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ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

North Pole Terminal
North Pole, Alaska
DEC File Number 100.38.090

January 8, 2020

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ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AHL	Arctic Home Living
Arcadis	Arcadis U.S., Inc.
AWS	alternative water solution
Barr	Barr Engineering Company
City	City of North Pole, Alaska
CSM	conceptual site model
FHRA	Flint Hills Resources Alaska, LLC
GAC	granular activated carbon
Offsite PMP	Offsite Groundwater Sulfolane Plume Monitoring Plan
Offsite SAP	Offsite Sampling and Analysis Plan
Pioneer Wells	Pioneer Wells Inc.
POE	point-of-entry
PWS	public water system
QA	quality assurance
QC	quality control
report	Annual 2019 Offsite Plume Monitoring Report
reporting period	November 8, 2018 through November 7, 2019
site	North Pole Terminal located on H and H Lane in North Pole, Alaska
Water Wagon	H20 2 U, LLC
WQA	Water Quality Association
µg/L	micrograms per liter

1 INTRODUCTION

Arcadis U.S., Inc. (Arcadis) prepared this Annual 2019 Offsite Plume Monitoring report (report) for groundwater located downgradient of the North Pole Terminal, located on H and H Lane in North Pole, Alaska (site). This report summarizes offsite field activities completed in areas beyond the site boundary from November 8, 2018 through November 7, 2019 (reporting period), as described in Section 2.

The data, analyses, and conclusions presented in this report are the product of a collaborative effort among a consulting team engaged by Flint Hills Resources Alaska, LLC (FHRA) to undertake the work discussed in this report. The team includes qualified professionals in a variety of technical disciplines from three environmental consulting firms: Arcadis, Shannon & Wilson, Inc., and Barr Engineering Co. (Barr). FHRA engaged these consulting firms to perform various tasks for the project. Pursuant to 18 Alaska Administrative Code (AAC) 75.335(c) (1), this report was prepared and submitted by Qualified Environmental Professionals. Samples were collected and analyzed in accordance with 18 AAC 75.355(a). Point-of-entry (POE) system sampling conducted by Arctic Home Living (AHL) was supervised by FHRA and its consultants, and the resulting sample data were reviewed and used in reports prepared by a Qualified Environmental Professional.

The site, offsite area, and their physical settings are described in the conceptual site model (CSM), which was presented as Appendix A of the Onsite Site Characterization Report – 2013 Addendum (Arcadis 2013). The site is shown on Figure 1-1. Offsite monitoring well locations are presented on Figure 1-2. Private well locations are shown on Figure A-1 of Appendix A.

This document presents the annual reporting following methods and plans summarized in the Offsite Groundwater Sulfolane Plume Monitoring Plan (Offsite PMP; Arcadis 2017). Annual reporting for the Alternative Water Solutions Program is also included in this report. Sampling of POE systems that remain in operation will conclude by the end of 2020 now that construction the City of North Pole, Alaska's (City's) expanded public water system (PWS) is completed, after which the alternative water supply systems will be phased out (Arcadis 2017).

2 CURRENT GROUNDWATER MONITORING PROGRAM AND METHODS

In June 2017, the Offsite PMP (Arcadis 2017) was approved by the Alaska Department of Environmental Conservation (ADEC). The monitoring network and frequency for sampling offsite monitoring wells identified in the Offsite PMP (Arcadis 2017) were updated in May 2018 (ADEC 2018) and are shown on Figure 2-1. Historical groundwater monitoring data are included in Appendix B.

2.1 Plume Monitoring Plan – Monitoring Well Sampling

Annual groundwater monitoring in 2019 was conducted based on the network of monitoring wells and private wells listed in the updated sulfolane monitoring network (ADEC 2018) and in accordance with methods included in the Offsite Sampling and Analysis Plan (Offsite SAP; provided as Appendix A of the Offsite PMP [Arcadis 2017]). Table 2-1 summarizes the offsite field activities completed during the reporting period. Offsite monitoring well locations are shown on Figure 1-2. The plume monitoring locations (ADEC 2018) are shown on Figure 2-1. In 2019, wells scheduled for sampling annually or every 2 years were sampled during the reporting period.

Groundwater monitoring data are used to monitor offsite dissolved-phase sulfolane concentrations and groundwater movement.

2.2 Plume Monitoring Plan – Private Well Sampling

During the reporting period, samples were collected from private wells identified in the updated Offsite PMP (ADEC 2018). Results are discussed in Section 3.2.

Private wells PW-266, PW-268, PW-591, PW-612, PW-627, PW-759, PW-864, PW-865, PW-914, PW-1450, PW-1458, and PW-2205 could not be sampled during the reporting period. Private wells PW-266, PW-268, PW-864, PW-865, PW-914, and PW-1450 were not sampled either due to owner refusal or following repeated unanswered attempts at contact. PW-591, PW-612, PW-627, PW-759, and PW-2205 could not be sampled because the well was disconnected prior to the sampling attempt. A sample from private well PW-1458 was not collected during the reporting period because the well was inoperable; however, the property has a second water well (PW-972), which was sampled. PW-972 is the primary water well for the property and is included in the updated sulfolane monitoring network. Potential access issues were anticipated during design of the well network identified in the Offsite PMP (Arcadis 2017; ADEC 2018); multiple wells were selected for sampling in key areas of interest to ensure that adequate data were collected to monitor the plume. Data from the wells sampled provided adequate representation of the plume to meet the objectives of the Offsite PMP (Arcadis 2017; ADEC 2018).

2.3 Monitoring Well Maintenance Activities

Monitoring wells MW-322-15, MW-322-150, and MW-335-41 were destroyed during the reporting period due to road construction. Monitoring wells MW-322-15 and MW-322-150 are located west of the sulfolane

plume and were not scheduled to be sampled in the updated Offsite PMP (ADEC 2018); however, the monitoring wells were part of the gauging network. Monitoring well MW-335-41 is located downgradient of the northwestern extent of the sulfolane plume and was not scheduled to be sampled in the updated Offsite PMP (ADEC 2018). These wells will not be replaced.

Well monuments were reinstalled at MW-165A-15, MW-165B-50, and MW-328-150. Monitoring wells MW-165-A-15 and MW-165B-50 were also redeveloped during the reporting period. Minor maintenance activities were performed as needed for the remaining offsite wells during the reporting period.

3 GROUNDWATER MONITORING RESULTS

Offsite groundwater impacts have been characterized and continue to be monitored through the analysis of water-level gauging data and/or groundwater samples collected from offsite monitoring wells and private wells. Groundwater level monitoring is conducted every 5 years in accordance with the Offsite PMP (Arcadis 2017; ADEC 2018). Offsite monitoring well field parameters for the annual plume monitoring event are summarized in Table 3-1 and laboratory analytical data are summarized in Tables 3-2 and 3-3.

Historical data for groundwater elevation, sulfolane analyses, and private well analyses are included in Appendix B. Laboratory reports are provided in Appendix C. A data quality evaluation, including ADEC quality assurance (QA)/quality control (QC) checklists, is included in Appendix D. Field data sheets are included in Appendix E.

3.1 Groundwater Elevation

The 5-year monitoring event was last conducted in 2017. Historical depth to water measurements and groundwater elevation data are included in Appendix B.

3.2 Sulfolane Distribution in Offsite Groundwater

During the annual 2019 groundwater monitoring event, samples were collected and submitted for sulfolane analysis from the updated offsite monitoring well and private well networks (ADEC 2018). The offsite monitoring well sulfolane data are presented in Table 3-2. Results of the private well sampling are presented in Table 3-3. Offsite sulfolane distribution are shown on Figures 3-1, 3-2, and 3-3. Historical and current sulfolane analytical results are included in Appendix B.

Analytical results indicated first-time (initial) detections in monitoring well MW-328-151 and private well PW-870 during the reporting period. The residence associated with private well PW-870 was already supplied with interim bottled water and will be eligible to connect to the PWS.

Data from monitoring and private wells included in the updated Offsite PMP (ADEC 2018) were evaluated for potential sulfolane concentration trends through 2019. Statistical and graphical evaluations of the data are discussed in Section 3.3 and included in Appendix F.

3.2.1 Subpermafrost and Suprapermafrost Aquifers

Figure 3-1 shows the combined 2019 sulfolane analytical results from offsite monitoring wells and private wells that are in both the suprapermafrost and subpermafrost aquifers. This figure includes private wells that do not have available or reliable well construction information and, therefore, cannot be designated to either the suprapermafrost or subpermafrost aquifer.

3.2.1.1 Offsite Sulfolane Distribution in the Suprapermafrost Aquifer

Offsite monitoring wells were sampled during third quarter 2019. A subset of these wells may indicate a mixing zone between the suprapermafrost and subpermafrost aquifers (Arcadis 2013; hereinafter referred to as the inferred mixing zone), as shown on Figures 3-2 and 3-3, due to an absence of permafrost beneath Badger Slough. Monitoring well results from the annual offsite plume monitoring event are presented in Table 3-2. Historical data are provided in Appendix B.

Overall distribution of offsite suprapermafrost sulfolane concentrations are consistent with the CSM (Arcadis 2013).

3.2.1.2 Offsite Sulfolane Distribution in the Subpermafrost Aquifer

The updated Offsite PMP (ADEC 2018) included sampling of select subpermafrost wells during third quarter 2019. Some suprapermafrost monitoring wells, which were installed in the mixing zone, were determined to have concentrations representative of the subpermafrost aquifer and are included as part of the subpermafrost dataset. Figure 3-3 presents sulfolane data collected during the annual offsite plume monitoring event in 2019 for offsite monitoring wells in the mixing zone and private wells installed through the permafrost in the deep aquifer system.

Consistent with past monitoring results, the greatest sulfolane concentration in wells located within the subpermafrost aquifer during the reporting period was detected in PW-1230 (420 micrograms per liter [µg/L], with a duplicate sample result of 468 µg/L, on July 19, 2019), which is located approximately 1 mile northwest of the northern site boundary. Note that these are the lowest concentrations reported for this well in its period of record. Private well PW-1230 has a total depth of approximately 231 feet below ground surface and is not used as a drinking water source. Overall distribution of offsite subpermafrost sulfolane concentrations are consistent with the CSM (Arcadis 2013).

