identified some shallow and deep borings and monitoring wells where groundwater was either not detected (dry) or of insufficient volume to collect a groundwater sample. Based on these monitoring results it was posited in the most recent Site documents that groundwater in both the shallow and deep horizons is discontinuous and predominantly present in relatively permeable lenses above and below the dusky red silt/clay. However, while a review of groundwater monitoring conducted since 2019 confirms dry areas of the shallow and deep horizons, such areas are isolated and inconsistently dry. MW-71 is one of the only wells that has been repeatedly observed to be dry, which may be due to a well screen that is too shallow to intercept the water table.

Based on Q2 2019 data, groundwater elevation decreases generally from north to south across the Site from elevations between 3352 and 3362 ft amsl in the north to 3309 ft amsl near the Missouri River (at sandpoint well MW-43). Hydraulic gradient (i) across the Site in the shallow groundwater can be calculated from the groundwater elevations measured for shallow wells from Q2 2019 (CMR 2019g) that are annotated on Figure 3 of Appendix F. Approximate hydraulic gradients for the shallow zone are calculated as follows (CMR indicates these hydraulic gradients do not appear to have significant seasonal variation, see CMR Comment #10 in Appendix G):

- Main Refinery (MW-85/MW-12): The groundwater elevation falls by 29.0 ft between these two wells, which are separated by a distance of approximately 866 ft. The hydraulic gradient between these two wells is 3.3E-02 ft/ft.
- Truck Loading Rack Area (MW-56/MW-60S): The groundwater elevation falls by 14.2 ft between these two wells, which are separated by a distance of approximately 338 ft. The hydraulic gradient between these two wells is 4.2E-02 ft/ft.

Site documents identify deep groundwater monitoring wells. However, as noted above, a number of these “deep” monitoring wells are not screened entirely below the dusky red silt/clay. Accordingly, there are too few wells screened in the deep aquifer zone to calculate a hydraulic gradient in the Truck Loading Rack Area based on a potentiometric surface map. Monitoring wells MW-79D and MW-91, located in the East Rail Rack Area, both appear to be screened beneath the dusky red silt/clay and are aligned in the general direction of groundwater flow (Figure 11 in Appendix B), and therefore can be used to calculate an approximate hydraulic gradient for the deep aquifer zone:

- Main Refinery (MW-79D/MW-91): Groundwater elevations observed during the RIAIM Field Investigation (CMR 2019i) fell by 11.68 ft between these two wells, which are separated by an approximate distance of 199 ft. The hydraulic gradient between these two wells is 5.7E-02 ft/ft.

Given the relative paucity of hydraulic data for the deep aquifer, it is not possible to determine if the hydraulic gradient calculated above is consistent throughout the Site or localized to the East Rail Rack Area where MW-79D and MW-91 wells are located.

As noted above, the approximate elevation of the Missouri River stage was 3309 ft amsl, based on the

[11] Some deep wells are used on the water table figure (e.g., MW-91 and MW-97), presumably because there are no shallow wells in those locations and the water table appears to be in or below the dusky red silt/clay at those locations.

groundwater elevation at sandpoint well MW-43 measured during Q2 2019 groundwater sampling (river stage appears to be relatively consistent over time at approximately 3309 to 3310 ft amsl). Measured groundwater elevations in shallow monitoring wells (e.g. MW-72 in the East Rail Rack Area and MW-60S in AOC #16) located nearby and upgradient of the river ranged between 3,332 and 3,337 ft amsl during the same timeframe. Thus, based on groundwater potential the flow would generally be towards the river; however, the elevation of the top of the dusky red silt/clay (discussed in Section 4.3) is approximately 10 to 15 ft higher than the river elevation. Therefore, for groundwater to discharge to the river, it would either need to discharge to ground surface on the slope near the river bank as a seep, or it would need to migrate down through the dusky red silt/clay to the deeper aquifer zone which is expected to be hydraulically connected to the river.

Potential for downward flow into and through the dusky red silt/clay is supported by lower groundwater elevations in the deep aquifer relative to the shallow aquifer, based on shallow/deep well screen pairs where the two screens are clearly separated by the dusky red silt/clay. For example, at wells MW-59S/D and MW-60S/D (both in AOC #16) the groundwater elevations measured in Q2 2019 in the shallow screens were 4.4 ft and 1.5 ft greater than those measured in the corresponding deep screens, respectively. Similarly, at wells 79 S/D and 81 S/D (both in the East Rail Rack Area), the groundwater elevations measured in Q3 2019[12] the shallow screens were 0.15 ft and 2.9 ft greater than those measured in the corresponding deep screens, respectively. The difference in water levels suggests resistance to flow is provided by the dusky red silt/clay but this does not necessarily preclude downward flow and contaminant transport. The relatively small water level difference at MW-79S/D could indicate better hydraulic connection between the deep and shallow aquifer zones at that location (perhaps due to the shallow well screen extending far into the dusky red silt/clay).

The existence of downward vertical seepage at the Site is also supported by the detection of relatively high benzene concentration in wells screened beneath the dusky red silt/clay in the East Rail Rack Area (e.g. EB-10D at 3500 µg/L, MW-79D at 1000 µg/L, MW-91 at 130 µg/L, and MW-97 at 2,100 µg/L)[13]. This is discussed further in Section 4.5.

4.4.2 Horizontal Hydraulic Conductivity

During the RIAIM Field Investigation, hydraulic conductivity (K) was measured at a number of monitoring wells and borings screened at elevations consistent with being above and below the dusky red silt/clay. Based on a cursory review of boring logs the following designations are assumed:

- Shallow Wells/Borings – MW-79S, MW-81S, EB-07S, EB-11S, WB-07, and WB-09S
- Deep Wells/Borings – MW-79D, MW-81D, EB-07D, EB-09D, EB-10D, MW-91, MW-97, MW-98, WB-03D, WB-11D, WB-13D, MW-11, MW-99

The geometric mean hydraulic conductivities calculated from measurements at these wells (calculated by the optimization review team from aquifer test results developed by the Site team) are 1.47 ft/d for the shallow zone and 2.6E-02 ft/d for the deep zone. The relatively higher hydraulic conductivity for the shallow zone is consistent with the presence of permeable backfill evident in a number of well logs. It is expected that there is variability of hydraulic conductivity over space given the heterogeneity of fill and native materials.

4.4.3 Horizontal Groundwater Flow Velocity

From the estimated horizontal hydraulic gradients and average hydraulic conductivity values discussed

[12] These wells were not measured in Q2 2019 because they did not yet exist.
[13] EB-10 and MW-79D were monitored in the RIAIM Field Investigation (CMR 2019i). MW-91 and MW-97 were monitored in Q2 2019 (CMR, 2019g).

above, and assuming a porosity (n) 0.40 which is within the expected range of porosities for sands, silts, and clays (Freeze & Cherry 1979), approximate groundwater velocity (v) for the shallow and deep aquifer zones can be calculated using the formula v = Ki/n, as follows:

- Shallow Zone
  - The geometric mean hydraulic conductivity is 1.47 ft/d
  - The horizontal hydraulic gradient ranges between 3.3E-02 f/ft and 4.2E-02 ft/ft
  - The calculated groundwater seepage velocity ranges between 0.12 ft/d and 0.15 ft/d, or 44 to 55 ft per year (ft/yr)
- Deep Zone
  - The geometric mean hydraulic conductivity is 2.6E-02 ft/d
  - The horizontal hydraulic gradient is 5.7E-02 ft/ft
  - The calculated groundwater seepage velocity is 3.7E-03 ft/d, or 1.4 ft/yr.

These calculated horizontal seepage velocities are approximate and can reasonably vary throughout the Site due to potential variations in hydraulic gradient, hydraulic conductivity, and porosity (which may be considerably lower than 0.40). The velocity will be higher if the hydraulic conductivity is higher and/or the porosity is lower.

4.4.4 Groundwater Flow Balance

There are two primary inflows of water into the shallow aquifer system beneath the Site: precipitation-based recharge and regional inflows from north of the Site. The potential outflows from the shallow aquifer system are downward seepage through the dusky red silt/clay into the deep aquifer zone (where groundwater presumably discharges to the Missouri River) and groundwater discharge along the steep banks of the Missouri River (i.e., seepage face) above the dusky red silt/clay. In order to understand the flux of groundwater (and groundwater contaminants) that potentially discharge from the Site, the flux of inflowing water from recharge and regional groundwater flow can be approximated and summed.

Average annual rainfall in Great Falls, MT is approximately 14 inches per year. If it is assumed that 90% of this rainfall evaporates, is captured by vegetation (transpiration), or flows into stormwater sewers (this is an initial approximation by the optimization review team predicated on an assumption that 10% of precipitation enters the groundwater as recharge), then 1.4 inches of rainfall per year has the potential to recharge the groundwater system. Assuming approximately 70 acres for portion of the Site of interest, it is further assumed that 40% (28 acres) is unpaved and/or undeveloped. This means, that every year, an average of approximately 2,900 gallons per day (gpd) of water enters the shallow groundwater system at the Site via recharge. This is equivalent to approximately 2 gallons per minute (gpm).

As previously mentioned, shallow groundwater flows across the Site from north to south, and groundwater flow from areas north of the Site is presumed to flow beneath the Site in a direction roughly perpendicular to the northern property boundary of the refinery. In order to estimate the flux of groundwater that flows from north of the Site, the average saturated thickness in the shallow aquifer was estimated from average Q2 2019 depths to groundwater (4.22 ft bgs) at three monitoring wells along the northern property boundary (MW-85, MW-86, and MW-87), and depth to the dusky red silt/clay (14 ft) was estimated from a northern Site monitoring well boring log (MW-96)[14]. The resulting saturated

[14] The dusky red silt/clay was not encountered at MW-85, MW-86, and MW-87, based on a review of boring logs, and may be deeper than the bottom of the boreholes at these locations.

thickness is 9.8 ft. This thickness along the approximately 3,100 ft northern property boundary creates a groundwater seepage area that is 30,318 ft^2. If shallow groundwater flows from the north through this seepage face at a rate of 0.15 ft/d (as calculated in Section 4.4.3), then the inflow of shallow groundwater from north of the Site is approximately 34,019 gpd (4,548 ft^3/day or 23.6 gpm). For comparative purposes a garden hose, on average, flows at a rate of approximately 18,000 gpd or 12.5 gpm.

The sum of the two water inflows to the shallow groundwater system beneath the Site is approximately 36,919 gpd, or 25.6 gpm. As mentioned above, this water can exit the Site via two potential outflows from the shallow horizon: 1) downward seepage into the deep aquifer and, ultimately, into the Missouri River, and 2) as seepage along the steeply sloping land immediately north of the Missouri River. Based on vertical water level differences between the shallow and deep aquifer zones, as well as observed benzene in the deep well screens, there is likely some downward groundwater flow from the shallow aquifer into the deep aquifer, where groundwater likely ultimately discharges to the Missouri River. Given the low permeability of silts and clays, however, vertical seepage into the deep aquifer is likely to be a smaller component of shallow groundwater outflow than the horizontal discharge of shallow groundwater above the dusky red silt/clay as seeps along the steep ground surface adjacent to the Missouri River. Consequently, the discharge of contaminants from the Site likely primarily occurs as a very low rate of seepage above the Missouri River. Since the estimated total outflow of shallow groundwater outflow at the Site is only 2 times the flow of a garden hose and distributed along a potentially large seepage face, it is unlikely to be readily detected.

4.5 Contaminant Distribution and Contaminant Fate and Transport

LNAPL

An illustration of general LNAPL presence in specific areas is suggested by the highest LIF/UVOST® responses in those areas, presented on the following figures:

- AOC #16 – Figure 3A in Appendix D
- East Rail Rack Area – Figure 4 in Appendix B
- West Rail Rack Area – Figure 5 in Appendix B
- Storm Sewer Area – Figure 4 in Appendix E

LNAPL is currently recovered in four general areas of the Site: AOC #16; East Rail Rack Area; West Rail Rack Area, and Storm Sewer Area. LNAPL collection volumes from March 2018 to October 2019 are summarized on Table 6. Based on this table, extensive LNAPL is present near MW-53 (AOC #16), near MW-73/75/76 (West Rail Rack Area), at the trench south of the West Rail Rack Area (CS-W and CS-E), and near SSI-S (Storm Sewer Area).

Table 6. LNAPL Collection (gallons) March 2018 to October 2019

	AOC #16				East Rail Rack Area			West Rail Rack Area						Storm Sewer Area	
	MW-41	MW-53	MW-63	MW-64	MW-14R	MW-48	MW-70	MW-73	MW-74	MW-75	MW-76	CS-W	CS-E	SSI-N	SSI-S
3/2018	0.4	0.0	0.1	0.4	0.0	0.0	0.1	6.0	0.6	11.0	5.0	n/a	n/a	0.5	2.8
4/2018	0.1	32.9	0.1	1.1	0.0	0.0	0.0	2.0	1.8	9.5	2.0	n/a	n/a	1.8	0.0
5/2018	0.1	63.1	0.1	0.3	0.3	0.0	0.0	1.7	0.5	2.0	1.5	n/a	n/a	1.1	2.0
6/2018	0.0	98.6	0.1	0.1	0.1	0.0	0.1	71.1	0.0	336.0	168.8	n/a	n/a	0.5	0.0
7/2018	0.0	242.7	0.1	0.0	0.1	0.0	0.0	301.0	0.1	102.4	195.7	n/a	n/a	0.1	0.0

	AOC #16				East Rail Rack Area			West Rail Rack Area						Storm Sewer Area	
	MW-41	MW-53	MW-63	MW-64	MW-14R	MW-48	MW-70	MW-73	MW-74	MW-75	MW-76	CS-W	CS-E	SSI-N	SSI-S
8/2018	0.1	392.0	0.1	0.1	0.1	0.0	0.0	145.7	0.1	165.1	187.3	1.9	9.8	0.1	84.5
9/2018	0.0	220.0	0.0	0.0	0.1	0.1	0.4	104.3	0.0	134.8	84.2	194.0	104.6	0.5	81.4
10/2018	0.3	90.0	0.0	0.3	0.0	0.3	0.6	182.0	0.2	168.0	208.8	127.6	143.6	4.0	118.0
11/2018	0.3	90.0	0.3	0.3	0.0	0.3	1.4	64.9	0.6	151.8	208.8	9.6	39.1	3.1	120.5
12/2018	0.2	90.0	0.6	0.0	0.3	0.0	0.0	20.1	0.0	170.9	208.8	0.9	10.2	1.6	116.2
1/2019	0.0	90.0	1.2	0.6	0.0	0.0	0.0	20.8	0.0	170.7	223.2	34.6	347.7	1.7	99.6
2/2019	0.5	90.0	0.5	0.0	0.0	0.0	0.0	35.9	0.4	179.0	201.6	0.0	161.2	1.2	96.3
3/2019	0.8	90.0	0.0	0.8	0.0	0.1	0.0	62.8	0.4	195.8	223.2	239.0	182.0	0.0	79.9
4/2019	0.0	310.0	0.0	0.0	0.0	0.0	0.4	38.0	0.0	90.0	164.0	693.1	843.8	0.9	112.9
5/2019	0.0	225.0	0.0	0.0	0.8	0.5	0.0	37.4	0.8	125.9	197.0	16.0	0.0	1.5	54.7
6/2019	0.0	540.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	3.9	0.3	22.2	20.7	0.0	54.7
7/2019	0.0	135.0	0.0	0.0	0.0	0.1	0.0	0.3	1.2	53.5	0.0	50.3	81.9	1.0	54.7
8/2019	0.1	130.0	0.0	0.0	0.0	0.1	0.0	0.0	1.9	22.0	0.0	36.6	71.3	0.7	109.3
9/2019	0.0	125.0	0.0	0.0	0.0	0.1	0.0	0.1	2.3	27.0	0.0	27.1	56.5	1.1	87.8
10/2019	0.0	300.0	0.0	0.0	0.2	0.1	0.0	2.4	0.8	90.4	2.5	59.5	119.1	0.3	110.0

There are some other well locations where sheens are sometimes observed, in some cases outside the four areas discussed above. For instance, in Q2 2019 and Q3 2019 LNAPL was observed at newly installed MW-89, located just west of 10th Street NE. In Q3 2019 a small amount of LNAPL was detected in deep well MW-97, located south of the East Rail Rack Area. In monthly reports there are notes of sheens at several other wells. In general, there have been multiple product releases over time, and it should be expected that LNAPL may be present in additional subsurface locations where there is no monitoring.

Benzene

Benzene serves as a good indicator for dissolved groundwater impacts because it is relatively mobile, and the extent of other constituents is generally more limited relative to the benzene impacts. Figure 4 in Appendix F illustrates benzene distribution in groundwater for Q2 2019 (note this figure does not differentiate between shallow versus deep wells). Observations from this figure include the following:

- Benzene concentrations in groundwater are relatively lower in the West Rail Rack Area (typically less than 50 µg/L except at MW-74 where concentrations were observed up to 200 µg/L) compared to the East Rail Rack, AOC #16, and Storm Sewer areas where benzene concentrations exceeding 1,000 µg/L are observed.
- Benzene concentrations well above the DEQ-7 standard of 5 µg/L are observed in close proximity to the Missouri River south of the East Rail Rack Area (e.g., MW-97 at 2,100 µg/L and MW-91 at 130 µg/L) and in the southern part of AOC #16 (e.g., MW-41 at 2,600 µg/L, MW-50 at 380 µg/L, and MW-52 at 260 µg/L).
- The sandpoint wells adjacent to the river in the southern part of AOC #16 do not have benzene detections, but those may be indicative of surface water concentrations rather than groundwater concentrations.
- There are no monitoring wells near the Missouri River south of the West Rail Rack Area.

A more robust evaluation of the benzene distribution in groundwater, and associated contaminant fate and transport, can be performed by considering depths of well screens and elevation of stratigraphic contacts. As noted in Section 4.3, assignment of wells to groundwater horizons is somewhat inconsistent in recent Site documents, and such assignments have not been made for all Site wells. Based on cursory review of well logs and water quality data by the optimization review team, the following observations are noted:

- In the East Rail Rack Area, the impacted wells closest to the Missouri River (MW-97 and MW-91) appear to be screened within and below the dusky red silt/clay. As discussed in Section 4.4, there are also wells further upgradient in the East Rail Rack Area where substantial benzene concentrations are detected in deep wells that appear to be entirely screened below the dusky red silt/clay (e.g., EB-10D, MW-79D). It is not clear if the groundwater impacts at off-Site wells MW-91 and MW-97 (both screened within and below the dusky red silt/clay) are due to horizontal flow in the shallow aquifer zone followed by downward vertical migration near these off-Site wells, or if these wells became impacted due to downward vertical migration on-Site followed by horizontal migration in the deeper zone. However, these observations collectively suggest potential for downward flow and contaminant transport into and through the dusky red silt/clay, and potential for horizontal contaminant migration within the deeper aquifer zone towards the Missouri River. Any such migration in the deeper aquifer is likely to be slow based on low hydraulic conductivity values.
- In the West Rail Rack Area, although temporary wells extended into the deep aquifer zone did not identify dissolved groundwater impacts, there do not appear to be any permanent wells screened in that deeper zone for long-term monitoring south (downgradient) of the West Rail Rack.
- In AOC #16, MW-41 had a benzene concentration of 2,100 µg/L in Q2 2019. MW-41 is screened above, within, and below the dusky red silt/clay. It is possible that this well may act as a conduit for downward benzene transport. There are detections of benzene above DEQ standards at well MW-62 located downgradient of MW-41 (e.g., 12 µg/L at MW-62 in August 2019). Well MW-62 appears to be screened within and below the dusky red silt/clay based on review of well logs by the optimization team.

With regard to the updated CSM presented in the RIAIM Field Investigation (CMR 2019i) regarding potential contaminant transport, observations include the following:

- The CSM presented in the RIAIM Field Investigation (CMR 2019i) suggests groundwater within the shallow horizon is discontinuous and associated with more permeable lenses. The optimization team agrees there is likely substantial subsurface heterogeneity, but groundwater flow in the shallow aquifer may be more continuous than suggested by that CSM, based on the apparent continuity of the hydraulic gradient and apparent downgradient migration of dissolved constituents and LNAPL.
- The CSM presented in the RIAIM Field Investigation (CMR 2019i) suggests that shallow groundwater does not have an apparent connection to the adjacent Missouri River, and impacted groundwater from the shallow zone would have the potential to daylight as seeps at the slope on the southern property boundary. The optimization review team agrees with that portion of the CSM.
- The CSM presented in the RIAIM Field Investigation (CMR 2019i) suggests there does not appear to be substantive vertical migration of the groundwater through the dry dusky red unit to the underlying units. Based on the observations above, the optimization review team questions this portion of the CSM.

- The CSM presented in the RIAIM Field Investigation (CMR 2019i) suggests that contaminant migration in the deeper groundwater unit is occurring through discontinuous preferential flow pathways, and that hydraulic conductivities measured in the downgradient wells near the river are quite low which minimizes the volume of impacted groundwater reaching the river. The optimization team agrees that the low hydraulic conductivity suggests a very low volumetric flux of impacted groundwater will reach the river in this deeper zone, although some variability in the hydraulic conductivity is likely, potentially resulting in higher discharge rates than calculated in Section 4.4.4. However, there is a substantial likelihood that some groundwater exceeding DEQ-7 standards discharges to the river in this deeper zone near MW-91 and W-97 (south of East Rail Rack Area), and potentially near MW-41 (AOC #16) given the long well screen at MW-41 (which is impacted by benzene well above the DEQ-7 standard) and detections of benzene above DEQ standards at well MW-62 located downgradient of MW-41 (e.g., 12 µg/L at MW-62 in August 2019). Well MW-62 appears to be screened within and below the dusky red silt/clay based on review of well logs by the optimization team.

Benzene readily attenuates under aerobic conditions, and it is possible that benzene concentrations could substantially attenuate if aerobic conditions are present between the impacted wells and the Missouri River in the deeper aquifer zone.

<u>Other Parameters</u>

The optimization review team focused primarily on benzene as an indicator parameter. Naphthalene is also widely detected in groundwater (see Figure 5 in Appendix F). Based on the tables in the 2019 quarterly reports, wells impacted by benzene often also have detections of toluene, ethylbenzene, and xylenes (BTEX compounds), sometimes above DEQ-7 standards, as would be expected. There are sporadic detections of 1,2-DCA above the DEQ-7 standard. There are also detections of parameters typically associated with hydrocarbons such as 2-methylnaphthalene and 2,4-dimethylphenol. For metals, there are sporadic detections above DEQ-7 standards for arsenic, barium, and selenium.

4.6 REMEDIAL SYSTEM PERFORMANCE

There is no final remedy because the Site is still in the RFI stage. IM performance identified in Site documents includes the following:

- Soil excavation at the LCA was conducted in 2013 to 2015. The contaminated soil was removed because it exceeded risk-based levels protective of human health and the environment. The following was removed: 25,503 tons of hazardous soil due to benzene; 2,511 tons of hazardous soil due to lead; and 5,549 tons of soil hazardous due to both benzene and lead. An additional 53,676 was disposed of as non-hazardous waste. Groundwater extraction was conducted for excavation dewatering, with separation of LNAPL and subsequent water treatment at the refinery WWTP.

- At AOC #16, two LNAPL recovery trenches operated from 1995 to 2004. A trench close to the Truck Loading Rack collected 21,000 gallons, and the second trench further south (just north of River Road) collected only 240 gallons.

- More recent LNAPL collection has occurred in AOC #16, the East Rail Rack Area, the West Rail Rack Area, and the Storm Sewer Area. LNAPL collection volumes from March 2018 to October 2019 were previously summarized on Table 6. Observations regarding recent LNAPL collection based on Table 6 include the following:
    - At AOC #16, nearly all the LNAPL is recovered at MW-53 (via active collection), with minor recovery typically less than 1 gallon per month (via socks) at MW-41, MW-63,

and MW-64. The recovery rate at MW-53 is typically several hundred gallons per month and the recovery rate does not appear to be decreasing.

  - At the East Rail Rack Area very little LNAPL is recovered, typically 1 or 2 gallons per month or less (via socks) from wells MW-14R, MW-48, and MW-70.
  - At the West Rail Rack Area hundreds of gallons per month have been recovered at the trench (sumps CS-W and CS-E) and hundreds of gallons per month have also been recovered (via active collection) at MW-73, MW-75, and MW-76. There has been less than 1 or 2 gallons per month (via socks) at MW-74. The recovery rates appear to be decreasing but remain substantial enough to merit continued recovery efforts.
  - At the Storm Sewer Area nearly all the LNAPL is recovered at SSI-S (via active collection), with minor recovery typically less than 2 gallons per month (via socks) at SSI-N. The recovery rate at SSI-S is typically on the order of 100 gallons per month and the recovery rate does not appear to be decreasing.

- On several occasions where LNAPL has been observed on the Missouri River booms have been placed to control the LNAPL.

At AOC #16 additional IM remedial actions have been approved (as discussed in Section 3.1) but not yet implemented.

4.7 POTENTIAL HUMAN AND ECOLOGICAL EXPOSURE PATHWAYS

The facility is expected to remain a refinery for the foreseeable future. Industrial workers could potentially come in contact with impacted surface soil, and construction workers could potentially come in contact with impacted soil (surface or subsurface) and groundwater. During the optimization review Site visit CMR indicated they are in the process of developing a soil management plan that addresses excavation protocols and training requirements to mitigate potential human exposure to contaminants from these activities.

There do not appear to be potential drinking water receptors. Connection to public water service is mandated for drinking water purposes within the city limits (TRC 2015). The nearest registered off-Site domestic well is across 11th Avenue to the northeast (upgradient of the Site) and is completed 34 to 40 ft bgs (TRC 2015). Presumably this well is not used for drinking water based on the availability of public water. The municipal WWTP obtains its water supply directly from the Missouri River (TRC 2015); the document does not specify the location of the intake.

Discharge of impacted groundwater and/or stormwater to the Missouri River is a potential concern from a regulatory standpoint. From a human exposure standpoint, it is highly unlikely that contaminants such as benzene would be detected in the Missouri River, given the very low groundwater flux of impacted groundwater to such a large river. However, MDEQ indicated during the optimization review Site visit (and reconfirmed after the meeting) that MDEQ does not allow for a mixing zone for groundwater into surface water in the context of RCRA corrective action, such that groundwater water must meet DEQ-7 groundwater standards before discharging to surface water.

Vapor intrusion (VI) is a potential concern with respect to potential human exposures:

- The office building on the northeast part of the main portion of the refinery (just south of MW-87 on Figure 4 in Appendix F) is within approximately 200 ft of monitoring wells impacted by benzene such as MW-56 (6,800 µg/L benzene in Q2 2019) and MW-90 (110 µg/L benzene in Q2

2019). MW-89, where LNAPL has been observed (CMR 2019g; CMR 2019j), is located even closer to the office building. Additionally, there are refinery operations areas located just west of the office building but no groundwater monitoring locations in that vicinity. As such, it seems prudent to assume there could be VI issues in this office building, unless a lack of a completed exposure pathway can otherwise be demonstrated based on engineering factors and considerations. Often in these types of situations it is more cost effective to implement VI mitigation measures at the building rather than to perform investigation via sampling in an attempt to prove there is no VI issue (which often provides uncertain results and leads to further investigation).

- Based on vapor migration in the Black Eagle sewer observed in 2016 at AOC #16, and historical observations where LNAPL entered a storm sewer on the main portion of the refinery (subsurface), underground piping provides potential preferential pathways for vapor migration in the subsurface.

Potential for VI exposure at the office building located east-northeast of the Truck Loading Rack Area (just south of MW-16 on Figure 4 in Appendix F) was previously evaluated (CMR 2018a) and it was determined there is no human exposure issue due to VI at that building.

CMR recently submitted a HHRA for AOC #25 which concludes no risk to receptors, partly based on a CSM that suggests no migration of Site groundwater to the Missouri River horizontally and no vertical transport though the dusky red silt/clay. That document is currently being reviewed by MDEQ and was not evaluated in detail by the optimization team. However, the optimization team questions those assumptions regarding groundwater transport, as discussed in Section 4.5.

4.8 INSTITUTIONAL CONTROLS

No formal institutional controls (ICs) were identified during the optimization review Site visit or in the documents reviewed. As mentioned in Section 4.7, CMR is in the process of developing a soil management plan that addresses excavation protocols and training requirements to mitigate potential human exposure to contaminants, and connection to public water service is mandated for drinking water purposes within the city limits. It is anticipated that a final remedy will likely incorporate an IC that requires vapor mitigation (e.g., vapor barrier, ventilation) for any occupied structures on most or all of the refinery property unless a lack of a completed exposure pathway can otherwise be demonstrated based on engineering factors and considerations.

4.9 GROUNDWATER MONITORING

A two-year Sitewide groundwater monitoring program (CMR 2017a) was implemented in 2019 to provide for a Site-wide groundwater investigation. This monitoring program is expected to provide an improved data set for completing the RFI. Results have already been obtained for the first, second, and third quarters of 2019. The plan included quarterly monitoring at 25 wells and semi-annual monitoring at 38 wells, and some additional wells have been drilled since the plan was developed. Thus, the number of samples is likely on the order of 200 per year.

During this two-year period water levels will be measured once per quarter at approximately 80 locations (new locations have been added since the work plan was developed). Corrections are applied for wells with measured LNAPL thickness. A potentiometric surface was developed for the first and second quarter of 2019 but not for the third quarter of 2019 (however, that report indicates potentiometric maps will be developed in subsequent events). In addition to quarterly groundwater sampling, monthly groundwater level monitoring has been conducted at select monitoring locations based on monthly reports from January 2018 to October 2019.

Samples are collected with a peristaltic pump using low-flow protocols, except for the sandpoint wells adjacent to the Missouri River (south of AOC #16) which are purged dry, allowed to recharge, and then grab-sampled. Samples are analyzed for VOCs, SVOCs, VPH, EPH, and modified Skinner-List metals (including mercury). Samples for metals are field-filtered. Purge water is discharged to a sewer line that discharges to the Refinery WWTP.