3.3 Statistical Analysis of Offsite Sulfolane Data

Statistical and graphical evaluations of sulfolane concentration trends, using Mann-Kendall trend analysis, are conducted annually for monitoring and private wells included in the well network identified in the updated Offsite PMP (ADEC 2018) and sampled during the reporting period. This analysis is conducted to evaluate plume migration and stability, and to help evaluate if the well network identified in the updated Offsite PMP (ADEC 2018) is protective of residences and businesses located outside the area to be served by the PWS.

The Monitoring and Remediation Optimization System software, developed by the Air Force Center for Engineering and the Environment for Mann-Kendall trend analysis, was applied to offsite groundwater monitoring data collected during the reporting period from monitoring wells and private wells.

The analysis trends are expressed as probably increasing, increasing, probably decreasing, decreasing, stable, or no trend. Results of the Mann-Kendall trend analysis for wells included in the updated Offsite PMP (ADEC 2018) are presented in Tables F-1 and F-2 and on Figures F-1A, F-1B, and F-1C of Appendix F and summarized in the table below.

Parameter/Trend	Monitoring Wells	Suprapermafrost Private Wells	Subpermafrost Private Wells	Private Wells with Unknown Depth
Number of wells	39	46	16	51
All results nondetect [a]	18	38	11	40
Insufficient data points [a]	1	0	2	6
Probably decreasing	1	0	0	0
Decreasing	9	0	1	0
Probably increasing	0	0	0	0
Increasing	7[b]	2	2	0
Stable	3	3	0	2
No trend	0	3	0	3

Note:

[a] Wells with insufficient data points for the statistical analysis (less than four points), but with all results less than detection limits, are listed under "All results nondetect."

[b] Six offsite monitoring wells in the suprapermafrost aquifer and one offsite monitoring well in the subpermafrost aquifer displayed increasing trends during the reporting period

Wells with increasing and decreasing trends that were screened within the suprapermafrost and the subpermafrost aquifers are discussed below.

3.3.1 Suprapermafrost Aquifer

Six offsite monitoring wells in the suprapermafrost aquifer displayed increasing trends during the reporting period. Concentration trend plots are shown on Attachment F-1 of Appendix F. Of these, monitoring wells MW-346-15 and MW-346-65 are located within the inferred mixing zone; therefore, these wells may be influenced by subpermafrost concentrations. In general, the monitoring wells with increasing trends are located at the leading edge of the plume, including monitoring well MW-352-40. The trend in MW-185C-120 is not visually apparent; results have all been nondetect or single-digit, estimated values. Visual evaluation of the trend charts indicates that the increasing trends indicated by the Mann-Kendall analyses may no longer be occurring at these wells:

- In MW-166B-30, concentrations have been fluctuating to stable since second quarter 2015.
- In MW-167B-35, concentrations have been decreasing since second quarter 2016.

Nine monitoring wells in the suprapermafrost aquifer displayed decreasing trends. Results of the Mann-Kendall trend analyses were evaluated and compared to visual evaluation of the trend charts; this evaluation confirms that sulfolane concentrations in these wells are continuing to decrease. The monitoring well locations with decreasing trends are located throughout the plume, with the majority of the wells located in the central and proximal portions of the detectable sulfolane plume. The decreasing

sulfolane concentration trends in wells in the central and proximal portions of the plume likely represent the effects of historical source control and remediation efforts at the site.

Two private wells identified as being screened within the suprapermafrost aquifer displayed increasing trends during the reporting period. The trend in private well PW-972 is not visually apparent on the concentration trend plots included as Attachment F-1 of Appendix F; results have all been nondetect or single-digit, estimated values. The increasing trend identified in private well PW-871 was confirmed through a visual observation of the concentration trend plots; the highest values in samples from this well are single-digit, estimated values (Attachment F-1 of Appendix F). These private wells are located along the leading edge of the offsite suprapermafrost sulfolane plume.

Review of current data from the updated offsite plume monitoring network indicates that the locations of increasing and decreasing trends within the suprapermafrost aquifer are in areas where such trends are expected and are consistent with the CSM (Arcadis 2013). The trend data also support that monitoring of the current offsite plume network of suprapermafrost wells is protective of residences and businesses located outside of the area to be served by the PWS.

3.3.2 Subpermafrost Aquifer

Mann-Kendall trends for wells identified as being screened in the subpermafrost zone are shown on Figure F-1C of Appendix F. The monitoring wells shown on this figure were installed in a thawed zone along Badger Slough. These monitoring wells are located in the inferred mixing zone of the subpermafrost and suprapermafrost aquifers and appear to be representative of subpermafrost aquifer conditions.

Three locations show increasing trends. MW-347-150 is in an area of likely suprapermafrost and subpermafrost mixing within the detectable subpermafrost plume. Note that the result at this location decreased from 2018 to 2019. Sulfolane concentrations in private wells PW-464 and PW-1230 also show increasing trends, as discussed in Section 3.2.1.2. Well PW-464 is located in the northeastern portion of the offsite plume. A visual evaluation of the trend chart for PW-464 confirms the increasing trend. Private well PW-1230 is located near the southern extent of the offsite plume. Visual evaluation of the trend chart for PW-1230 (Attachment F-1 of Appendix F) indicates that the increasing trend indicated by the Mann-Kendall analysis may no longer be occurring, and the concentrations in this well may be stabilizing or declining.

Review of the current data from the updated plume monitoring network indicates that the locations of increasing trends within the subpermafrost aquifer are in areas where such trends are expected and are consistent with the CSM (Arcadis 2013).

3.4 Groundwater Monitoring Conclusions

Distribution of offsite sulfolane concentrations in both the suprapermafrost and subpermafrost aquifers is consistent with the CSM (Arcadis 2013). Locations within the plume that indicate increasing or decreasing trends are in areas where such trends are expected, based on the CSM (Arcadis 2013). These trend data support that monitoring of the current network of wells (ADEC 2018) is protective of residences and businesses located outside the area to be served by the PWS.

4 ALTERNATIVE WATER SOLUTIONS

In 2019, 241 connections were made to the City's expanded PWS. Of the 241 connections, 172 were made to locations previously receiving alternative water solutions (AWSs). The AWSs at these locations have been discontinued. Approximately 97% of the feasible connections planned for 2019 have been completed.

Concurrent to initiating the connection of properties to the PWS, FHRA continued providing AWSs as necessary to the properties affected and potentially affected by the plume of dissolved-phase sulfolane identified in various studies performed by FHRA and ADEC. These AWSs include delivery of bottled water, bulk water tank systems, POE in-home water treatment systems, and interim bottled water. The POE maintenance monitoring is not part of the monitoring network identified in the updated Offsite PMP (ADEC 2018) and will be discontinued by the end of 2020 now that the City's PWS is available for connection.

All known private well locations are shown with well identifiers on Figure A-1 of Appendix A. The most recent sulfolane results for all wells sampled during the reporting period are shown on Figure A-2 of Appendix A.

4.1 Alternative Water Solution Property Information

Through 2019, 174 long-term AWSs remain in place at 146 properties as presented in Table G-1 of Appendix G (note that some properties have more than one AWS). AWSs installed to date are shown on Figure G-1 of Appendix G and the number of current remaining AWSs are listed below:

- POE treatment systems (77)
- Bulk water tanks (50)
- Locations with long-term bottled water options (19).

In addition to the AWSs provided above, in 2019, interim bottled water continues to be supplied to 203 addresses (some addresses have multiple residences). These addresses are affected properties inside the plume where the owner did not select a long-term AWS when previously offered, properties where sulfolane has not been detected, or properties located within or near the edge of the plume. With the completion of the PWS, these interim bottled water deliveries will be discontinued by the end of 2020.

Twenty-seven garden tanks have also been provided to affected properties. With the completion of the PWS, these garden water tank deliveries will be discontinued by the end of 2020.

A routine process was followed in 2019 to identify new construction or property transactions within the plume or at or near the edge of the sulfolane plume area.

4.2 Private Well Water Data Summary

Private wells with POE systems are monitored during each granular activated carbon (GAC) changeout. A map showing private well locations is provided on Figure A-1 of Appendix A. Table G-2 of Appendix G presents results for raw water (Port A) and treated water (Port C or Port D), and identifies commercial

locations. Analytical laboratory reports and ADEC QA/QC checklists for 2019 are provided in Appendices C and D, respectively.

No initial groundwater samples were collected from private wells during the reporting period. Results from previously sampled private wells are included in Appendix B.

4.3 Point-of-Entry System Performance

POE treatment systems installed at homes use sediment filters, a softener, ultraviolet filter, and GAC vessels to remove sulfolane. The POE treatment systems also include a water meter that transmits a remote signal to allow tracking of the water usage to schedule routine maintenance, and a series of sampling ports that allow sampling of the raw and treated water during service visits. AHL maintains the POE treatment systems.

4.3.1 Treatment System Performance

The collected data verify that the POE systems are performing as designed to properly treat the groundwater prior to its use (Table G-2 of Appendix G). The data also confirm that the systems are being properly operated and maintained.

Sulfolane results for the final treated water samples (Port D) were all less than detection limits during the reporting period.

4.3.2 Volume of Water Treated

Water usage data were collected monthly at each POE system in 2019 to confirm water usage rates and to determine the GAC replacement schedule. This data collection is completed via remote reading of a flow totalizer unit by AHL personnel. Water usage rates were calculated and compared to the treatment volumes included in the Water Quality Association (WQA) certification, as described in the Alternative Water Solutions Program – Management Plan (Barr 2014) and used to schedule GAC vessel replacements. Water usage in 2019 for each POE system is summarized in Table G-4 of Appendix G and totals approximately 5,104,986 gallons for 2019.

Through 2019, the POE systems have treated approximately 56,550,000 gallons of water.

4.3.3 Granular Activated Carbon Usage

As noted in Section 4.4.2, scheduling of GAC changeouts is determined by the water usage rate and raw water sulfolane concentration in accordance with the WQA certification. During the reporting period, changeouts were completed for 566 carbon vessels, resulting in a total volume of 1,415 cubic feet of GAC used.

4.4 Bottled and Bulk Water Supply Information

As described in Section 4.2, bottled or bulk water was provided to residents who selected these options as their AWS or are receiving interim bottled water. Additionally, water is provided to residences with a

garden tank. The source and delivery schedule for the bottled and bulk water supplies is discussed below.

4.4.1 Bottled Water

In 2019, bottled water was delivered weekly by Spring Alaska. Spring Alaska receives the water from Twin Springs Water (Alaska PWS ID # AK312813).

Prior to delivery, Spring Alaska contacts residents weekly to confirm the number of bottles required. This allows residents receiving this service to manage delivery for their individual needs from week to week. In 2019, 16,529 gallons of water were delivered to these locations. This water volume is estimated based on water delivery invoiced in 2019. Nineteen locations selected long-term bottled water as their AWS. In 2019, interim bottled water was provided to 203 locations where the owner did not select a long-term AWS when previously offered, where sulfolane has not been detected, or are within or near the edge of the sulfolane plume.

4.4.2 Bulk Water Tanks

In 2019, homeowners had the option of receiving bulk water from two local suppliers who are permitted by the State of Alaska: Pioneer Wells Inc. (Pioneer Wells) and H20 2 U, LLC (Water Wagon). Pioneer Wells sources their water from either a well in Fairbanks (the water is subsequently treated in a water softener system prior to delivery [PWS ID #AK2310714]), or from an untreated well located at Fox Spring (PWS ID #AK2312156) upon request from homeowners. Water Wagon sources treated water from College Utilities in Fairbanks (PWS ID# AK2310900). A total of 2,162,652 gallons of water were provided to the 50 bulk water tanks in 2019. Water volumes provided are estimated based on water deliveries invoiced in 2019.

In 2019, water was delivered weekly to commercial properties and weekly or biweekly to residential properties, as needed. One commercial greenhouse (Hawks Greenhouse) is located at 2260 Old Richardson Highway and is within the sulfolane-impacted area. Four bulk water tanks were previously installed at this location with a total storage capacity of 10,000 gallons. The bulk water tanks are filled by Pioneer Wells, with water sourced from the untreated well located at Fox Spring (PWS ID #AK2312156).

4.4.3 Garden Tanks

For residents who chose to have a garden tank installed, up to 2,000 gallons of water per season have been provided. In 2019, the water was supplied by Pioneer Wells, with water sourced from an untreated well located at Fox Spring (PWS ID# AK2312156), an untreated well located in Fairbanks (PWS ID# A2310714), or treated water from Fairbanks (PWS ID# AK2110714). A total of 12,223 gallons of water were provided to 27 garden tanks in 2019.

5 ALTERNATIVE WATER SOLUTION PROGRAM UPDATES

In 2019, 241 properties were added to the City's PWS; and172 AWSs associated with these locations have been discontinued, including:

- POE treatment systems (86)
- Bulk water tanks (70)
- Locations with long-term bottled water options (16).

On December 5, 2018 and December 4, 2019, the City, ADEC, and FHRA held open houses to discuss the progress of the City's expanded PWS and begin signups for the 2019 and 2020 seasons, respectively.

5.1 Description of Issues, Problems, or Complaints

A few minor issues in 2019 were addressed as follows:

- Several homeowners complained about frozen systems. The systems were subsequently thawed and repaired, as needed.
- Several homes reported broken or faulty fill pipes or pumps. The equipment was replaced or corrected, as needed.
- A homeowner complained about condensation from the water system leaking onto the electrical box, causing rust. Personnel investigated the condensation and added additional insulation to the cold-water pipes to correct the problem.
- A homeowner complained about flooding in a basement following a recent tank refill. Personnel investigated the situation and found no obvious issues outside of an overfill.
- A homeowner complained about flooring issues around the GAC system. Personnel investigated the situation and performed flooring repairs, including floor and subfloor demolition and replacements.
- A homeowner complained about flooding in a basement following recent tank refill. Personnel investigated the situation and determined that the excess water was from a clogged sewer line and was therefore not an AWS issue. The property manager was notified.
- A leaking pipe and sinkhole were reported by a water company during a home visit. Personnel investigated the situation and determined that the fill tube was cracked, allowing water to leak and cause settlement in the surrounding area. The issue was corrected with new pipe installation, reinsulating, and additional fill.

5.2 Program Changes

There were no significant AWS program changes in 2019 outside of those previously discussed.

5.3 Water Quality Association Certification

The POE systems are maintained in accordance with a certification through the WQA. The current WQA certification can be viewed at: https://www.wqa.org/Find-Products/ctl/Detail/mid/1054/cid/RICHARDS_DISTRIBUTIN/sid/3/keyword/richards%20distributing

6 CONCLUSIONS

Annual groundwater monitoring in 2019 was conducted based on the network of monitoring wells and private wells identified in the updated sulfolane plume monitoring network (ADEC 2018) and in accordance with methods included in the Offsite SAP (Arcadis 2017). The 2019 event included wells scheduled for sampling annually and every 2 years.

Based on the monitoring data collected throughout the reporting period, the plume behavior is consistent with previous site characterizations and the CSM (Arcadis 2013). An evaluation of sulfolane trends in the groundwater monitoring network that includes both monitoring wells and private wells shows that most of the wells with decreasing trends are located near the site boundary and center of the plume, while wells showing increasing trends are concentrated along the leading edge and distal portions of the plume. Locations within the plume that indicate increasing or decreasing trends are in areas where such trends are expected, based on the CSM (Arcadis 2013). These trend data support that monitoring of the current offsite plume network of wells is protective of residences and businesses located outside of the area to be served by the PWS.

In 2019, 241 properties were added to the City's PWS. Construction of the main line of the City's PWS is complete; construction of service lines is ongoing and is anticipated to be generally completed in 2020.

In 2019, drinking water was provided to impacted residents and businesses through delivery of bottled water, delivery of bulk water, and operation of POE treatment systems. The total volumes of clean water provided by AWSs in 2019 are summarized below:

- Bottled water (16,529 gallons).
- Bulk water (2,162,652 gallons), including delivery to residences, businesses, a greenhouse, and garden tanks.
- Treatment of approximately 5,104,986 gallons of water through POE treatment systems.

Monitoring under the Offsite PMP will continue in 2020. The results from 2020 monitoring activities will be submitted in an annual report in January 2021.

7 REFERENCES

ADEC. 2018. North Pole – 2018 PMP Network and Onsite Reporting Schedule. Email correspondence between ADEC and FHR. May 17.

Arcadis. 2013. Offsite Site Characterization Report – 2013 Addendum. December 20.

Arcadis. 2017. Offsite Groundwater Sulfolane Plume Monitoring Plan. June.

Barr. 2014. Alternative Water Solutions Program – Management Plan. October.