4.10 Approximate Annual Costs

Annual costs were not evaluated as part of this review. The Site is still in the RFI stage and annual costs are not routine.

4.11 Summary of Key Data Gaps or Uncertainties

Key uncertainties or data gaps include the following:

- Stratigraphic contact elevations have not been re-characterized for older wells across the entire Site based on the new geologic model. Similarly, monitoring wells have not been fully or consistently assigned to "hydrogeologic layers" they screen based on the updated geology framework (e.g., shallow for above the dusky red silt/clay; intermediate for within the dusky red silt/clay; deep for below the dusky red silt/clay; and hybrids thereof). CMR indicates work has continued on this item in reports completed subsequent to the optimization team completing their technical review (see Appendix G).

- The distance west of MW-91 and east of MW-97 (south of the East Rail Rack Area) where deep groundwater is impacted above DEQ-7 standards is not precisely known, although there are delineation wells further west and east. This width of impacted groundwater could be factor when evaluating potential groundwater remediation approaches in this area.

- It is not clear if the groundwater impacts downgradient of the East Rail Rack Area at off-Site wells MW-91 and MW-97 (both screened within and below the dusky red silt/clay) are due to horizontal flow in the shallow aquifer zone followed by downward vertical migration near these off-Site wells, or if these wells became impacted due to downward vertical migration on-Site followed by horizontal migration in the deeper zone.

- It is not clear if deep groundwater (below the dusky red silt/clay) is impacted in the southern part of AOC #16 due to the long well screen at MW-41, where LNAPL has been observed and recovered). That well is screened above, within, and below the dusky red silt/clay. There are detections of benzene above DEQ standards at well MW-62 located downgradient of MW-41 (e.g., 12 µg/L at MW-62 in August 2019). Well MW-62 appears to be screened within and below the dusky red silt/clay based on review of well logs by the optimization team

- It is not clear if the sandpoint wells south of AOC #16 represent groundwater quality or if they are really measuring surface water quality in the Missouri River.

- In the West Rail Rack Area, although temporary wells extended into the deep aquifer zone did not identify dissolved groundwater impacts, there do not appear to be any permanent wells screened in that deeper zone for long-term monitoring south of the West Rail Rack.

- Although existing information suggests benzene impacts do not likely extend near the office building located east of the Truck Loading Rack Area (which could cause a VI issue), there is no monitoring well directly between potential source areas (e.g., MW-53) and the building to confirm no benzene impacts (though the likelihood of such impacts is relatively low).

Recommendations are provided in Section 5 to address these uncertainties and data gaps.

4.12 SUMMARY OF ISSUES REGARDING RCRA EIS CA725 AND CA750

A number of IMs have been implemented, with corresponding improvements to environmental conditions. However, based on findings presented above, the optimization team believes that the current answer should be "NO" for CA 725 (Current Human Exposures Under Control) and "NO" for CA 750 (Migration of Contaminated Groundwater Under Control) because one or more issues suggests an answer of "NO" for each EI.

For CA 725:

- MDEQ does not allow for a mixing zone for groundwater discharge to surface water and requires that groundwater meet DEQ-7 groundwater standards before discharging to surface water. From a regulatory standpoint this is an issue because there appears to be potential for discharge of groundwater above DEQ-7 standards to the river south of the East Rail Rack Area, and perhaps south of AOC #16 as well. It is very unlikely for there to be human exposures (due to the large amount of dilution) but based on their requirements MDEQ will likely require remedial action to mitigate this issue prior to answering "YE" for CA 725 (this may be stricter than required by RCRA in general).

- Potential for VI issues at the office building in the northeast part of the main portion of the refinery will likely need to be investigated, or addressed via engineering controls in lieu of an investigation, to answer "YE" for CA 725. This item has not been adequately monitored or otherwise mitigated and therefore merits a "NO" for CA 725 at this time.

- A Site-wide HHRA has not yet been completed, and MDEQ indicated at the optimization review Site visit that they have not answered "YE" for CA 725 at refinery Sites without an HHRA (this may be stricter than required by RCRA in general).

For CA 750:

- There appears to be uncontrolled contaminant migration to the south near MW-97 and MW-91 in the deep aquifer (downgradient of the East Rail Rack Area) towards the Missouri River. This items merits a "NO" for CA 750 at this time.

- There is potential for uncontrolled vertical contaminant migration to deeper groundwater near MW-41 (south of AOC #16) due to the long well screen at MW-41 and/or vertical transport across the dusky red silt/clay. Given benzene impacts above the DEQ-7 standard at deep well MW-62, located downgradient of MW-41, this item merits a "NO" for CA 750 until such time as MW-41 is abandoned and subsequent benzene concentrations are consistently below the DEQ-7 standard at MW-62.

- In the West Rail Rack Area, the lack of a permanent monitoring well in the deep aquifer zone between the recovery trenches and the Missouri River precludes the confirmation that impacted groundwater is not migrating towards the Missouri River in this area (in this location the elevation is likely low enough that the shallow aquifer zone is not present). This lack of adequate monitoring merits a “NO” for CA 750.

Recommendations are provided in Section 5 to address these issues.

5.0 RECOMMENDATIONS

Site-specific recommendations are provided for the six major areas associated with optimization: remedy effectiveness, cost reduction, technical improvement, progress toward Site closure, property reuse or revitalization, and energy and materials efficiency. Table 6 provides a summary of the recommendations and estimated costs (or savings) for implementing each recommendation. The levels of certainty for the cost estimates provided are comparable to those typically prepared for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Study (FS) reports (-30 to +50 percent) and are considered rough estimates for planning purposes.

5.1 REVIEW AND EXPAND REVISED GEOLOGIC MODEL SITE-WIDE

Data gathered during the RIAIM Field Investigation (CMR 2019i) resulted in a revised CSM that describes two aquifer zones (shallow and deep) separated by a low permeability dusky red silt/clay. Consequently, several permanent monitoring wells and temporary boreholes installed during the investigation were described as "shallow" or "deep" wells. However, the methodology employed to distinguish between shallow and deep wells is unclear and potentially inconsistent. As such, it is recommended that the Site team review boring logs and recharacterize wells according to the hydrogeologic zones that they screen: "shallow" = screened above the dusky red silt/clay; "intermediate" = screened across the dusky red silt/clay; "deep" = screened beneath the dusky red silt/clay. Wells screened across units could be indicated as such (e.g., "intermediate/deep"). It is appropriate that this revised geologic model be applied to the characterization of monitoring wells Site-wide, based on elevations of stratigraphic contacts interpreted from older geologic logs (to the extent possible)[15].

During the activities recommended above, it may be determined that existing wells on the northern part of the Site (both east and west of 10th Street NE) may not be deep enough to confirm the presence of the dusky red silt/clay. In that case, there would not be shallow/deep clusters in the northern portion of the Site to determine potential for contamination in the deeper zone below the dusky red silt/clay. Although deeper monitoring wells could address this issue (if such an issue exists), there could also be a risk of creating preferred pathways for downward contaminant migration to deeper intervals during drilling. It is therefore recommended that MDEQ and the responsible party discuss the relative pros and cons of drilling deeper wells in the northern part of the site to improve understanding of the geologic framework. At this point, no specific wells are recommended by the optimization review team for this purpose.

The optimization review team further recommends developing geologic cross-sections along transects throughout the Site at a vertical scale that allows elevations to be adequately discerned. Such cross-sectional figures would improve upon the current fence diagrams by comprehensively illustrating geologic contacts (e.g. the top and bottom of the dusky red silt/clay), ground surface elevations, screen elevations, groundwater elevations, concentrations of COCs, and the stage of the Missouri River. Geologic cross-sections that include this information will be helpful in validating and/or revising the CSM of groundwater flow and contaminant transport.

[15] Per multiple CMR comments on the draft optimization review report (see Appendix G) work conducted by CMR and submitted in January and February 2020 includes a reevaluation of "shallow" and "deep" wells in relation to the dusky red silt/clay. Therefore, implementation of this recommendation appears to be in progress. However, reports discussing that work were completed after the optimization review team completed its technical evaluation, and therefore those reports and associated data could not be reviewed or considered in this optimization report.

The items in this recommendation are assumed to be included in planned Site activities for ongoing Site work given the very recent changes to the understanding of Site stratigraphy, and as such no added cost is estimated for implementing this recommendation.

5.2 VI MITIGATION AT OFFICE BUILDING WEST OF 10TH STREET NE

Given the relatively high potential for VI impacts at this office building in the northeast part of the main portion of the refinery (south of MW-87), it is recommended that VI mitigation measures be implemented assuming none are currently in place, unless a lack of a completed exposure pathway can otherwise be demonstrated based on engineering factors and considerations. If mitigation is needed, the optimization team believes it will be more cost-effective to implement a sub-slab depressurization system than it will be to perform an investigation to rule out VI impacts. Estimated cost is likely on the order of $30,000 to construct, and on the order of $2,000 per year for operation and maintenance (O&M). Other mitigation approaches might also be possible, perhaps at a lower cost, if mitigation is needed.

5.3 ABANDON MW-41 AND ADD A DEEP MONITORING WELL IN THE SAME GENERAL AREA

Benzene was detected in groundwater at a concentration of 2,100 µg/L at monitoring well MW-41, located in AOC #16. Because this well appears to be screened above, within, and below the dusky red silt/clay, it is impossible to know if the detection of benzene is indicative of an impact to the shallow zone, deep zone, dusky red silt/clay, or a combination of these. Additionally, this long well screen may act as a direct vertical conduit for downward migration of contaminants from the shallow aquifer zone into the deep zone, where they could migrate to the Missouri River.

In order to mitigate potential migration of contaminants to the deep aquifer zone through this well, the optimization team recommends abandoning it. Deep well MW-62, located downgradient of MW-41, would be a good location to monitor benzene concentration changes over time. If benzene concentrations decline at MW-62 after MW-41 is abandoned, then it is likely that the long well screen at MW-41 was the primary cause of deep impacts in that area. The expected cost for abandoning MW-41, if done in conjunction with other drilling work, is likely on the order of $5,000.

5.4 ADD DEEP MONITORING WELL SOUTH OF WEST RAIL RACK RECOVERY TRENCH

In the West Rail Rack Area, the lack of a permanent monitoring well in the deep aquifer zone between the recovery trenches and the Missouri River precludes the confirmation that impacted groundwater is not migrating towards the Missouri River in this area (in this location the elevation is likely low enough that the shallow aquifer zone is not present). This is an issue regarding RCRA EI CA 750.

The optimization team recommends the installation of a permanent deep monitoring well, screened above the river elevation, approximately 50 ft downgradient of the recovery trench on the municipal WWTP property. The expected cost for the installation and one-time sampling is likely on the order of $15,000. Assuming no impacts, sampling this location as a sentinel well (only for VOCs) every two years might cost approximately $300 per year on an annualized basis. If substantial groundwater impacts are detected, additional monitoring wells closer to the Missouri River might need to be subsequently installed and sampled.

5.5 ELIMINATE SOME METALS FROM ONGOING MONITORING

Based on the quarterly monitoring performed in 2019 (three quarters) the only metals that appear to be detected above DEQ-7 standards are arsenic, barium, and selenium. Historically, some inorganics including cadmium and lead have been detected sporadically above groundwater standards. Unlike analysis for VOCs or SVOCs, laboratory costs for metals are typically charged per constituent. Upon completion of the two years of quarterly sampling, analytical results can be reviewed to determine if future samples need to be analyzed for the current set of 13 metals. For example, eliminating approximately 10 metals might save approximately $50 per sample. Assuming approximately 200 samples per year for a quarterly monitoring program, this could result in savings of approximately $10,000 per year. Savings would be less for a monitoring program with fewer wells, reduced frequency, or fewer metals removed from analysis.

5.6 DEVELOP A NEW RFI WORK PLAN

A draft RFI work plan (TRC 2015) was submitted in 2015 to comply with the 2012 Order. The 2015 draft RFI work plan has not been approved, and stakeholders are currently considering the relative merits of modifying the 2015 submittal or completely replacing the submittal with a new RFI work plan. The optimization review team recommends developing a new RFI work plan given the releases discovered since 2015, the extensive amount of new information collected since 2015, the IMs implemented since 2015, and the revised understanding of Site stratigraphy. It is assumed that a Sitewide HHRA will be conducted as part of the RFI activities, which will help address one of the issues identified regarding RCRA EI CA 725. No specific cost is estimated for this recommendation, because it is assumed this approach is already planned for implementation by the Site team.

5.7 RECOMMENDATIONS REGARDING REMEDY APPROACH

The optimization team provides the following recommendations regarding IMs currently underway and/or potential additional IMs:

- LNAPL removal efforts appear to be relatively successful, and it is recommended that these efforts continue.

- In the area near MW-91 and MW-97, there appears to be potential for impacted groundwater in the deep aquifer zone to migrate to the Missouri River. The extent of these deep aquifer zone impacts west of MW-91 and east of MW- 97 are not precisely known, although there are delineation wells further west and east. MDEQ may require remediation despite the relatively low groundwater flux estimated to flow towards the river. A potential remedial approach that could be considered would include digging a trench to the deep aquifer zone on refinery property (along an east-west line upgradient of MW-91 and MW-97), and then implementing one of the following: 1) groundwater extraction from the trench with discharge to the adjacent refinery WWTP; 2) filling the trench with oxygen releasing compounds (ORC) to stimulate aerobic degradation; or 3) fill the trench with PlumeStop which promotes stabilization and biodegradation of VOCs. It is recommended that an informal feasibility and cost evaluation be performed for these alternatives (and others if they are identified), similar to the evaluation recently performed to compare IM alternatives at AOC #16. This evaluation might cost on the order of $15,000 and could include determination of whether or not any additional monitoring wells are needed to refine the western and eastern limits targeted for remediation. Cost for remedy reimplementation would depend on approach selected and information developed in the feasibility analysis.

- For AOC #16, if abandoning MW-41 (see Section 5.3) does not eliminate deep aquifer zone concerns in that location, additional remediation for the deep aquifer zone in that area may be appropriate (i.e., (above and beyond the planned shallow remedial activities). In that case (which is not assumed herein), the feasibility and cost evaluation recommended above for the area near MW-97 could be extended to also include deep aquifer remediation in the area near MW-41.

5.8 RECOMMENDATIONS REGARDING CA 725 AND CA 750

Section 4.12 indicated items identified by the optimization team that might need to be addressed to answer "YE" (under control) for CA 725 (Current Human Exposures Under Control) and CA 750 (Migration of Contaminated Groundwater Under Control). A summary of which recommendations (above) pertain to addressing each item identified in Section 4.12 is provided below (estimated costs for addressing these items is already included for the recommendations referenced below).