TABLES

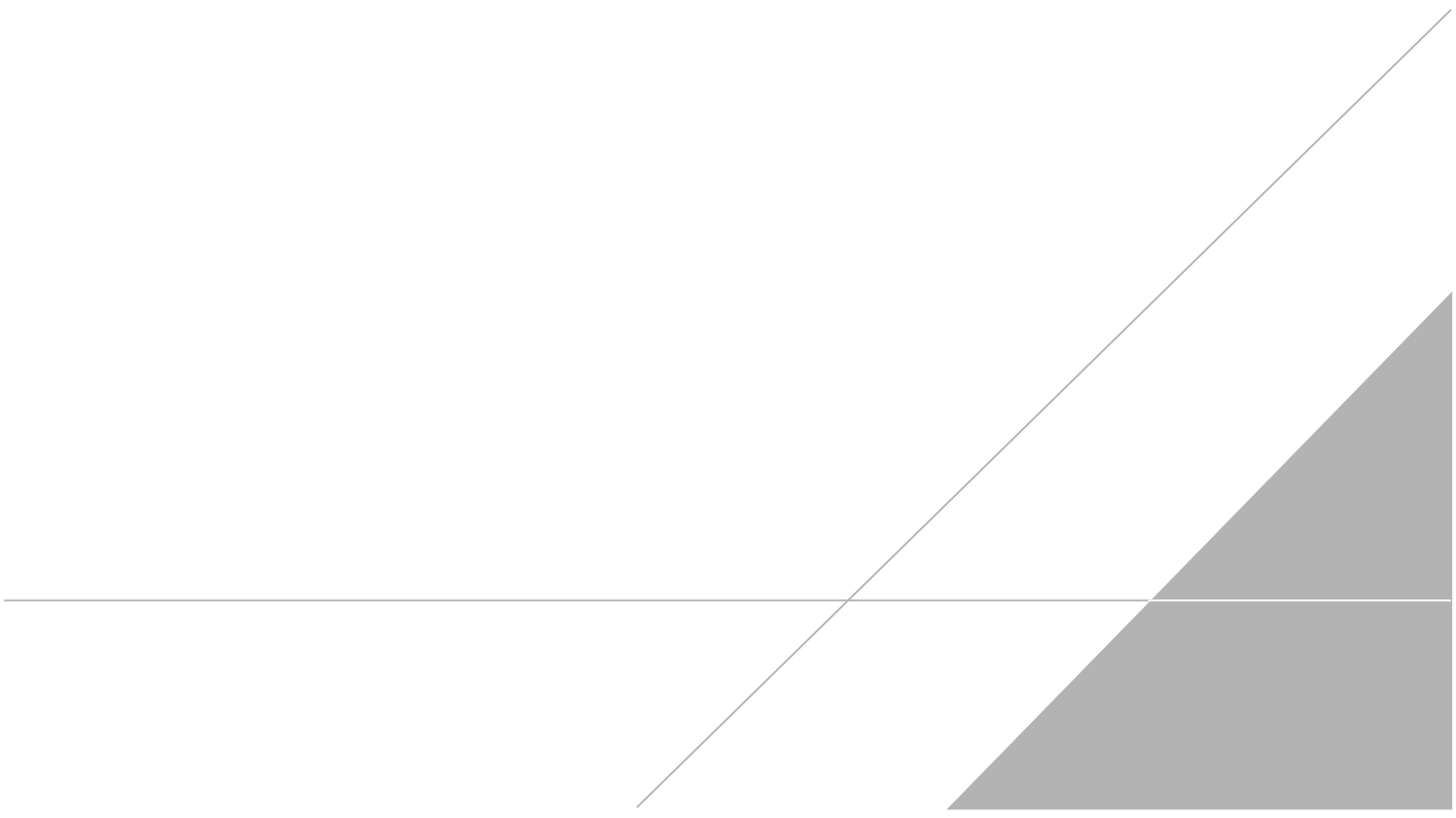

Table 2-1
Offsite Field Activities

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Off-Site Activity	Frequency during 2019
Residential Initial Sampling (includes call-ins)	No initial sampling
Resample Residential Locations, includes annual long-term monitoring list	Throughout Q2 and Q3; sampled annually.
Sulfolane Network Sampling - Monitoring Wells	End of June and throughout Q3
Well Repair and Maintenance	Routine maintenance by sampling staff and monuments reinstalled at MW-165A-15, MW-165B-50 and MW-328-150.
Well destroyed by others due to road construction	MW-335-41, MW-322-15, and MW-322-150
Wells Installed	No wells installed
Wells Redeveloped	MW-165A-15 and MW-165B-50

General Notes:
Q1 = Generally represents activities conducted between November 8, 2018 and March 31, 2019.
Q2 = Generally represents activities conducted between April 1, 2019 and June 30, 2019.
Q3 Generally represents activities conducted between July 1, 2019 and September 30, 2019.
Q4 = Generally represents activities conducted between October 1, 2019 and November 7, 2019.

Table 3-1
Plume Monitoring Plan - Offsite Monitoring Well Parameters

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North Pole Terminal, North Pole, Alaska

Well ID	Date	Analysis	Depth to Water (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH	ORP (mV)	Water Clarity	Sample Collection Notes
MW-150A-10	7/17/2019	Sulfolane	4.78	4.3	0.11	276.0	6.76	84.4	Clear	Parameters Stabilized
MW-150B-25	7/17/2019	Sulfolane	4.8	3.0	0.11	248.3	6.76	118.0	Clear	>3 Well Volumes
MW-165A-15	7/19/2019	Sulfolane	4.90	0.4	0.87	273.9	7.29	59.9	Clear	Parameters Stabilized
MW-165B-50	7/19/2019	Sulfolane	4.45	0.6	0.85	269.3	7.29	29.2	Clear	Parameters Stabilized
MW-166B-30	7/18/2019	Sulfolane	9.2	0.4	1.97	255.2	7.03	63.6	Clear	>3 Well Volumes
MW-167B-35	7/17/2019	Sulfolane	9.2	0.1	0.56	426.3	6.71	52.6	Clear	Parameters Stabilized
MW-171BR-40	6/26/2019	Sulfolane	8.93	1.7	3.31	251.9	6.72	24.6	Clear	>3 Well Volumes
MW-181A-15	7/29/2019	Sulfolane	8.95	3.9	0.52	203.3	7.11	56.1	Clear	Parameters Stabilized
MW-181B-50	7/17/2019	Sulfolane	8.84	3.4	0.41	167.2	7.23	77.4	Clear	Result flagged, insufficient purging
MW-181C-150	7/29/2019	Sulfolane	8.79	3.7	0.38	178.0	7.28	52.8	Clear	Result flagged, insufficient purging
MW-185B-50	7/22/2019	Sulfolane	7.03	4.0	0.86	197.2	7.49	-115.2	Clear	Parameters Stabilized
MW-185C-120	7/22/2019	Sulfolane	7.01	3.7	0.94	167.3	7.49	-59.6	Clear	Parameters Stabilized
MW-190BR-60	7/18/2019	Sulfolane	7.89	4.1	0.87	195.4	7.30	-49.3	Clear	Parameters Stabilized
MW-190-150	7/26/2019	Sulfolane	8.23	4.0	0.42	158.7	6.65	115.6	Clear	Result flagged, insufficient purging
MW-191A-15	7/17/2019	Sulfolane	4.72	4.7	0.30	220.5	6.92	127.3	Clear	Parameters Stabilized
MW-191B-60	7/17/2019	Sulfolane	4.56	3.9	0.10	202.5	7.11	133.1	Clear	Parameters Stabilized
MW-311-15	7/18/2019	Sulfolane	4.39	4.9	0.92	219.3	6.87	34.5	Clear	>3 Well Volumes
MW-311-46	7/18/2019	Sulfolane	4.27	0.6	1.59	187.5	6.77	85.2	Clear	>3 Well Volumes
MW-314-15	7/17/2019	Sulfolane	8.17	1.8	2.51	308.5	6.66	82.1	Clear	>3 Well Volumes
MW-314-150	7/24/2019	Sulfolane	7.95	4.7	0.40	200.7	6.93	62.2	Clear	Result flagged, insufficient purging
MW-328-15	7/17/2019	Sulfolane	7.25	2.6	1.44	207.1	6.84	45.2	Clear	>3 Well Volumes
MW-328-151	7/22/2019	Sulfolane	7.58	2.2	1.70	156.6	7.35	-68.8	Clear	Parameters Stabilized
MW-332-41	7/18/2019	Sulfolane	7.31	2.5	0.50	233.9	6.92	18.6	Clear	>3 Well Volumes
MW-332-110	7/26/2019	Sulfolane	6.74	2.5	0.62	201.3	7.04	78.7	Clear	Result flagged, insufficient purging
MW-332-150	7/22/2019	Sulfolane	7.01	2.0	0.89	169.1	7.47	-86.4	Clear	Parameters Stabilized
MW-346-15	6/26/2019	Sulfolane	5.45	1.1	0.21	225.0	7.00	-35.7	Clear	Parameters Stabilized
MW-346-65	6/26/2019	Sulfolane	5.1	1.7	0.20	181.1	6.98	-14.4	Clear	Parameters Stabilized
MW-346-150	6/26/2019	Sulfolane	4.67	4.4	0.23	164.6	7.21	-34.1	Clear	Parameters Stabilized
MW-347-65	6/26/2019	Sulfolane	9.7	3.9	1.41	186.5	6.91	-17.2	Clear	>3 Well Volumes

Table 3-1
Plume Monitoring Plan - Offsite Monitoring Well Parameters

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Well ID	Date	Analysis	Depth to Water (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH	ORP (mV)	Water Clarity	Sample Collection Notes
MW-347-150	6/26/2019	Sulfolane	10.41	3.6	0.20	161.4	7.23	-30.0	Clear	Parameters Stabilized
MW-349-45	7/19/2019	Sulfolane	7.03	1.4	1.00	224.7	7.20	25.4	Clear	>3 Well Volumes
MW-352-40	6/26/2019	Sulfolane	8.89	1.0	3.04	331.3	6.76	-13.1	Clear	Parameters Stabilized
MW-353-15	7/17/2019	Sulfolane	5.5	2.6	0.20	287.6	6.76	139.9	Clear	>3 Well Volumes
MW-353-65	7/17/2019	Sulfolane	5.71	0.9	0.16	226.6	7.12	106.0	Clear	Parameters Stabilized
MW-353-100	7/17/2019	Sulfolane	5.98	1.6	0.19	220.0	7.03	85.7	Clear	Parameters Stabilized
MW-356-65	7/17/2019	Sulfolane	7.56	4.6	0.25	226.5	7.16	79.6	Clear	Parameters Stabilized
MW-356-90	7/24/2019	Sulfolane	7.69	4.7	0.41	224.6	7.11	68.7	Clear	Result flagged, insufficient purging
MW-357-65	7/18/2019	Sulfolane	11.82	4.4	0.42	176.2	7.36	22.2	Clear	Parameters Stabilized
MW-357-150	7/22/2019	Sulfolane	11.91	4.1	0.96	165.3	7.61	-75.2	Clear	Parameters Stabilized

Acronyms and Abbreviations:
> = greater than
° C = degrees Celsius
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
mV = millivolt
MW = monitoring well
ORP = oxidation-reduction potential

Table 3-2
Plume Monitoring Plan - Offsite Monitoring Well Sulfolane Results

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Well ID	Sample Name	Zone	Sample Date	Sample Type	Sulfolane µg/L
MW-150A-10	MW-150A-10	Water Table	7/17/2019		11.8
MW-150A-10	MW-250A-10	Water Table	7/17/2019	DUP	13.4
MW-150B-25	MW-150B-25	10-55	7/17/2019		7.21J
MW-165A-15	MW-165A-15	Water Table	7/19/2019		<5.15
MW-165B-50	MW-165B-50	10-55	7/19/2019		<5.10
MW-166B-30	MW-166B-30	10-55	7/18/2019		56.7
MW-167B-35	MW-167B-35	10-55	7/17/2019		13.9
MW-171BR-40	MW-171BR-40	10-55	6/26/2019		<5.25
MW-181A-15	MW-181A-15	Water Table	7/29/2019		<5.25
MW-181B-50	MW-181B-50	10-55	7/17/2019		<5.00J*
MW-181C-150	MW-181C-150	90-150	7/29/2019		<5.15J*
MW-185B-50	MW-185B-50	10-55	7/22/2019		<5.05
MW-185C-120	MW-185C-120	90-150	7/22/2019		4.71J
MW-190BR-60	MW-190BR-60	10-55	7/18/2019		<5.20
MW-190-150	MW-190-150	90-150	7/26/2019		<5.15J*
MW-191A-15	MW-191A-15	Water Table	7/17/2019		<5.15
MW-191B-60	MW-191B-60	10-55	7/17/2019		<5.15
MW-191B-60	MW-291B-60	10-55	7/17/2019	DUP	<5.15
MW-311-15	MW-311-15	Water Table	7/18/2019		<5.15
MW-311-46	MW-311-46	10-55	7/18/2019		<5.00
MW-314-15	MW-314-15	Water Table	7/17/2019		<5.05
MW-314-150	MW-314-150	90-150	7/24/2019		<5.20J*
MW-328-15	MW-328-15	Water Table	7/17/2019		<5.00J*
MW-328-151*	MW-328-151	90-150	7/22/2019		3.96J
MW-332-41	MW-332-41	10-55	7/18/2019		<5.05
MW-332-110	MW-332-110	90-150	7/26/2019		7.35J*
MW-332-150	MW-332-150	90-150	7/22/2019		40.3
MW-346-15	MW-346-15	Water Table	6/26/2019		24.8
MW-346-65	MW-346-65	10-55	6/26/2019		61.3
MW-346-150	MW-346-150	90-150	6/26/2019		<5.20
MW-347-65	MW-347-65	10-55	6/26/2019		10.9
MW-347-150	MW-347-150	90-150	6/26/2019		18.7
MW-349-45	MW-349-45	10-55	7/19/2019		<5.00
MW-349-45	MW-449-45	10-55	7/19/2019	DUP	3.15J
MW-352-40	MW-352-40	10-55	6/26/2019		16.1
MW-353-15	MW-353-15	Water Table	7/17/2019		37.2
MW-353-65	MW-353-65	10-55	7/17/2019		39.7
MW-353-100	MW-353-100	55-90	7/17/2019		38.5
MW-356-65	MW-356-65	10-55	7/17/2019		<5.05
MW-356-90	MW-356-90	55-90	7/24/2019		<5.20J*
MW-357-65	MW-357-65	10-55	7/18/2019		<5.00
MW-357-150	MW-357-150	90-150	7/22/2019		<5.05
MW-357-150	MW-457-150	90-150	7/22/2019	DUP	<5.00

Acronyms and Abbreviations:

* = Initial detection in MW-328-151

< = not detected; limit of detection listed.

DUP = Field Duplicate Sample

J = estimated concentration detected below the laboratory limit of quantitation. Flag applied by laboratory.

J* = estimated concentration due to quality control (QC) failures or lack of field QC samples. Flag applied by Shannon & Wilson, Inc.

µg/L = micrograms per liter

Table 3-3
Plume Monitoring Plan - Private Well Sulfolane Results

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Private Well ID	Latitude/Longitude	Well Depth	Zone	Sample Type	Sample Date	Sulfolane µg/L
PW-0250	64.7932, -147.4060	80	55-90		7/15/2019	<5.00
PW-0262	64.7909, -147.3986	200	>160		8/16/2019	<5.05
PW-0265	64.7900, -147.3958	35	10-55		5/23/2019	<5.00J*
PW-0267	64.7900, -147.4000	60	55-90		5/10/2019	<5.25
PW-0270	64.7889, -147.4074	--	--		8/16/2019	<5.10
PW-0271	64.7889, -147.4054	48	10-55		7/11/2019	<5.00
PW-0272	64.7891, -147.4043	220	>160		7/11/2019	<5.05
PW-0273	64.7893, -147.4029	170	>160		7/15/2019	<5.00
PW-0274	64.7893, -147.4015	158	90-160		5/7/2019	<5.30
PW-0275	64.7893, -147.3986	57	55-90		7/15/2019	<5.00
PW-0275	64.7893, -147.3986	57	55-90	DUP	7/15/2019	<5.00
PW-0276	64.7893, -147.3972	49	10-55		7/11/2019	<5.00
PW-0277	64.7893, -147.3958	45	10-55		5/21/2019	<5.10
PW-0280	64.7899, -147.3940	40	10-55		5/23/2019	<5.10
PW-0281	64.7893, -147.3939	40	10-55		8/2/2019	<5.05
PW-0282	64.7886, -147.3941	41	10-55		7/11/2019	<5.00
PW-0284	64.7885, -147.3968	63	55-90		7/11/2019	<5.10
PW-0285	64.7885, -147.3982	63	55-90		7/15/2019	<5.00
PW-0286	64.7885, -147.3996	160	>160		5/7/2019	<5.15
PW-0287	64.7885, -147.4010	186	>160		5/21/2019	<5.10
PW-0288	64.7882, -147.4038	200	>160		7/11/2019	<5.00
PW-0289	64.7881, -147.4052	40	10-55		5/21/2019	<5.15
PW-0290	64.7880, -147.4080	205	>160		5/7/2019	<5.10
PW-0358	64.7662, -147.3569	105	90-160		5/7/2019	6.78J
PW-0358	64.7662, -147.3569	105	90-160	DUP	5/7/2019	8.53J
PW-0365	64.7664, -147.3459	--	--		1/18/2019	<2.50
PW-0365	64.7664, -147.3459	--	--		3/22/2019	<2.50
PW-0365	64.7664, -147.3459	--	--		6/17/2019	<2.50
PW-0365	64.7664, -147.3459	--	--		8/23/2019	<2.50
PW-0365	64.7664, -147.3459	--	--		9/27/2019	<2.50
PW-0365	64.7664, -147.3459	--	--	DUP	9/27/2019	<2.50
PW-0366	64.7672, -147.3428	--	--		5/3/2019	<5.05J*
PW-0367	64.7684, -147.3435	--	--		8/5/2019	<5.00
PW-0368	64.7682, -147.3431	--	--		8/5/2019	<5.05
PW-0369	64.7690, -147.3445	--	--		8/13/2019	<5.00
PW-0369	64.7690, -147.3445	--	--	DUP	8/13/2019	<5.05
PW-0370	64.7704, -147.3466	--	--		5/2/2019	<5.10
PW-0370	64.7704, -147.3466	--	--	DUP	5/2/2019	<5.05
PW-0371	64.7708, -147.3475	--	--		5/2/2019	<5.10
PW-0372	64.7714, -147.3498	--	--		7/3/2019	<5.15
PW-0373	64.7717, -147.3507	--	--		4/25/2019	<5.20
PW-0374	64.7720, -147.3514	--	--		4/25/2019	<5.15

Table 3-3
Plume Monitoring Plan - Private Well Sulfolane Results

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Private Well ID	Latitude/Longitude	Well Depth	Zone	Sample Type	Sample Date	Sulfolane µg/L
PW-0379	64.7697, -147.3485	--	--		5/3/2019	<5.05J*
PW-0464	64.7754, -147.3686	98	90-160		6/24/2019	111
PW-0508	64.7764, -147.3553	80	55-90		5/21/2019	<5.05
PW-0512	64.7744, -147.3534	300	>160		7/3/2019	<5.10
PW-0513	64.7738, -147.3530	45.6	10-55		7/3/2019	<5.25
PW-0531	64.7850, -147.3641	--	--		5/10/2019	<5.05
PW-0532	64.7848, -147.3579	--	--		5/9/2019	<5.10
PW-0533	64.7842, -147.3569	--	--		5/2/2019	<5.05
PW-0534	64.7834, -147.3568	--	--		4/26/2019	<5.20
PW-0535	64.7826, -147.3567	--	--		4/26/2019	<5.25
PW-0536	64.7817, -147.3565	--	--		4/26/2019	<5.25
PW-0537	64.7809, -147.3563	--	--		4/26/2019	<5.20
PW-0538	64.7797, -147.3558	40	10-55		5/23/2019	<5.05
PW-0546	64.7808, -147.3604	--	--		5/8/2019	<5.20
PW-0547	64.7801, -147.3605	40	10-55		5/24/2019	<5.15
PW-0548	64.7793, -147.3595	40	10-55		7/3/2019	<5.15
PW-0549	64.7774, -147.3570	--	--		7/3/2019	<5.30
PW-0555	64.7816, -147.3635	36	10-55		8/5/2019	3.16J
PW-0587	64.7890, -147.3881	--	--		5/2/2019	<5.05
PW-0589	64.7893, -147.3904	--	--		5/2/2019	<5.10
PW-0594	64.7896, -147.3905	--	--		6/4/2019	<5.15
PW-0623	64.7671, -147.4167	--	--		5/9/2019	64.1J*
PW-0623	64.7671, -147.4167	--	--	DUP	5/9/2019	64.5J*
PW-0628	64.7634, -147.4157	30	10-55		5/21/2019	<5.05
PW-0628	64.7634, -147.4157	30	10-55	DUP	5/21/2019	<5.00
PW-0630	64.7638, -147.4173	--	--		5/21/2019	3.71J*
PW-0749	64.7881, -147.3846	32	10-55		6/4/2019	<5.25
PW-0750	64.7876, -147.3847	--	--		6/4/2019	<5.05J*
PW-0751	64.7872, -147.3850	60	55-90		5/9/2019	<5.40
PW-0752	64.7867, -147.3853	--	--		6/4/2019	<5.15J*
PW-0753	64.7862, -147.3856	55	55-90		5/13/2019	<5.45
PW-0761	64.7871, -147.3773	30	10-55		5/6/2019	<5.15J*
PW-0762	64.7877, -147.3775	40	10-55		8/2/2019	<5.00
PW-0770	64.7875, -147.3821	--	--		5/8/2019	<5.15
PW-0771	64.7870, -147.3824	--	--		8/2/2019	<5.00
PW-0772	64.7865, -147.3830	--	--		5/9/2019	<5.10J*
PW-0774	64.7861, -147.3817	--	--		8/16/2019	<5.05
PW-0775	64.7865, -147.3808	55	55-90		6/4/2019	<5.10
PW-0776	64.7868, -147.3797	40	10-55		5/13/2019	<5.30
PW-0777	64.7875, -147.3801	--	--		5/13/2019	<5.10J*
PW-0790	64.8047, -147.4145	120	90-160		8/6/2019	<5.05
PW-0863	64.7872, -147.3721	65	55-90		8/8/2019	<5.05