EI	Item from Section 4.12	Pertinent Recommendation
CA 725	MDEQ does not allow for a mixing zone for groundwater discharge to surface water and requires that groundwater meet DEQ-7 groundwater standards before discharging to surface water. From a regulatory standpoint this is an issue because there appears to be potential for discharge of groundwater above DEQ-7 standards to the river south of the East Rail Rack Area, and perhaps south of AOC #16 as well. It is very unlikely for there to be human exposures based (due to the large amount of dilution) but based on their requirements MDEQ will likely require remedial action to mitigate this issue prior to answering "YE" for CA 725 (perhaps stricter than RCRA in general).	Section 5.7
	Potential for VI issues at the office building in the northeast part of the main portion of the refinery will likely need to be investigated, or addressed via engineering controls in lieu of an investigation, to answer "YE" for CA 725.	Section 5.2
	A Site-wide HHRA has not yet been completed, and MDEQ indicated at the optimization review Site visit that they have not answered "YE" for CA 725 at refinery Sites without an HHRA (perhaps stricter than RCRA in general).	Section 5.6
CA 750	There appears to be uncontrolled contaminant migration to the south near MW-97 and MW-91 (downgradient of the East Rail Rack Area).	Section 5.7
	There is potential for uncontrolled vertical contaminant migration to deeper groundwater near MW-41 (south of AOC #16) due to the long well screen at MW-41 and/or vertical transport across the dusky red silt/clay.	Section 5.3
	In the West Rail Rack Area, the lack of a permanent monitoring well in the deep aquifer zone between the recovery trenches and the Missouri River precludes the confirmation that impacted groundwater is not migrating towards the Missouri River in this area (in this location the elevation is low enough that the shallow aquifer zone is likely not present).	Section 5.4

TABLE 6. Recommendations and Cost Summary

RECOMMENDATION	EFFECTIVENESS	COST REDUCTION	TECHNICAL IMPROVEMENT	SITE CLOSURE	REUSE REVITALIZATION	ENERGY AND MATERIAL EFFICIENCY	ESTIMATED CAPITAL COST	CHANGE IN ANNUAL COST
5.1 Review and Expand Revised Geologic Model Site-Wide	X						Assumed part of planned Site activities	
5.2 VI Mitigation at Office Building West of 10th Street NE	X						$30,000	$2,000
5.3 Abandon MW-41	X						$5,000	$0
5.4 Add Deep Monitoring Well South of West Rail Rack Recovery Trench	X						$15,000	$300
5.5 Eliminate Some Metals from Ongoing Monitoring		X					$0	($10,000)
5.6 Develop A New RFI Work Plan			X				Assumed part of planned Site activities	
5.7 Recommendations Regarding Remedy Approach	X						$15,000 for feasibility analysis, subsequent costs depend on approach selected	
5.8 Recommendations Regarding CA 725 and CA 750	X						Incorporated in other recommendations	

"X" Indicates that the recommendation pertains to the indicated optimization category
Values in parentheses "()" indicate estimated annual cost savings

APPENDIX A:

REFERENCES

CMR-Monthly [January 2018 to October 2019]. *Monthly Interim Measures Report* {Referenced in this optimization review report as "CMR-Monthly-January 2018" for the report pertaining to January 2018, "CMR-Monthly-February 2018" for the report pertaining to February 2018, etc.)

CMR, 2017. *Final Summary Report - RCRA Facility Investigation Interim Measures Work Plan for Newly Accessible Area in and around Former Doctor Treatment Unit and Former Gasoline Storage Tanks and Pumps (Lead Consolidated Area, LCA),* November 14.

CMR, 2018a. *AOC-16 Interim Measures Report Addendum*, August 2.

CMR, 2018b. *Investigation Scope Summary for the Rail Investigation Area Interim Measures (RIAIM) Work Plan,* October 15.

CMR, 2018c. *Rail Investigation Area Interim Measure (RIAIM) Work Plan,* November.

CMR, 2019a. *Site-Wide Groundwater Monitoring (SWGM) Work Plan,* January.

CMR, 2019b. *AOC-16 Emergency Interim Measures (IM) Investigation Summary Report,* February 7.

CMR, 2019c. *AOC-25 Human Health Risk Assessment Work Plan,* May 3.

CMR, 2019d. *1st Quarter 2019 Groundwater Sampling Summary Report,* May.

CMR, 2019e. *AOC-16 Interim Measures Evaluation Report,* June.

CMR, 2019f. *Rail Investigation Area Interim Measure (RIAIM) Work Plan Addendum,* June.

CMR, 2019g. 2nd *Quarter 2019 Groundwater Sampling Summary Report,* July.

CMR, 2019h. *Human Health Risk Assessment AOC 25 (Old Ponded Area)*, September.

CMR, 2019i. *Rail Investigation Area Interim Measure Field Investigation Report*, September.

CMR, 2019j. *3rd Quarter 2019 Groundwater Sampling Summary Report*, October.

Freeze, A and J. Cherry, 1979, *Groundwater*, Prentice Hall: Englewood Cliffs, New Jersey.

Jacobs Engineering Group, Inc. (Jacobs), 1988. *Final – RCRA Facility Assessment Report*. December 12.

Montana DEQ, 2019. *DEQ Approval Letter – AOC #16 Interim Measures Evaluation Report*. July 19.

Montana Refining Company, 1998. *MTHWP-95-02: Final Description of Current Conditions Report*, Revised October 13.

TRC, 2015. *Site-Wide RFI Work Plan* [not approved by MDEQ], July 20.

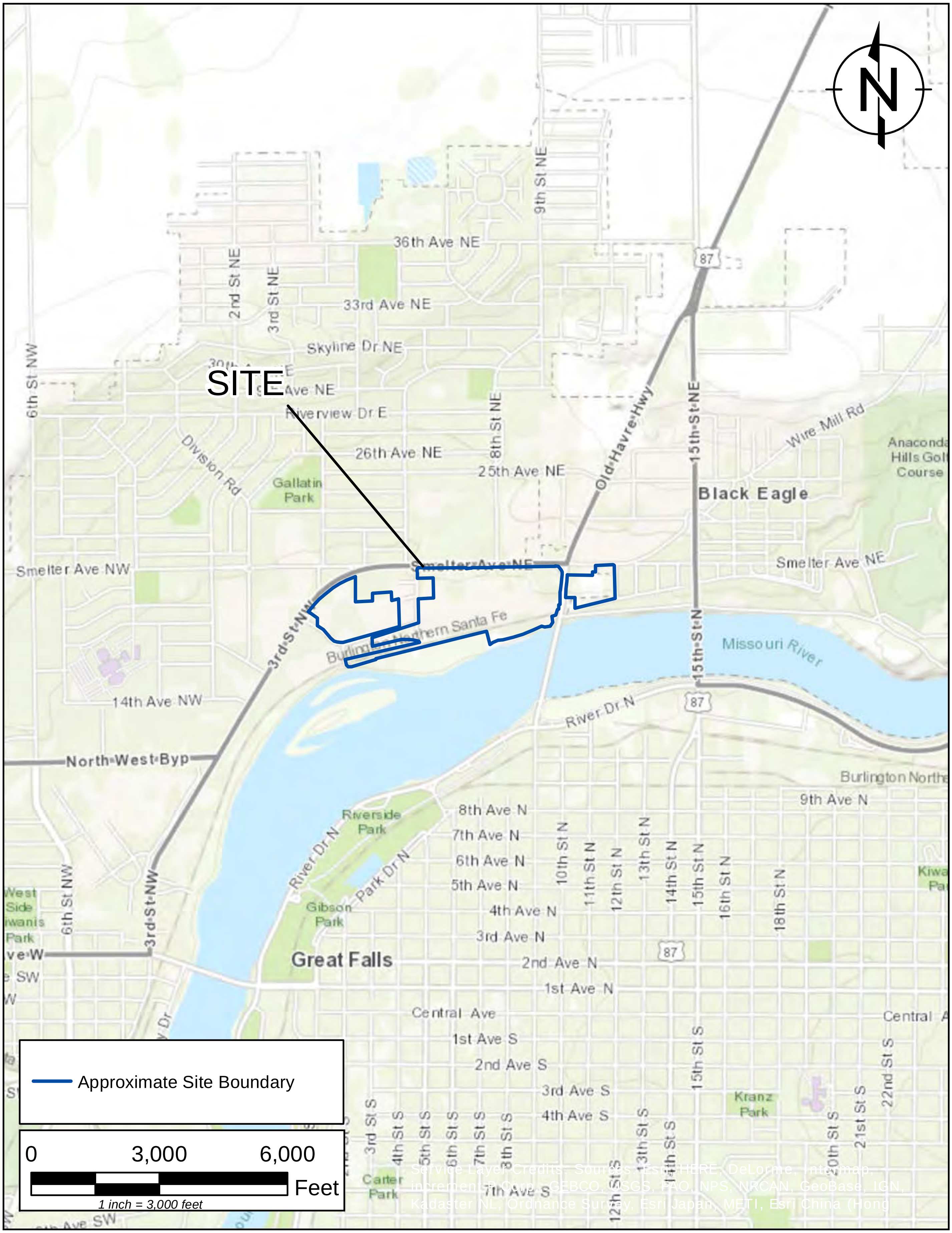
Trihydro, 2016. *AOC-16/Black Eagle Sewer Investigation Interim Measures Report Plan*, November 22.

Trihydro, 2017a. *AOC-16 Interim Measures Work Plan*, January 24.

Trihydro, 2017b. (Draft for Review) *Storm Sewer Release Investigation and Interim Measures Report*, October 5

APPENDIX B:

Figures from *Rail Investigation Area Interim Measure Field Investigation Report* (CMR 2019i)



K:\KCData (K)\GIS\PROJECT\2018\CALUMET\DOCS\Figure 1.mxd

RAMBOLL	Site Location CALUMET MONTANA REFINING, LLC 1900 10TH STREET NORTHEAST GREAT FALLS, MT	FIGURE 1
DRAFTED BY: DFM / Date: 8/13/2018		PROJECT: 1690013825

Site Layout and Operations Map

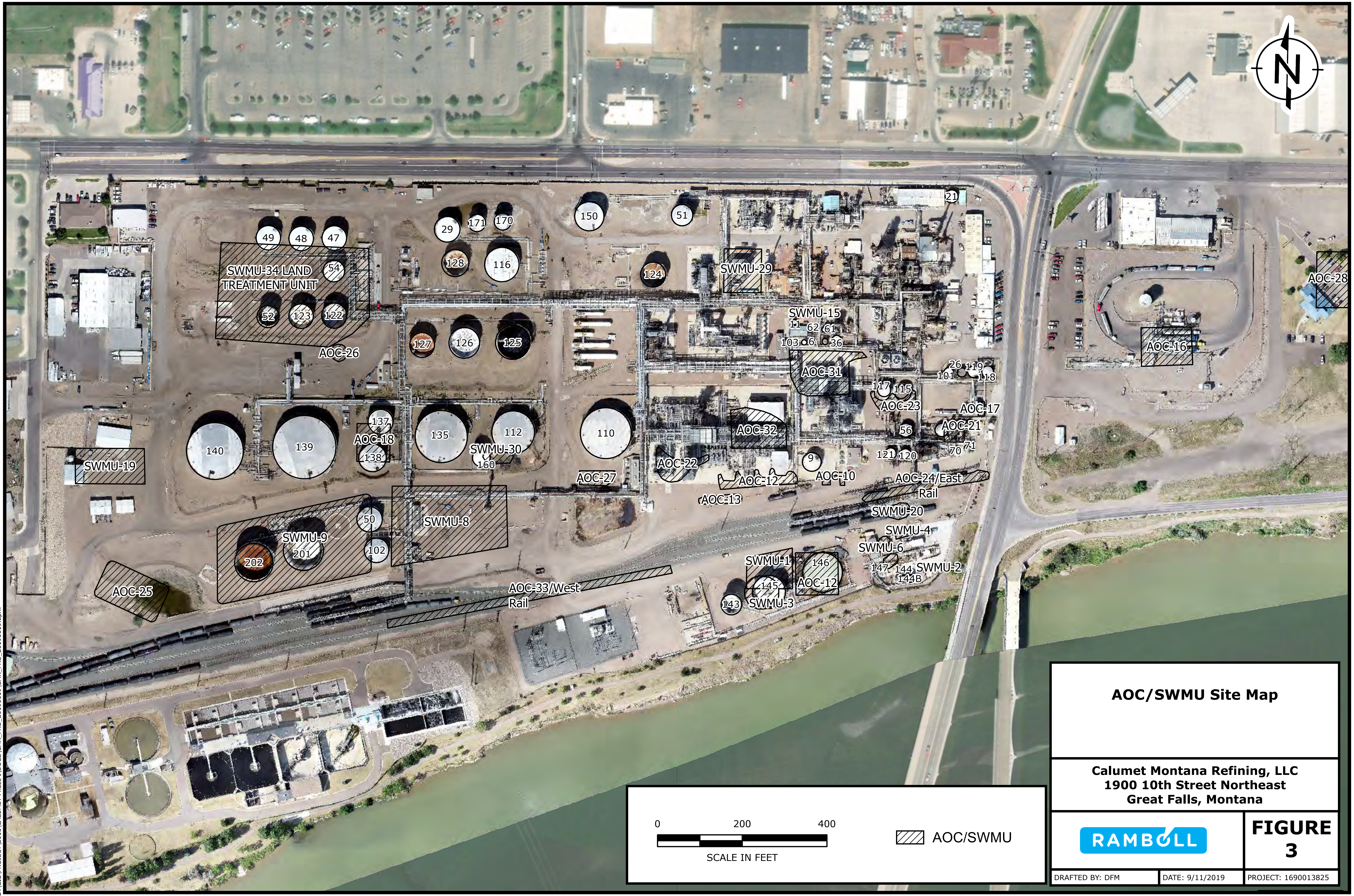
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 2

DRAFTED BY: DFM | DATE: 7/17/2019 | PROJECT: 1690013825

D:\GIS\PROJECT\2018\CALUMET Phase I\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