Table 3-3
Plume Monitoring Plan - Private Well Sulfolane Results

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Private Well ID	Latitude/Longitude	Well Depth	Zone	Sample Type	Sample Date	Sulfolane µg/L
PW-0866	64.7872, -147.3754	42	10-55		8/16/2019	<5.05
PW-0868	64.7865, -147.3743	57	55-90		8/2/2019	<5.05
PW-0869	64.7865, -147.3721	42	10-55		5/24/2019	<5.10
PW-0870*	64.7856, -147.3721	42	10-55		5/9/2019	3.69J
PW-0871	64.7857, -147.3732	50	10-55		5/6/2019	4.90J
PW-0871	64.7857, -147.3732	50	10-55	DUP	5/6/2019	4.77J
PW-0872	64.7858, -147.3749	--	--		8/6/2019	7.31J
PW-0905	64.7872, -147.3709	40	10-55		8/12/2019	<5.05
PW-0906	64.7872, -147.3697	34	10-55		5/10/2019	<5.40
PW-0907	64.7873, -147.3684	45	10-55		5/3/2019	<5.10
PW-0908	64.7866, -147.3684	50	10-55		7/15/2019	<5.00
PW-0909	64.7865, -147.3697	50	10-55		5/24/2019	<5.10
PW-0910	64.7865, -147.3709	80	55-90		5/23/2019	<5.05
PW-0911	64.7858, -147.3684	60	55-90		7/15/2019	<5.00
PW-0912	64.7851, -147.3710	42	10-55		7/19/2019	4.75J
PW-0972	64.7696, -147.4319	236	>160		5/23/2019	<5.00J*
PW-0973	64.7695, -147.4305	70	55-90		7/15/2019	<5.00
PW-0974	64.7692, -147.4293	40	10-55		5/8/2019	<5.35
PW-0976	64.7698, -147.4291	38	10-55		5/14/2019	<5.45J*
PW-0977	64.7702, -147.4319	--	--		5/9/2019	<5.20J*
PW-0978	64.7684, -147.4307	218	>160		4/25/2019	<5.15
PW-0979	64.7683, -147.4294	--	--		5/6/2019	<5.15
PW-0998	64.7710, -147.3517	--	--		5/6/2019	<5.05
PW-1087	64.7686, -147.3502	--	--		7/3/2019	<5.20
PW-1088	64.7874, -147.3886	60	55-90		6/4/2019	<5.15
PW-1093	64.7889, -147.4064	220	>160		5/3/2019	<5.00
PW-1185	64.7617, -147.3566	--	--		5/13/2019	<5.05
PW-1230	64.7579, -147.3716	231	>160		7/19/2019	420
PW-1230	64.7579, -147.3716	231	>160	DUP	7/19/2019	468
PW-1333	64.7831, -147.3648	--	--		5/24/2019	<5.20
PW-1333	64.7831, -147.3648	--	--	DUP	5/24/2019	<5.50
PW-1433	64.7670, -147.4222	--	--		6/27/2019	45.8J*
PW-1433	64.7670, -147.4222	--	--	DUP	6/27/2019	43.1J*
PW-1454	64.7787, -147.3588	--	--		5/8/2019	<5.20
PW-1473	64.7865, -147.3732	42	10-55		5/24/2019	<5.05J*
PW-1608	64.7900, -147.3986	60	55-90		5/10/2019	<5.05
PW-1812	64.8052, -147.4541	150	90-160		5/6/2019	<5.05J*
PW-1921	64.7815, -147.3603	--	--		5/3/2019	<5.05
PW-1930	64.7735, -147.3528	--	--		7/3/2019	<5.25
PW-1930	64.7735, -147.3528	--	--	DUP	7/3/2019	<5.20
PW-2211	64.7945, -147.4407	180	--		8/8/2019	<5.00
PW-2219	64.7645, -147.4148	60	55-90		4/2/2019	31.6

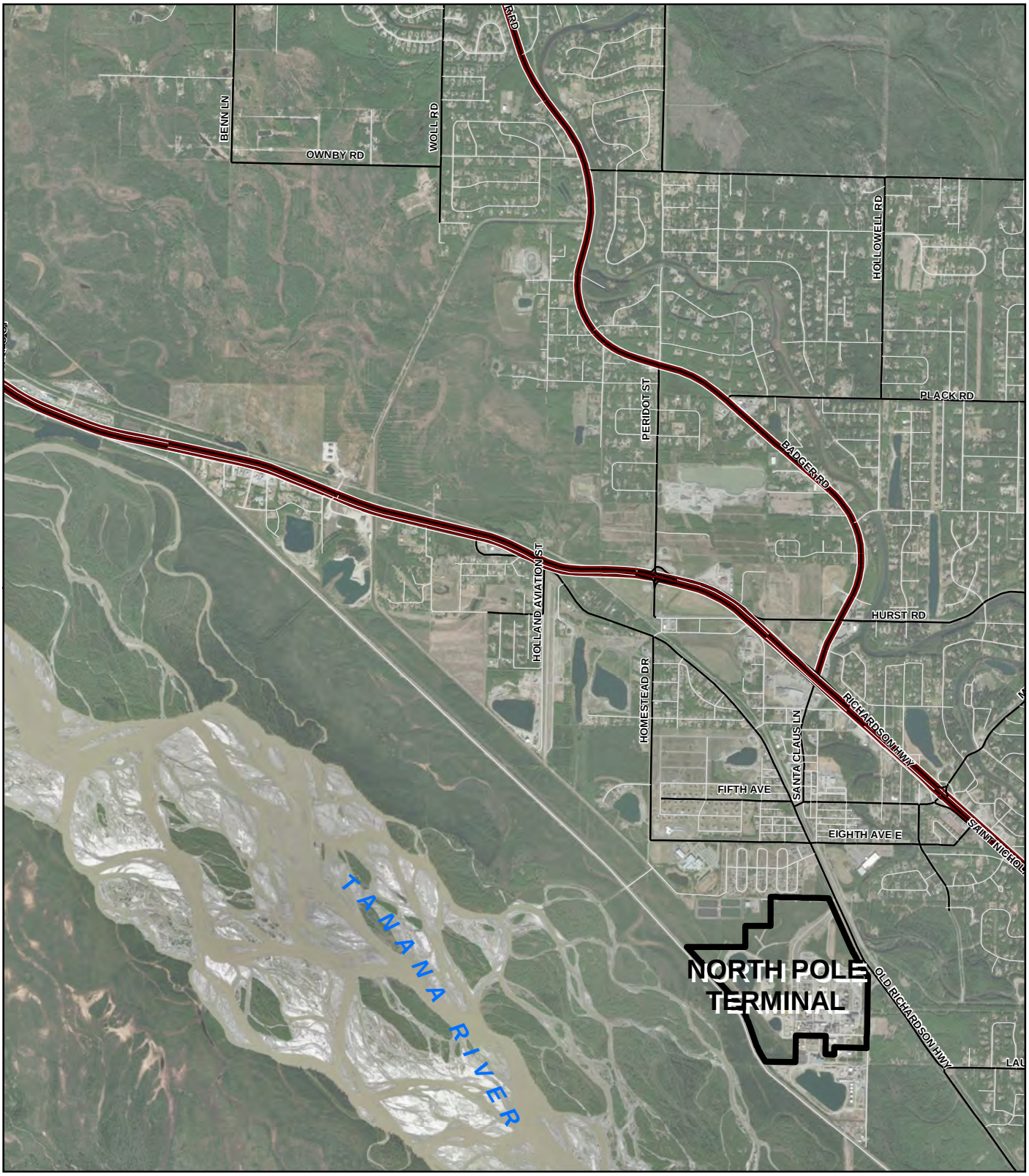
Table 3-3
Plume Monitoring Plan - Private Well Sulfolane Results

Annual 2019 Offsite Plume Monitoring Report
North Pole Terminal, North Pole, Alaska

Private Well ID	Latitude/Longitude	Well Depth	Zone	Sample Type	Sample Date	Sulfolane µg/L
PW-2219	64.7645, -147.4148	60	55-90	DUP	4/2/2019	31.5
PW-2233	64.7863, -147.3757	--	--		7/15/2019	<5.00
PW-2234	64.7885, -147.3951	--	--		5/23/2019	<5.10
PW-2237	64.7851, -147.3599	40	--		5/10/2019	<5.40

Acronyms and Abbreviations:
* = Initial detection in PW-0870
-- = not available
< = not detected; limit of detection listed
> = greater than
DUP = field-duplicate sample
J = Estimated concentration, detected greater than the detection limit and less than the limit of quantitation. Flag applied by the laboratory.
J* = Estimated concentration due to quality control failures. Flag applied by Shannon & Wilson, Inc.
µg/L = micrograms per liter

FIGURES



LEGEND:

PROPERTY BOUNDARY

0 0.5 1 Miles

GRAPHIC SCALE

Note:
-May 2015 ESRI Cloud Imagery

NORTH POLE TERMINAL, NORTH POLE, ALASKA

ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

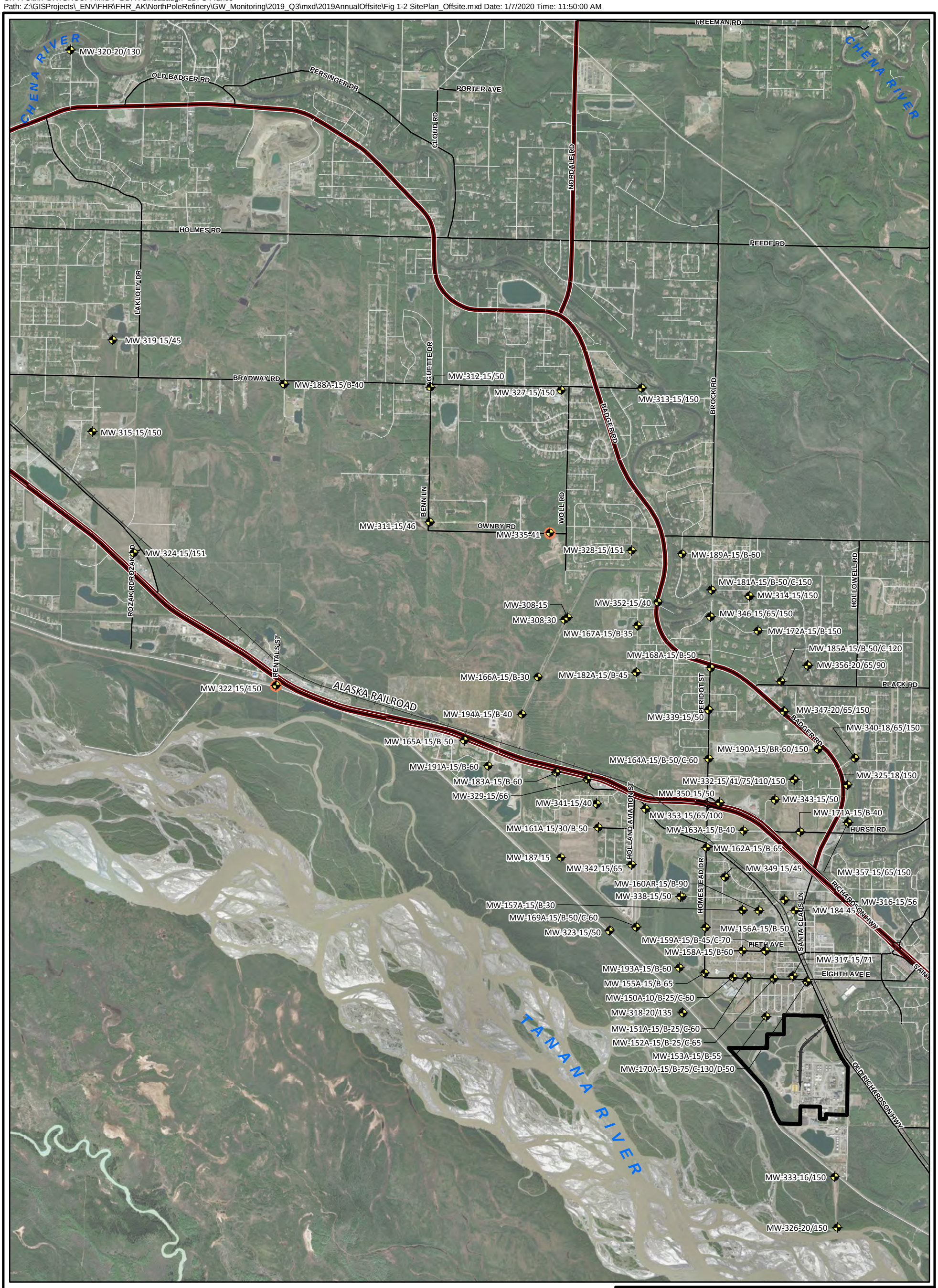
SITE LOCATION

ARCADIS

FIGURE 1-1

CITY: Citrix_DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENVFHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig 1-1 SiteLocation.mxd Date: 1/7/2020 Time: 11:48:10 AM

CITY: Citrix DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig 1-2 SitePlan_Offsite.mxd Date: 1/7/2020 Time: 11:50:00 AM



Legend:

- Monitoring Well
- Monitoring Well destroyed by others
- Property Boundary
- Highway
- Major Road
- Local Road
- Rail Line

0 3,300 6,600 Feet
GRAPHIC SCALE

Note:
-May 2015 ESRI Cloud Imagery

NORTH POLE TERMINAL, NORTH POLE, ALASKA

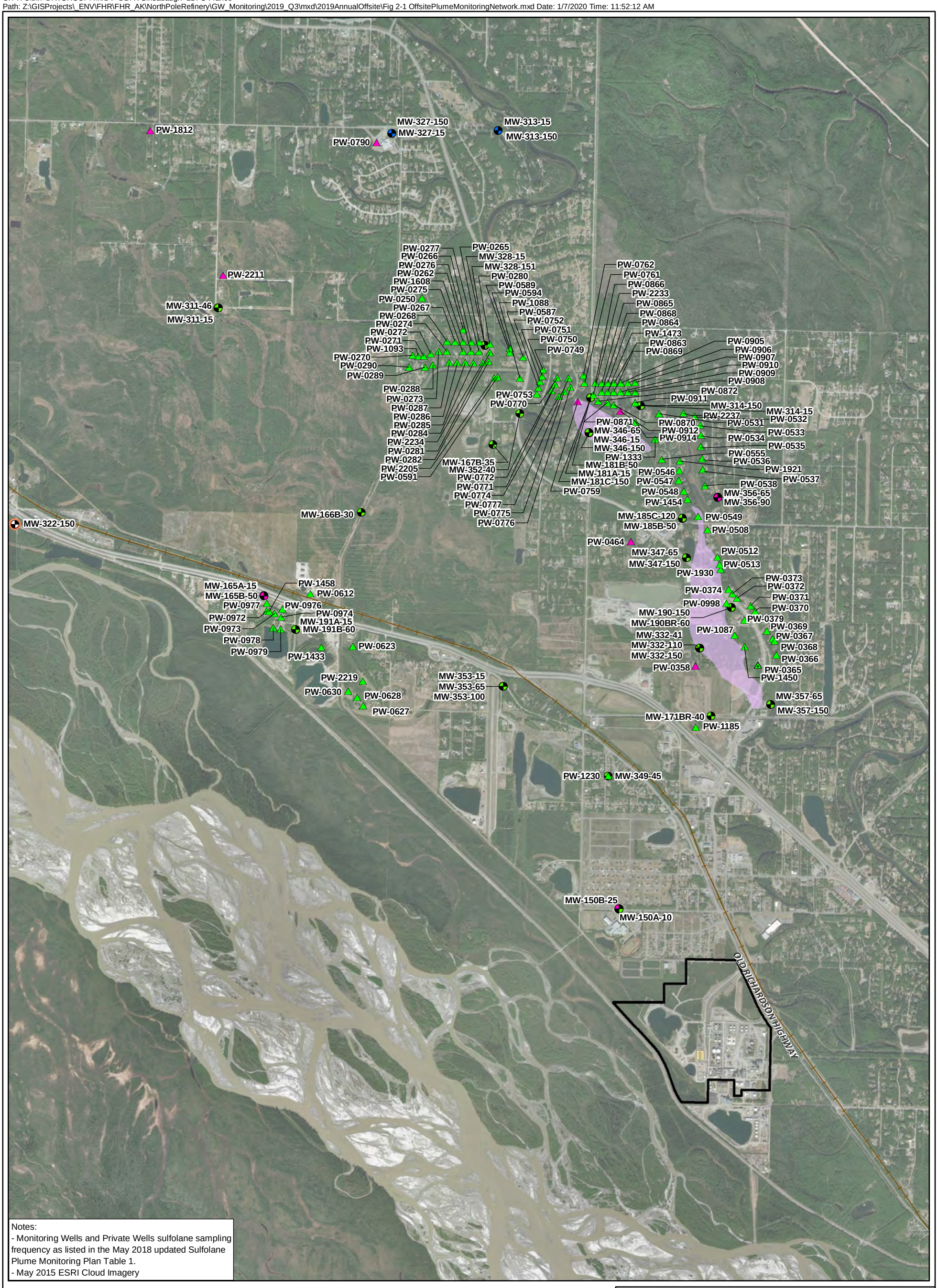
ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

SITE PLAN - OFFSITE

ARCADIS

FIGURE
1-2

CITY: Citrix DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig 2-1 OffsitePlumeMonitoringNetwork.mxd Date: 1/7/2020 Time: 11:52:12 AM



Notes:
- Monitoring Wells and Private Wells sulfolane sampling frequency as listed in the May 2018 updated Sulfolane Plume Monitoring Plan Table 1.
- May 2015 ESRI Cloud Imagery

Legend

- Monitoring Well
- Private Well
- Point-of-entry treatment system sample collected
- Monitoring Well destroyed by others
- Inferred Suprapermafrost and Subpermafrost Mixing Zone
- Property Boundary