AOC/SWMU Site Map

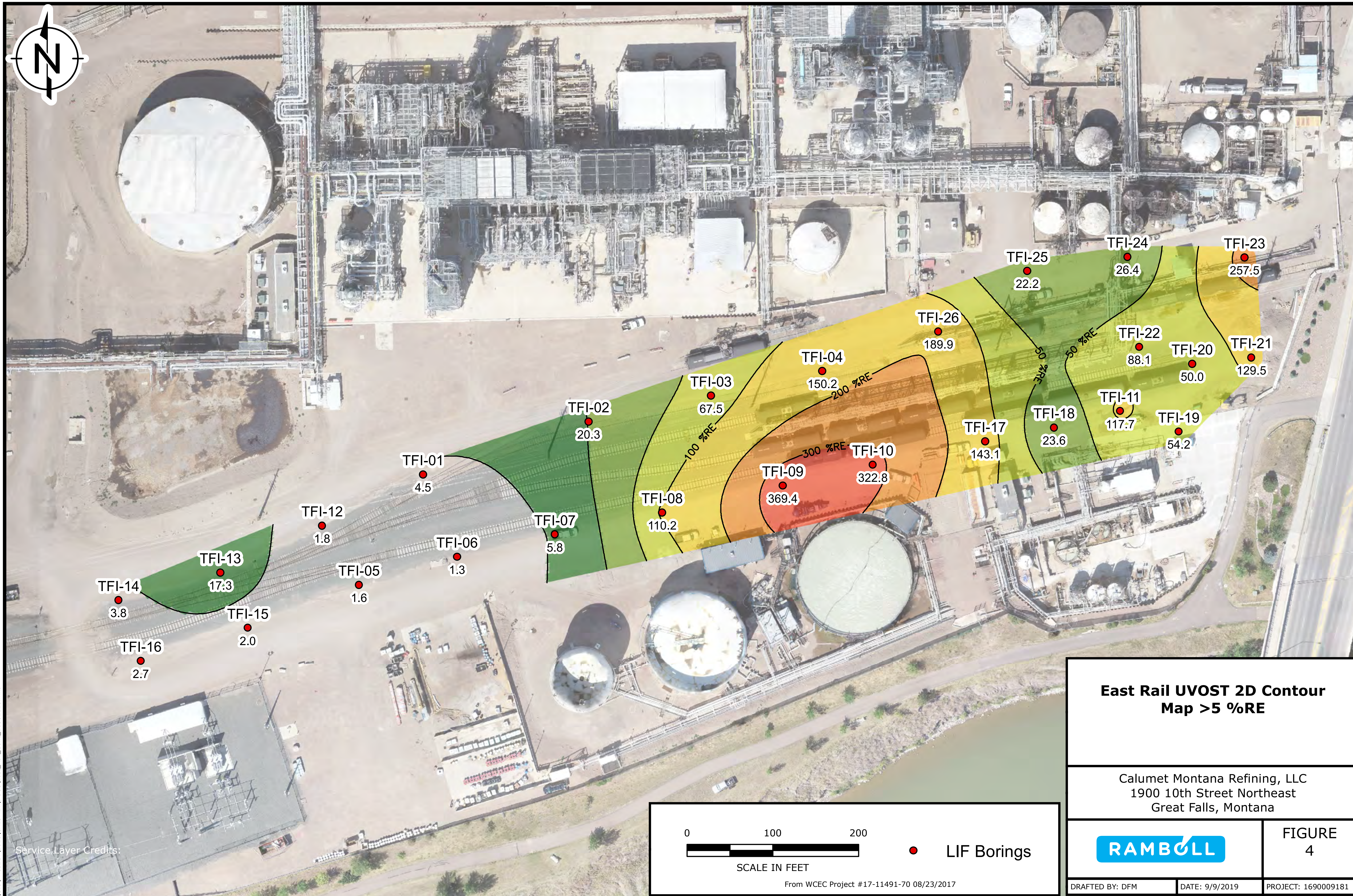
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 3

DRAFTED BY: DFM | DATE: 9/11/2019 | PROJECT: 1690013825

D:\GIS\PROJECT\2018\CALUMET Phase 1\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



East Rail UVOST 2D Contour Map >5 %RE

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

RAMBOLL

FIGURE 4

DRAFTED BY: DFM	DATE: 9/9/2019	PROJECT: 1690009181

D:\GIS\PROJECT\2018\CALUMET\DOCS\East_Rail_Conc_10302018.mxd

West Rail UVOST
2D Contour Map > 5 %RE

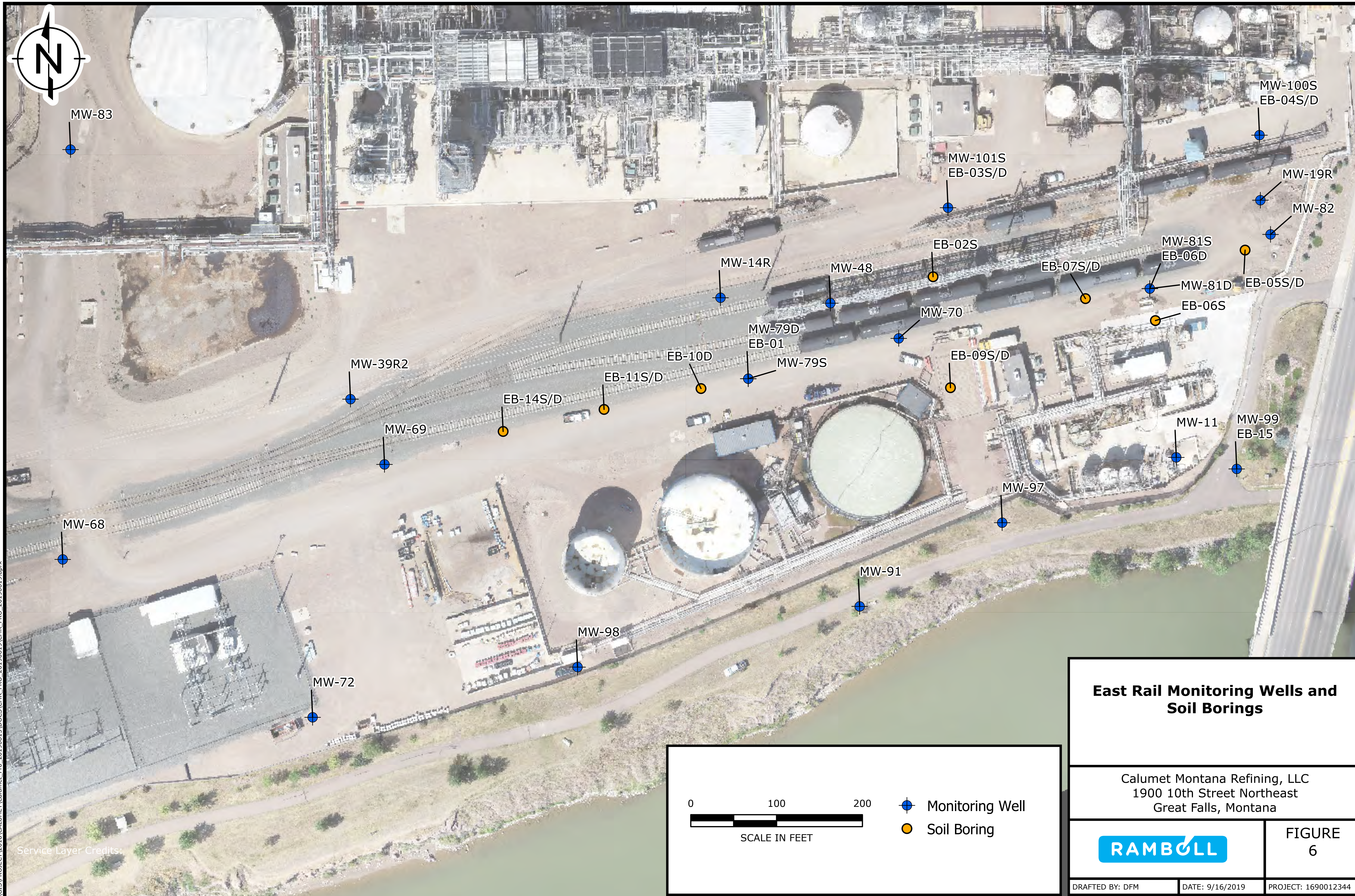
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE
5

DRAFTED BY: DFM | DATE: 9/9/2019 | PROJECT: 1690009181

D:\GIS\PROJECT\2018\CALUMET\DOCS\West_Rail_Conc_10302018.mxd



East Rail Monitoring Wells and Soil Borings

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

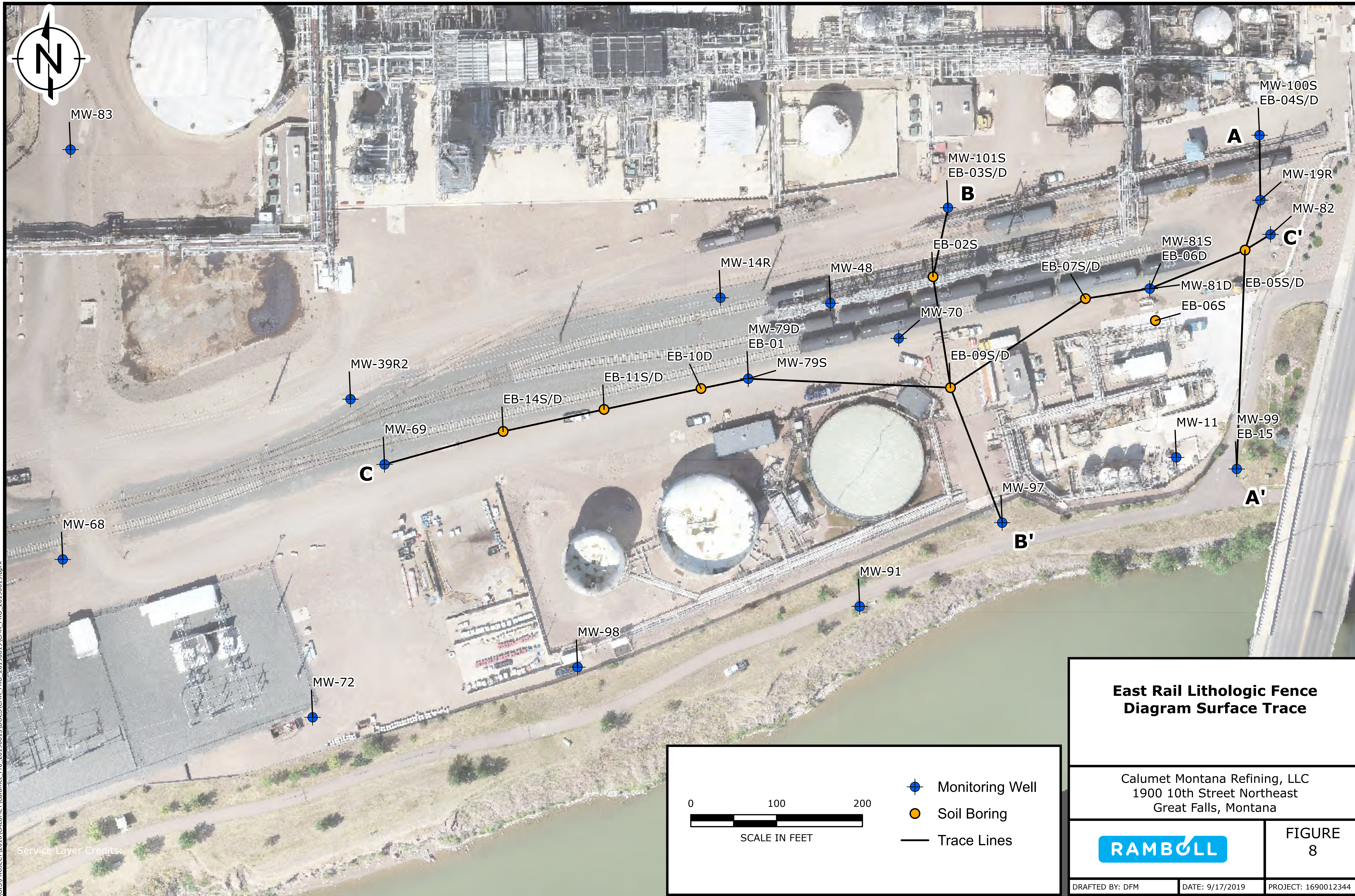
RAMBOLL

FIGURE
6

DRAFTED BY: DFM | DATE: 9/16/2019 | PROJECT: 1690012344

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



East Rail Lithologic Fence Diagram Surface Trace

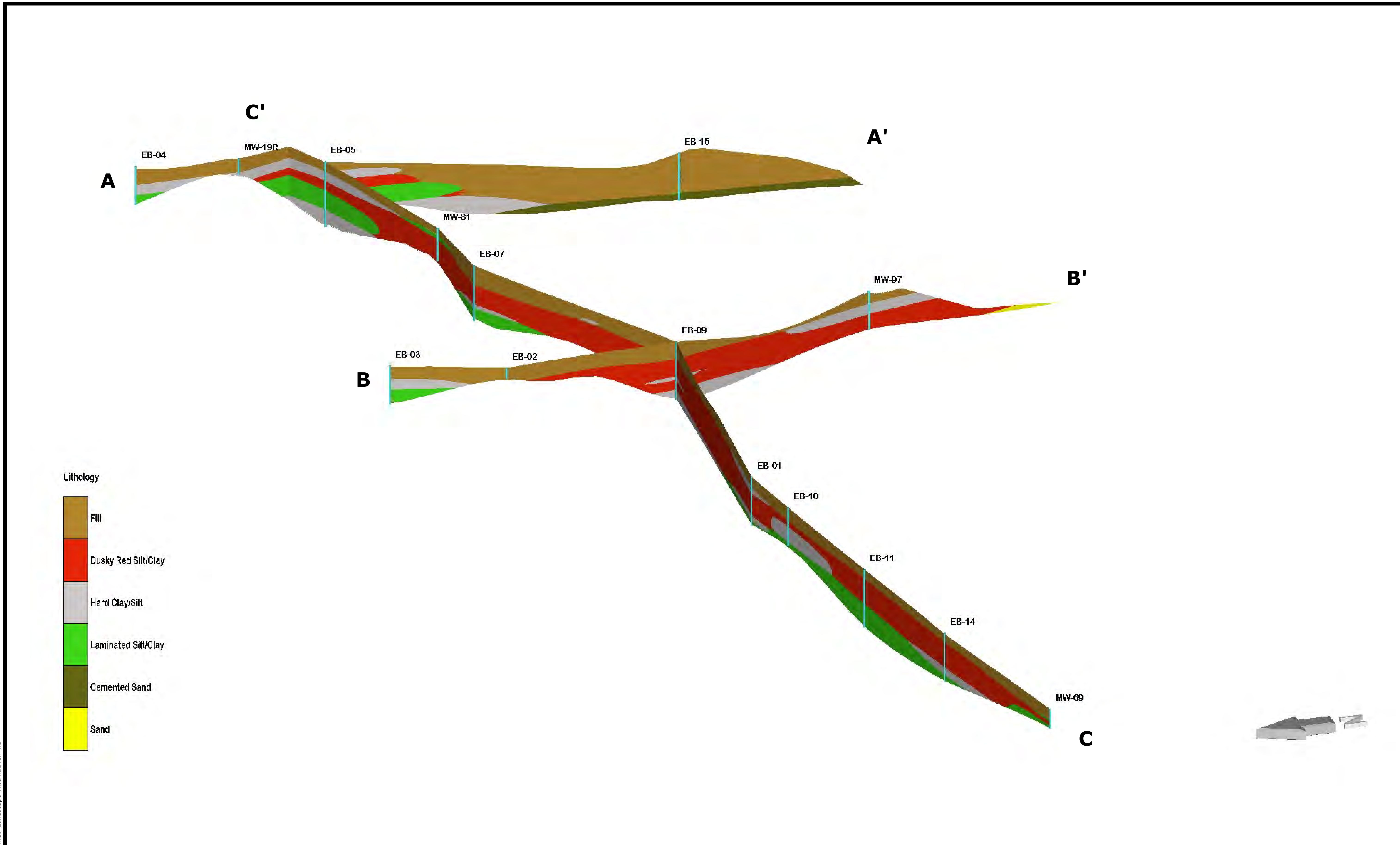
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 8

DRAFTED BY: DFM | DATE: 9/17/2019 | PROJECT: 1690012344

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



E:\Projects\Calumet\GIS\B_ANSI_Landscape_Alternative.mxd

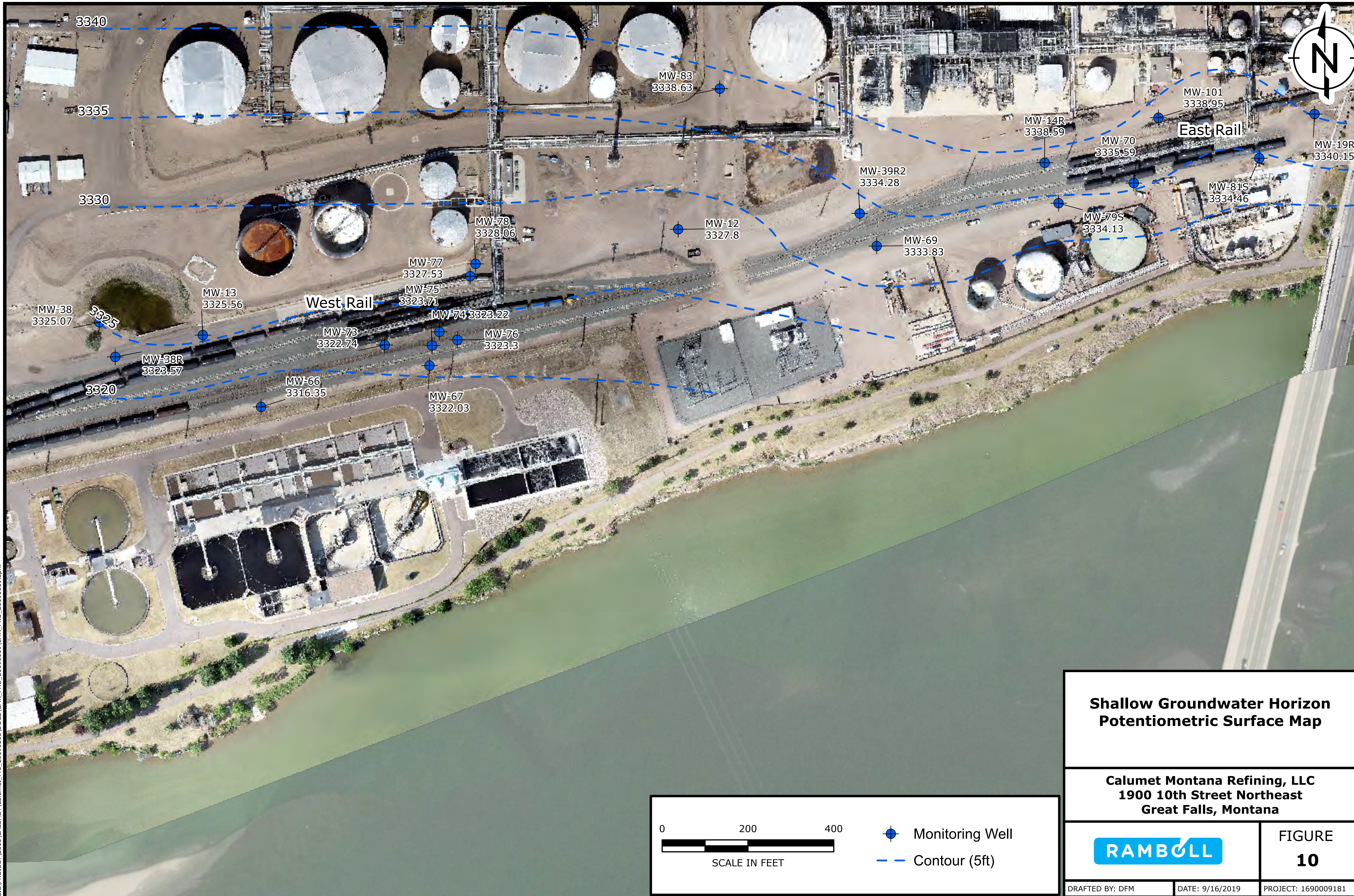
RAMBOLL

DRAFTED BY: MKE | DATE: 9/7/2019

East Rail Lithology
Calumet Montana Refinery
Great Falls, Montana

FIGURE
9

PROJECT:1690012344



Shallow Groundwater Horizon Potentiometric Surface Map

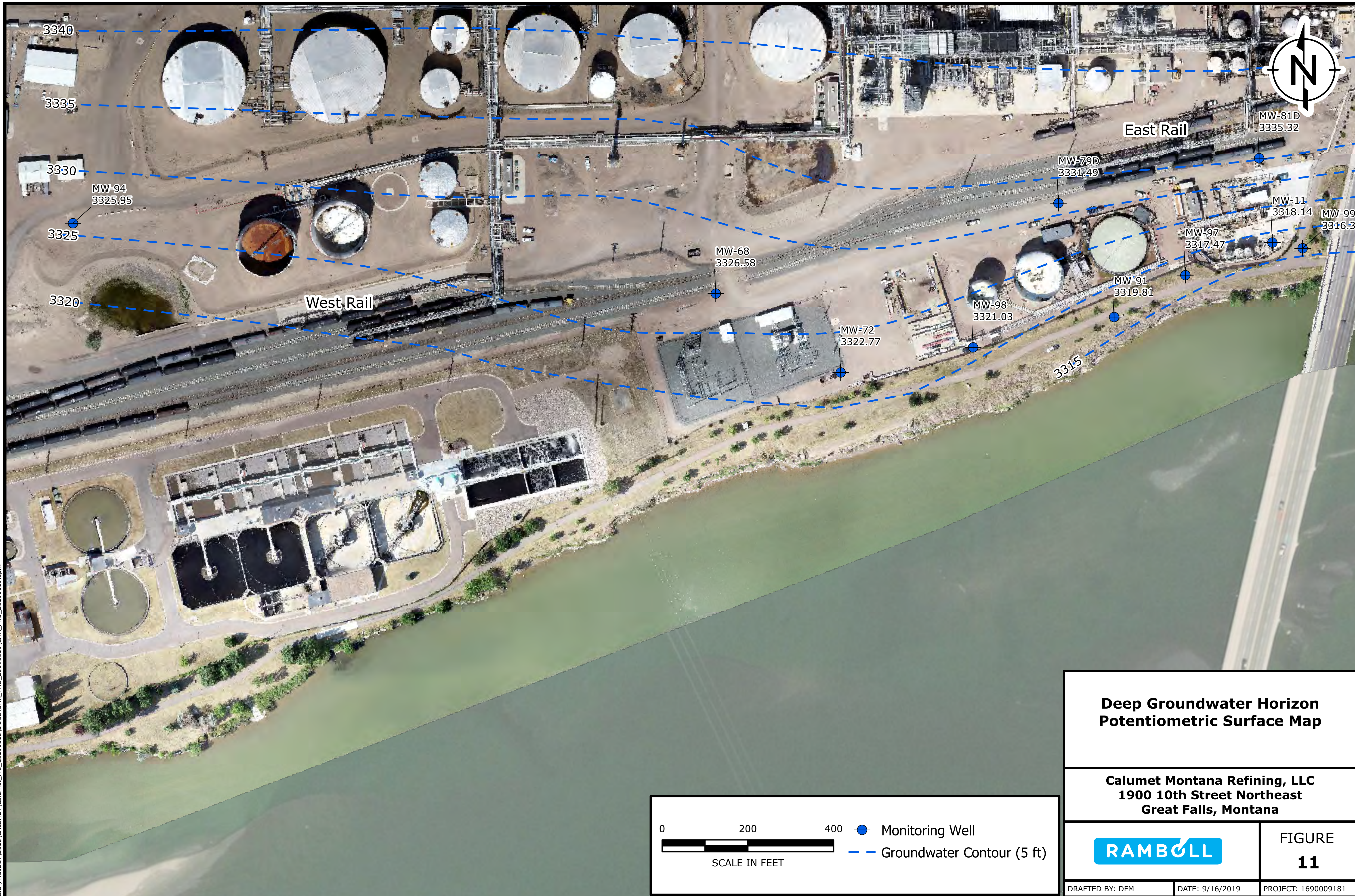
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE
10

DRAFTED BY: DFM | DATE: 9/16/2019 | PROJECT: 1690009181

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



Deep Groundwater Horizon Potentiometric Surface Map

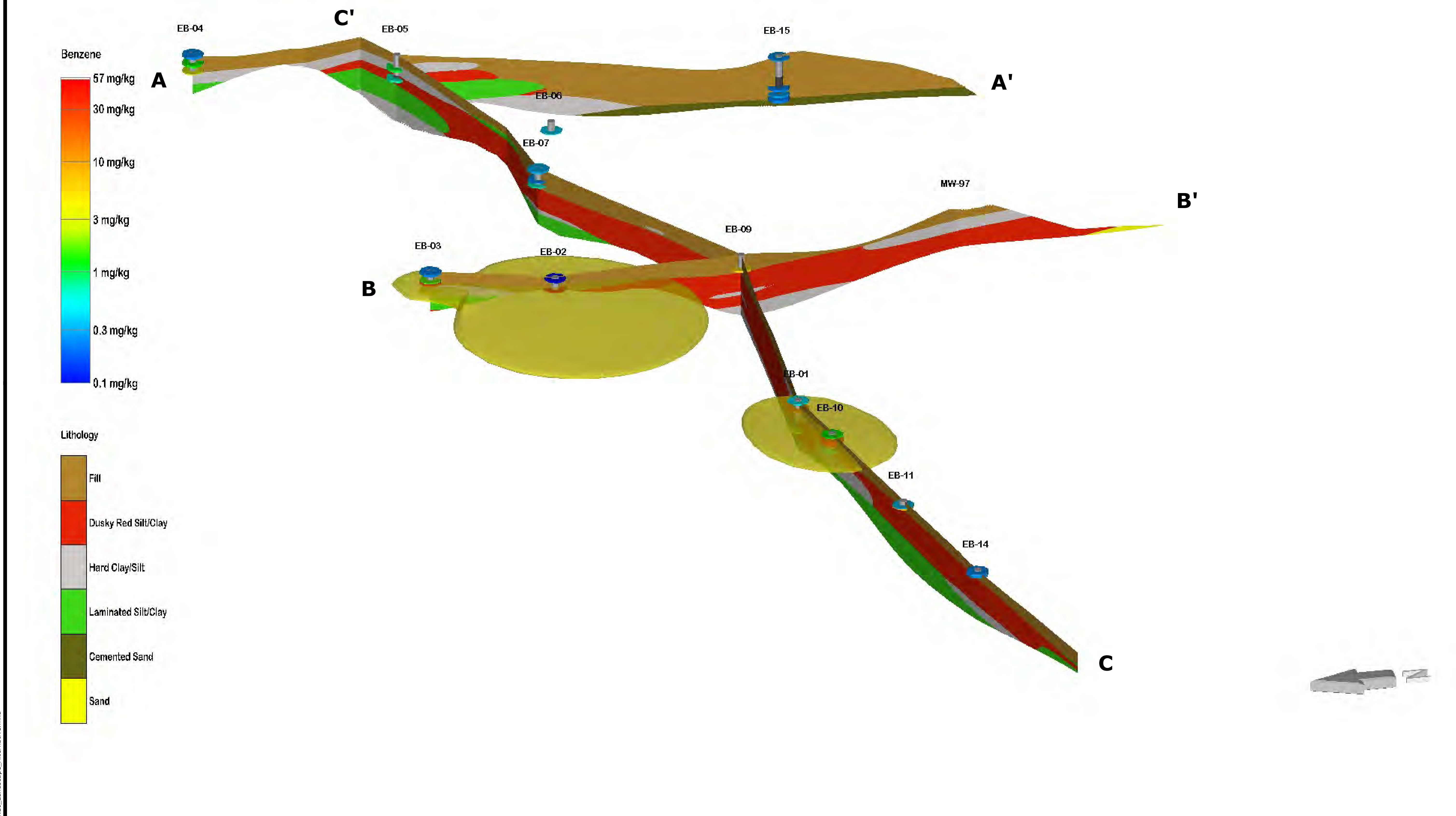
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE **11**

DRAFTED BY: DFM | DATE: 9/16/2019 | PROJECT: 1690009181

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



E:\Projects\Calumet\GIS\B_ANSI_Landscape_Alternative.mxd

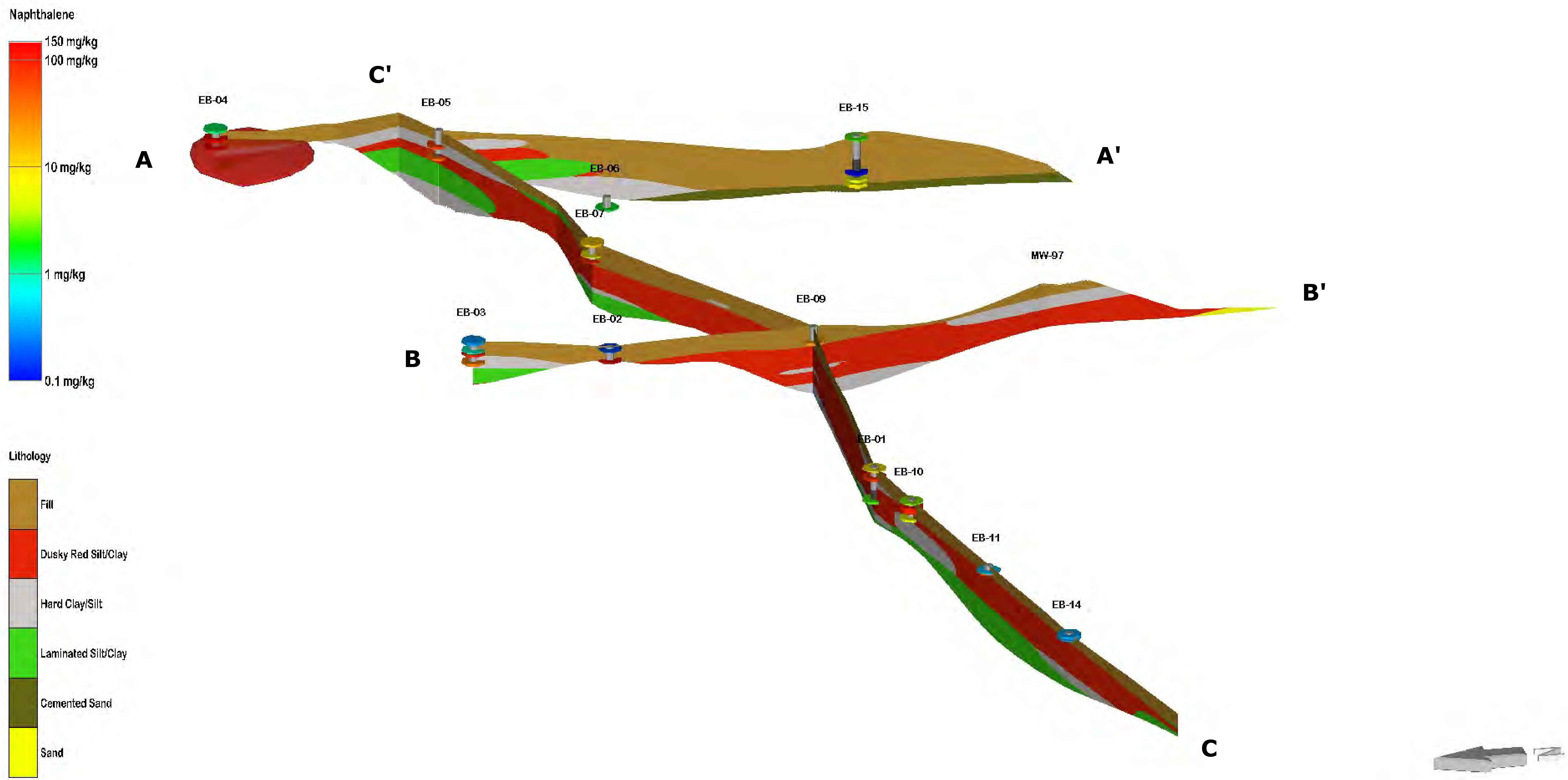
RAMBOLL

DRAFTED BY: MKE | DATE: 9/7/2019

East Rail Benzene in Soil
Calumet Montana Refinery
Great Falls, Montana

FIGURE
12

PROJECT:1690012344



E:\Projects\Calumet\GIS\B_ANSI_Landscape_Alternative.mxd

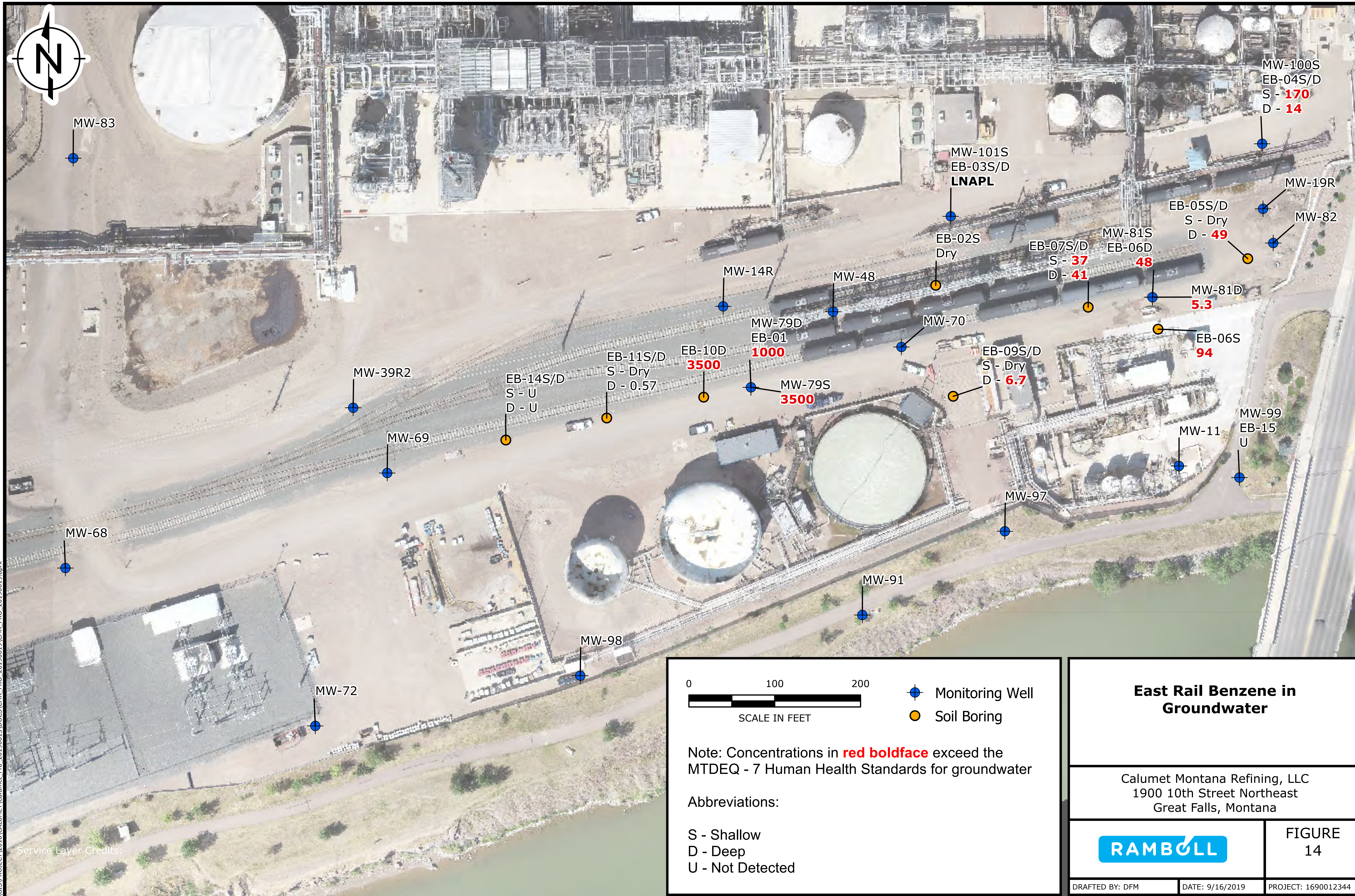
RAMBOLL

DRAFTED BY: MKE | DATE: 9/7/2019

East Rail Naphthalene in Soil
Calumet Montana Refinery
Great Falls, Montana

FIGURE
13

PROJECT:1690012344



0 100 200

SCALE IN FEET

Monitoring Well

Soil Boring

Note: Concentrations in **red boldface** exceed the MTDEQ - 7 Human Health Standards for groundwater

Abbreviations:

S - Shallow
D - Deep
U - Not Detected

East Rail Benzene in Groundwater

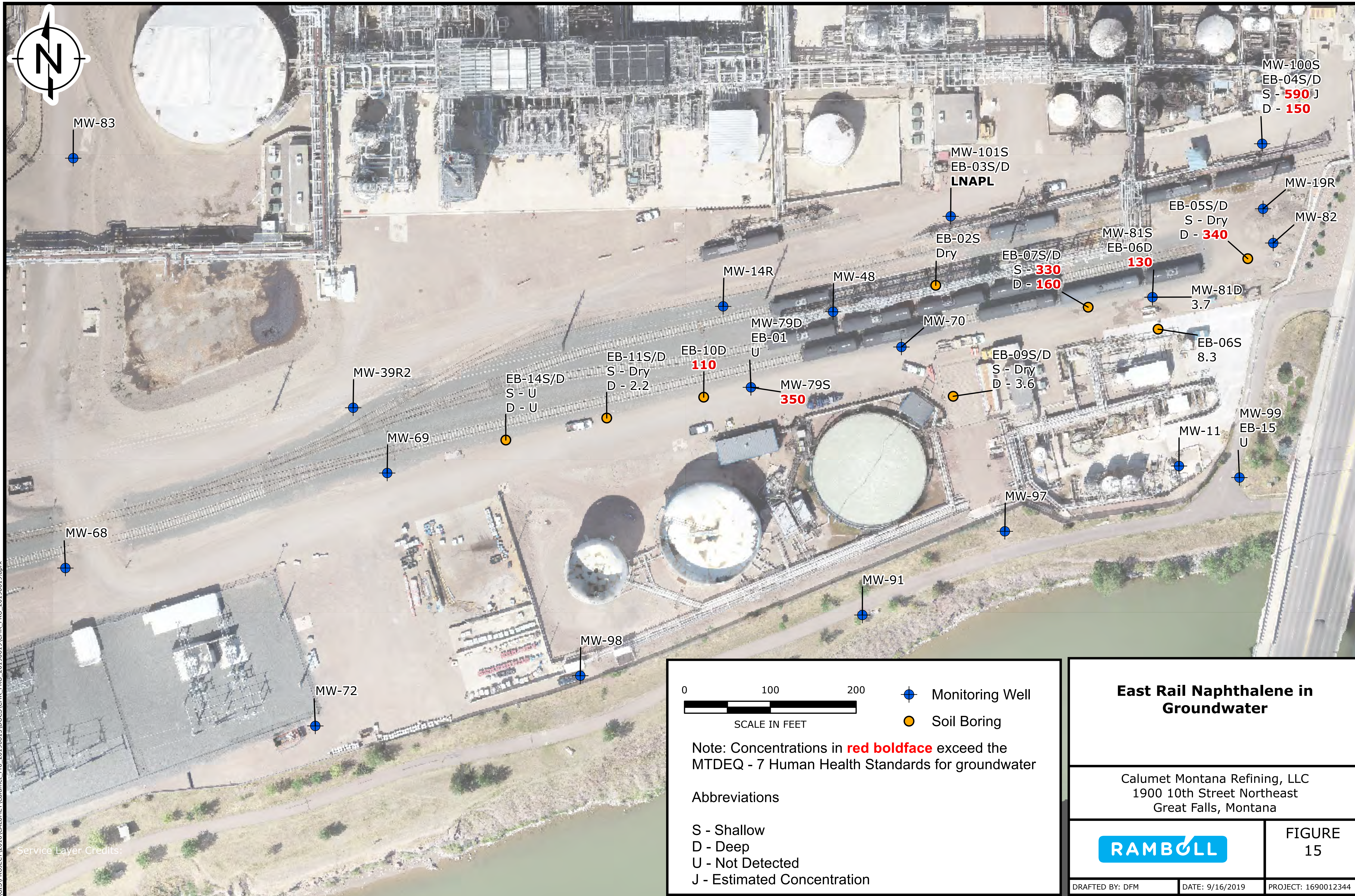
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 14

DRAFTED BY: DFM | DATE: 9/16/2019 | PROJECT: 1690012344

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



0 100 200
SCALE IN FEET

Monitoring Well

Soil Boring

Note: Concentrations in **red boldface** exceed the MTDEQ - 7 Human Health Standards for groundwater

Abbreviations

S - Shallow
D - Deep
U - Not Detected
J - Estimated Concentration

East Rail Naphthalene in Groundwater

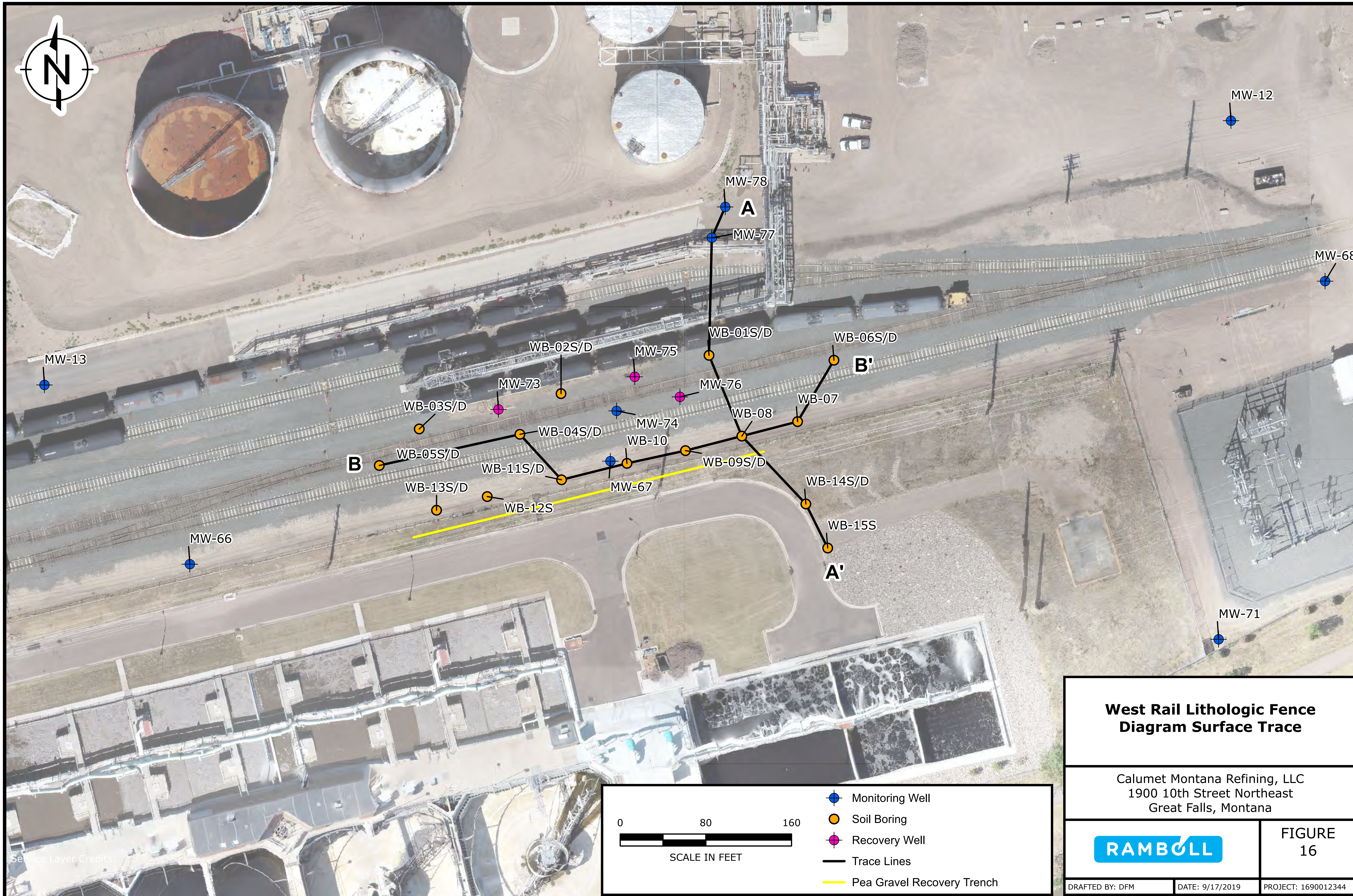
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 15

DRAFTED BY: DFM | DATE: 9/16/2019 | PROJECT: 1690012344

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



West Rail Lithologic Fence Diagram Surface Trace

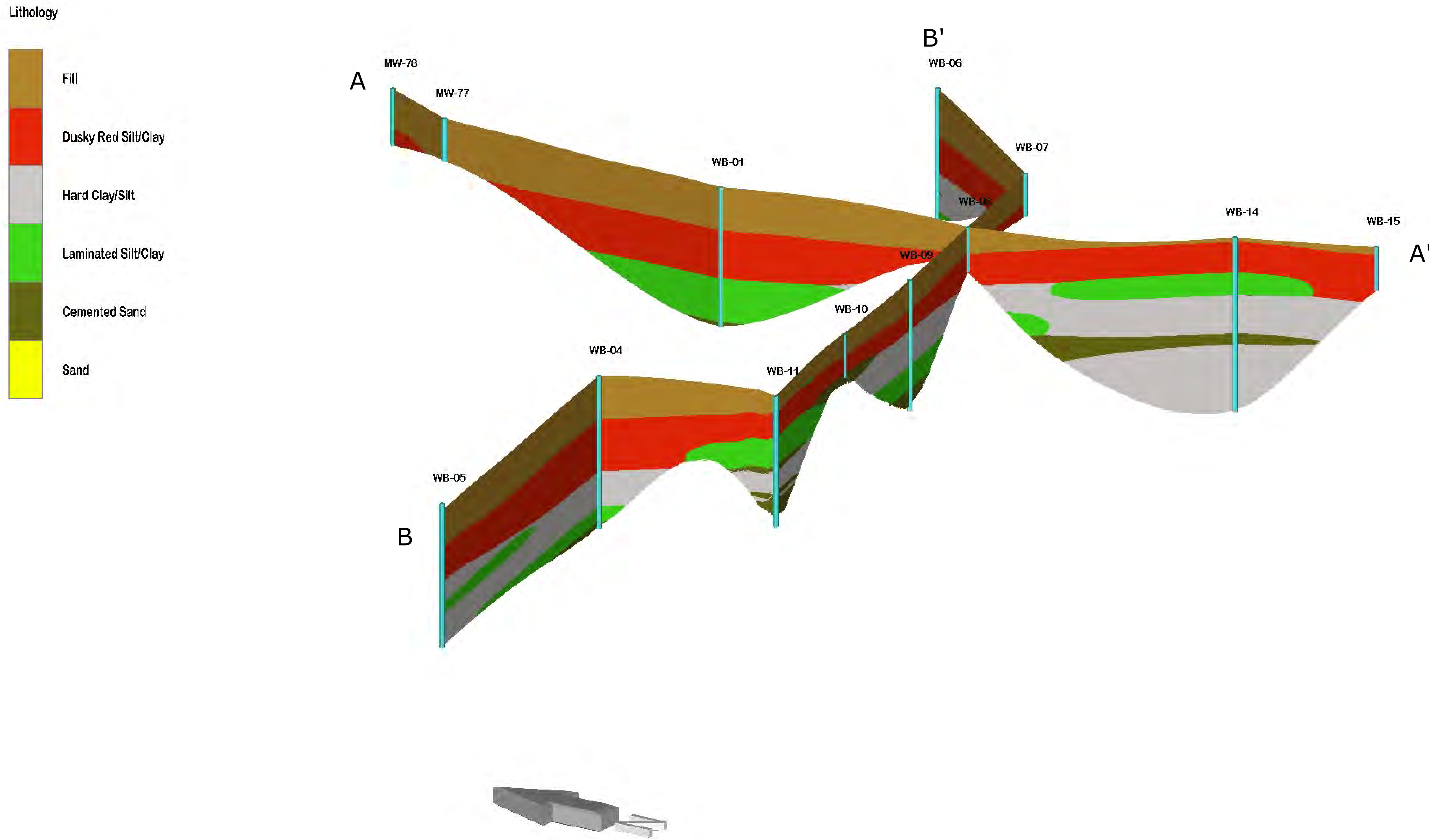
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 16

DRAFTED BY: DFM | DATE: 9/17/2019 | PROJECT: 1690012344

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



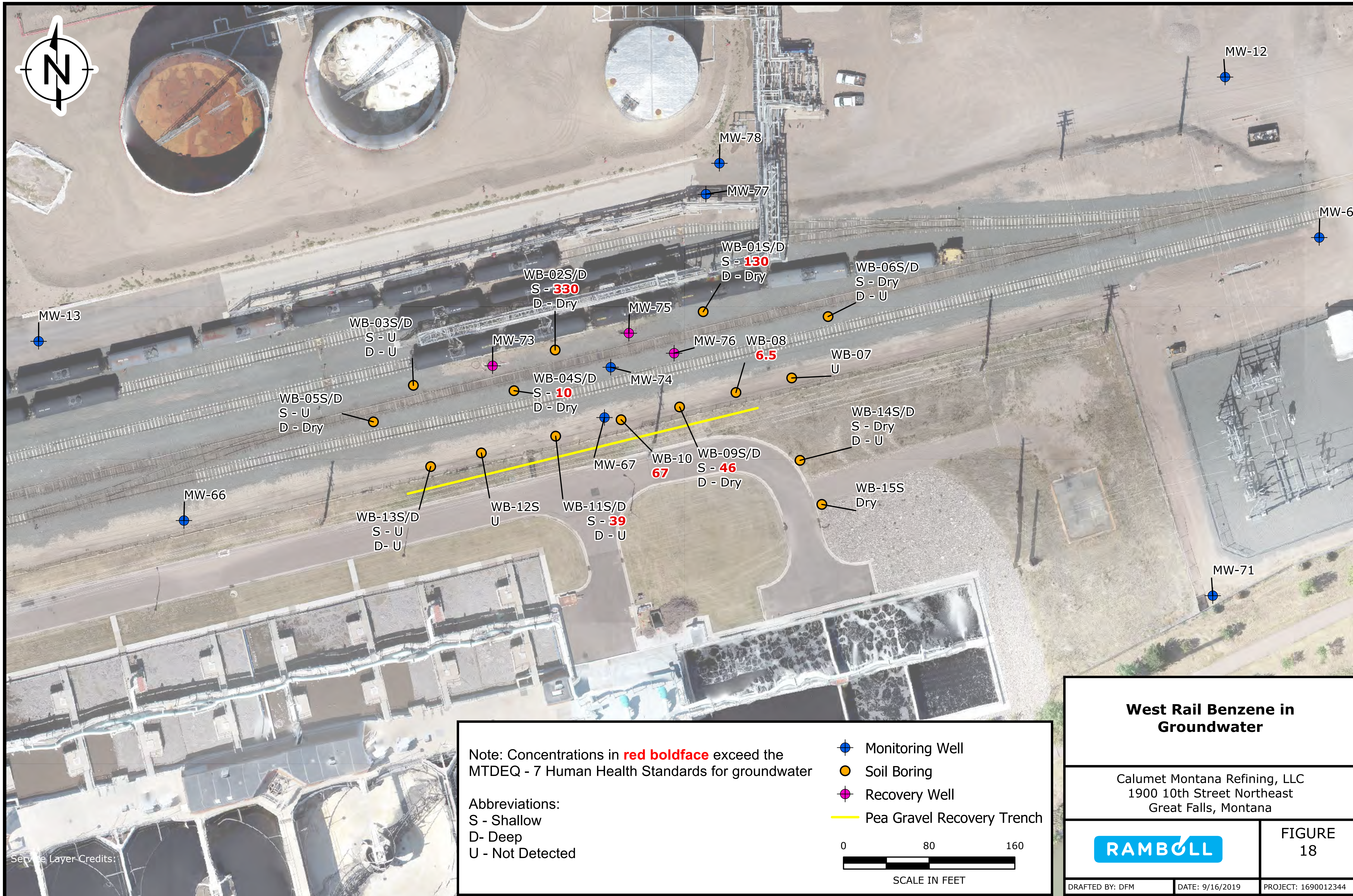
RAMBOLL

DRAFTED BY: MKE | DATE: 9/7/2019

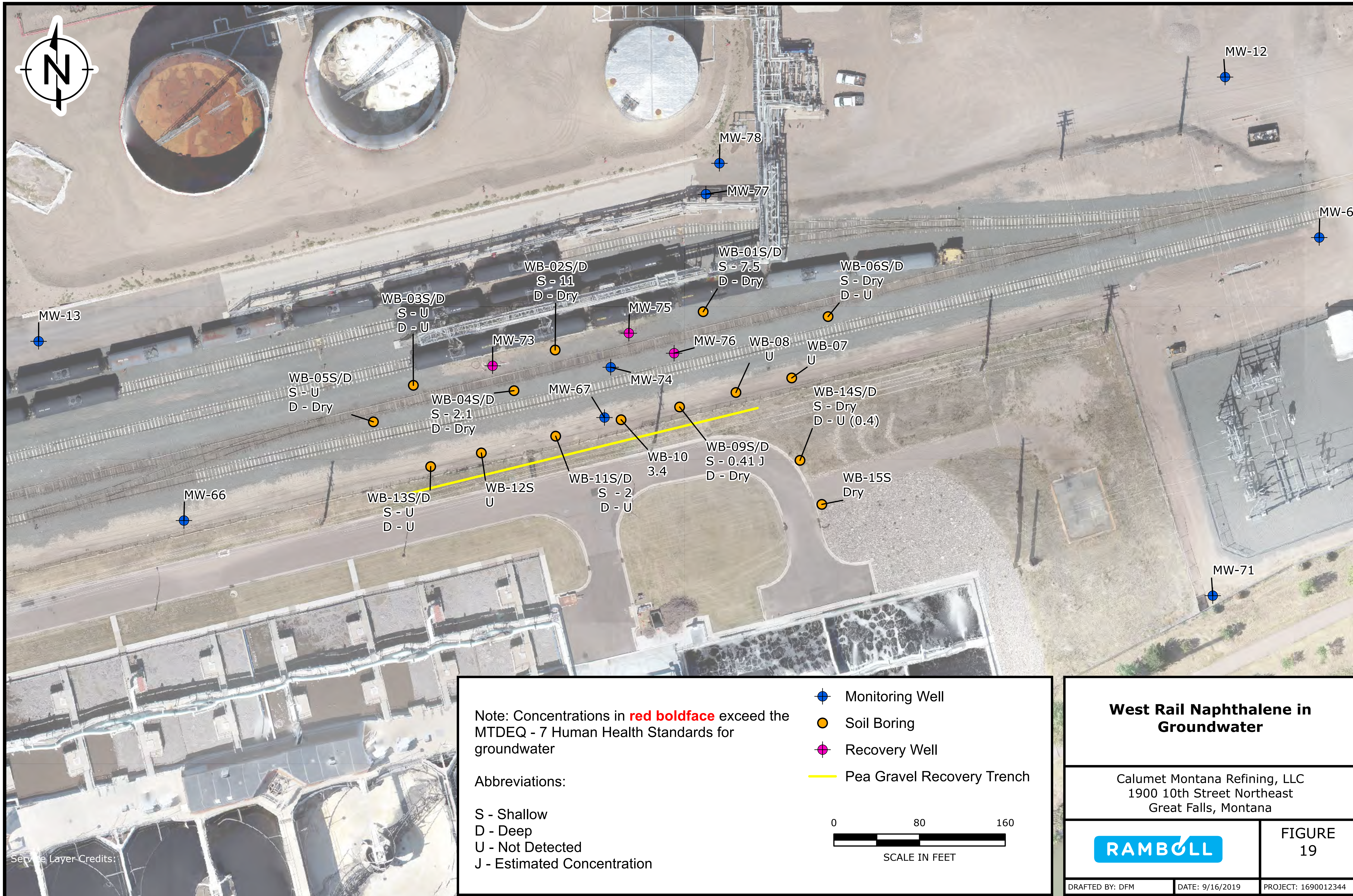
West Rail Lithology
Calumet Montana Refinery
Great Falls, Montana

FIGURE
17

PROJECT:1690012344



D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



Note: Concentrations in **red boldface** exceed the MTDEQ - 7 Human Health Standards for groundwater

Abbreviations:

S - Shallow
D - Deep
U - Not Detected
J - Estimated Concentration

Monitoring Well
Soil Boring
Recovery Well
Pea Gravel Recovery Trench

0 80 160
SCALE IN FEET

West Rail Naphthalene in Groundwater

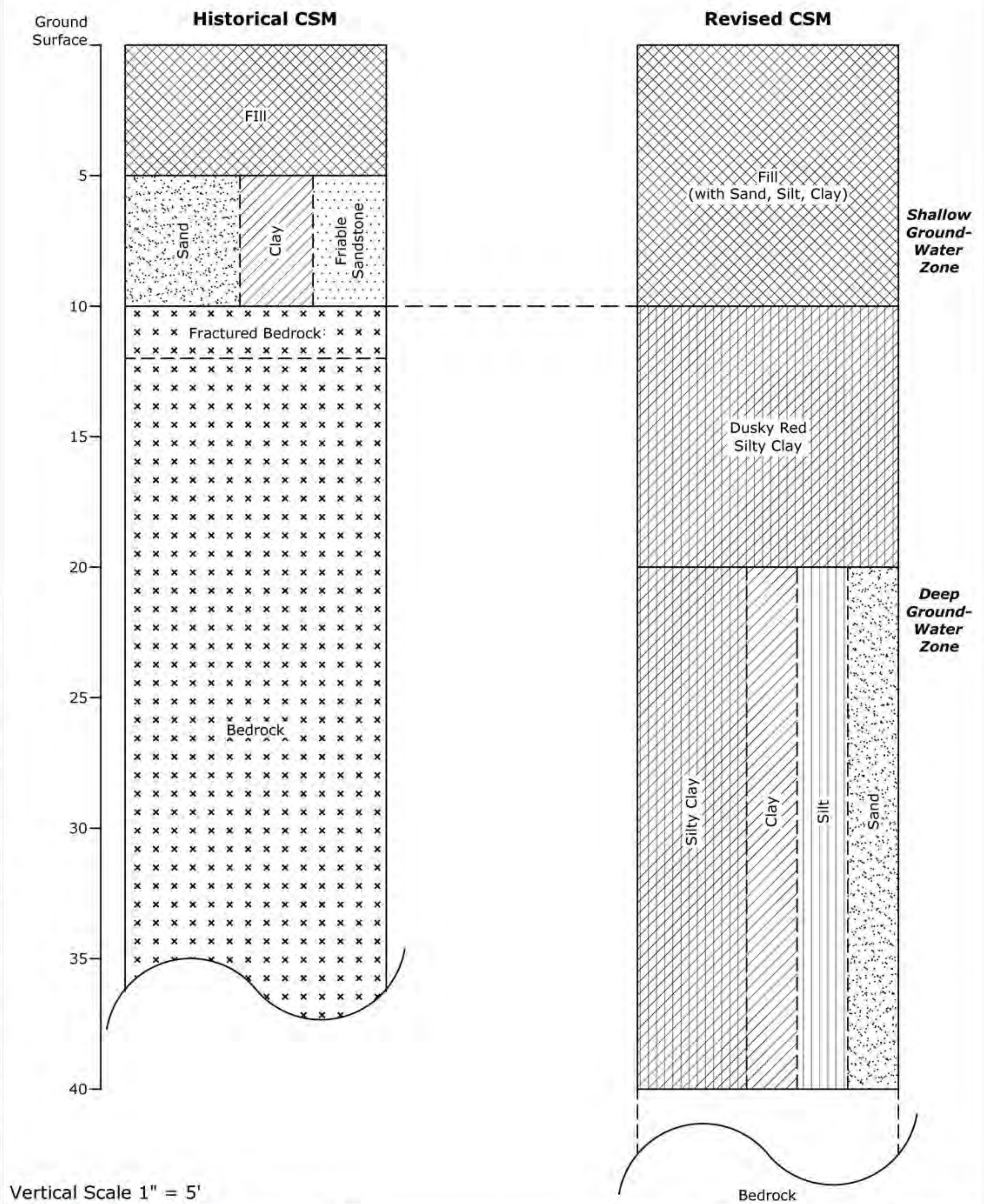
Calumet Montana Refining, LLC
1900 10th Street Northeast
Great Falls, Montana

RAMBOLL

FIGURE 19

DRAFTED BY: DFM | DATE: 9/16/2019 | PROJECT: 1690012344

D:\GIS\PROJECT\2018\CALUMET\Calumet_Pro_20190815\DOCS\CMR_PRO_20190619\CMR_PRO_20190619.aprx



RAMBOLL

CMR Lithology - Typical Stratigraphic Column Schematic

FIGURE **20**

DRAFTED BY: APR | DATE: 9/25/19

1690012344

L:\Loop Project Files_CAD\1690012344_Calumet_003\RIAIM Investigation\20_CMR Lithology-Typ Stratigraphic Column Schematic.dwg