MW-332-150 Monitoring Well Location ID
PW-0627 Private Well Location ID

Well Sampling Frequency
- Annual
- Every 2 years
- Every 5 years

0 2,500 5,000
SCALE IN FEET

NORTH POLE TERMINAL, NORTH POLE, ALASKA

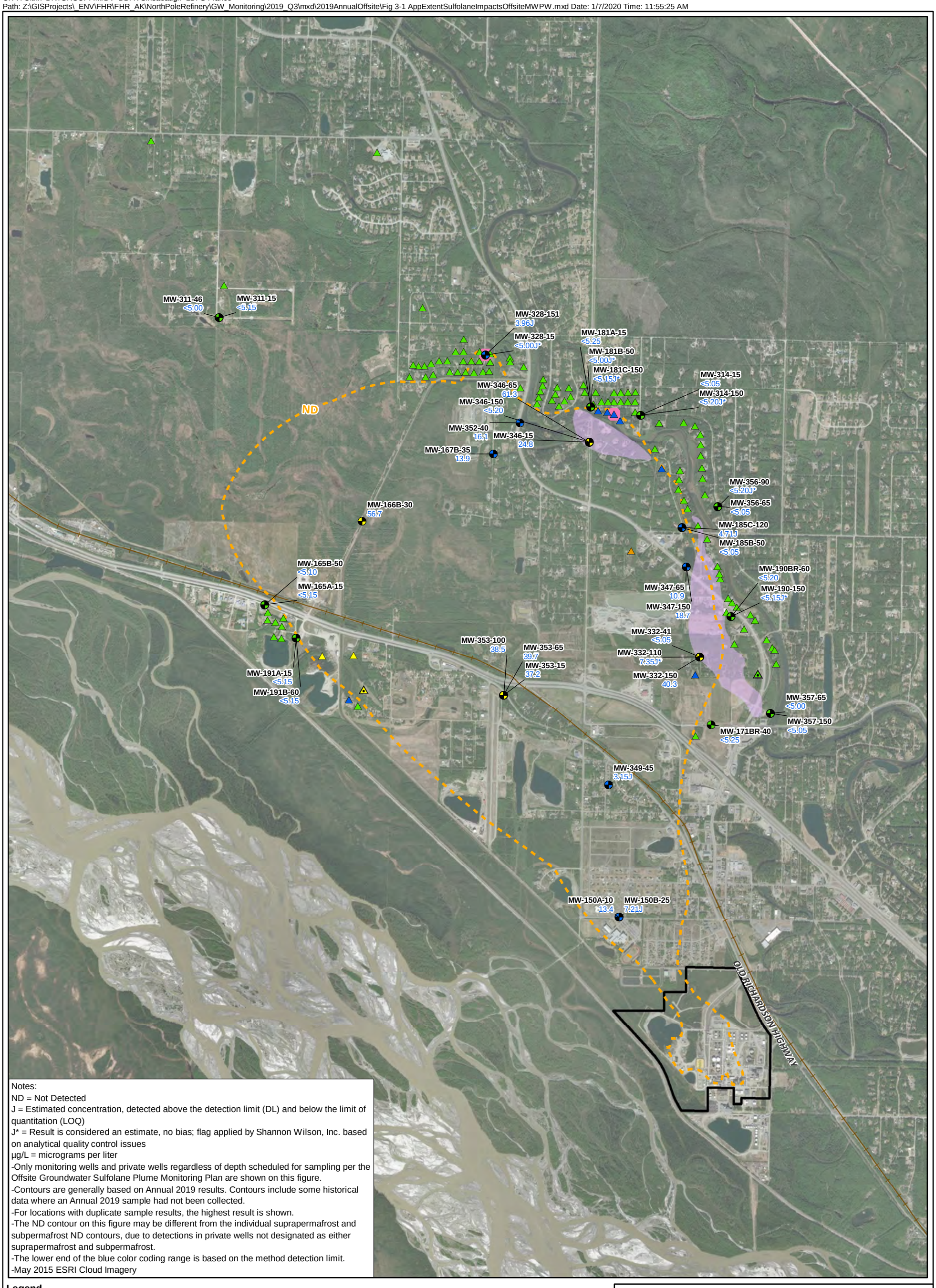
ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

OFFSITE PLUME MONITORING PLAN NETWORK

ARCADIS

FIGURE 2-1

CITY: Citrix DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig 3-1 AppExtentSulfolaneImpactsOffsiteMWPW.mxd Date: 1/7/2020 Time: 11:55:25 AM



Notes:
ND = Not Detected
J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
J* = Result is considered an estimate, no bias; flag applied by Shannon Wilson, Inc. based on analytical quality control issues
µg/L = micrograms per liter
-Only monitoring wells and private wells regardless of depth scheduled for sampling per the Offsite Groundwater Sulfolane Plume Monitoring Plan are shown on this figure.
-Contours are generally based on Annual 2019 results. Contours include some historical data where an Annual 2019 sample had not been collected.
-For locations with duplicate sample results, the highest result is shown.
-The ND contour on this figure may be different from the individual suprapermafrost and subpermafrost ND contours, due to detections in private wells not designated as either suprapermafrost and subpermafrost.
-The lower end of the blue color coding range is based on the method detection limit.
-May 2015 ESRI Cloud Imagery

Legend

- Monitoring Well
- Point-of-entry treatment system sample collected
- Private Well
- Initial Detection
- Approximate Sulfolane Isopleth Regardless of Depth
- Inferred Suprapermafrost and Subpermafrost Mixing Zone
- Property Boundary

Private Well Sulfolane Results

- Not Detected
- 1.0 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L
- 200 - 300 µg/L
- 300 - 400 µg/L
- Greater than 400 µg/L

MW-153A-15 Monitoring Well Location ID
128 Sulfolane Concentration (µg/L)
< Not detected: detection limit listed

Monitoring Well Sulfolane Results

- Not Detected
- 3.1 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L

0 2,500 5,000
SCALE IN FEET

NORTH POLE TERMINAL, NORTH POLE, ALASKA

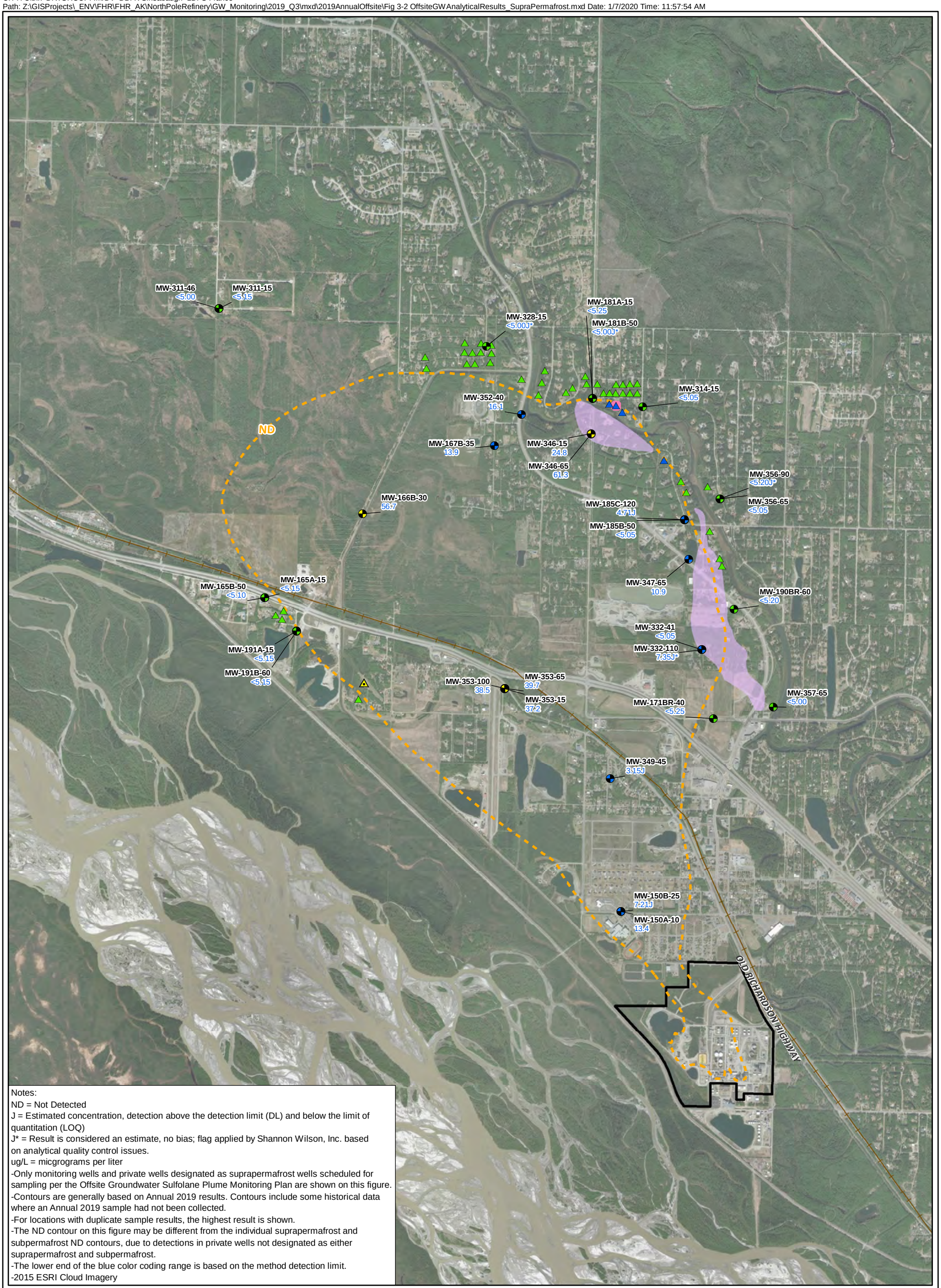
ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

ANNUAL 2019 APPROXIMATE EXTENT OF SULFOLANE IMPACTS

ARCADIS

FIGURE
3-1

CITY: Citrix DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig 3-2 OffsiteGWAnalyticalResults_SupraPermafrost.mxd Date: 1/7/2020 Time: 11:57:54 AM



Notes:
ND = Not Detected
J = Estimated concentration, detection above the detection limit (DL) and below the limit of quantitation (LOQ)
J* = Result is considered an estimate, no bias; flag applied by Shannon Wilson, Inc. based on analytical quality control issues.
ug/L = micgrograms per liter
-Only monitoring wells and private wells designated as suprapermafrost wells scheduled for sampling per the Offsite Groundwater Sulfolane Plume Monitoring Plan are shown on this figure.
-Contours are generally based on Annual 2019 results. Contours include some historical data where an Annual 2019 sample had not been collected.
-For locations with duplicate sample results, the highest result is shown.
-The ND contour on this figure may be different from the individual suprapermafrost and subpermafrost ND contours, due to detections in private wells not designated as either suprapermafrost and subpermafrost.
-The lower end of the blue color coding range is based on the method detection limit.
-2015 ESRI Cloud Imagery

Legend

- Monitoring Well
- Point-of-entry treatment system sample collected
- Private Well
- Initial Detection
- Approximate Sulfolane Isopleth
- Inferred Suprapermafrost and Subpermafrost Mixing Zone
- Property Boundary

Private Well Sulfolane Results

- Not Detected
- 1.0 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L
- 200 - 300 µg/L
- 300 - 400 µg/L
- Greater than 400 µg/L

MW-338-50 Monitoring Well Location ID
61.4 Sulfolane Concentration (µg/L)
< Not detected: detection limit listed

Monitoring Well Sulfolane Results

- Not Detected
- 3.1 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L

0 2,500 5,000
SCALE IN FEET

NORTH POLE TERMINAL, NORTH POLE, ALASKA

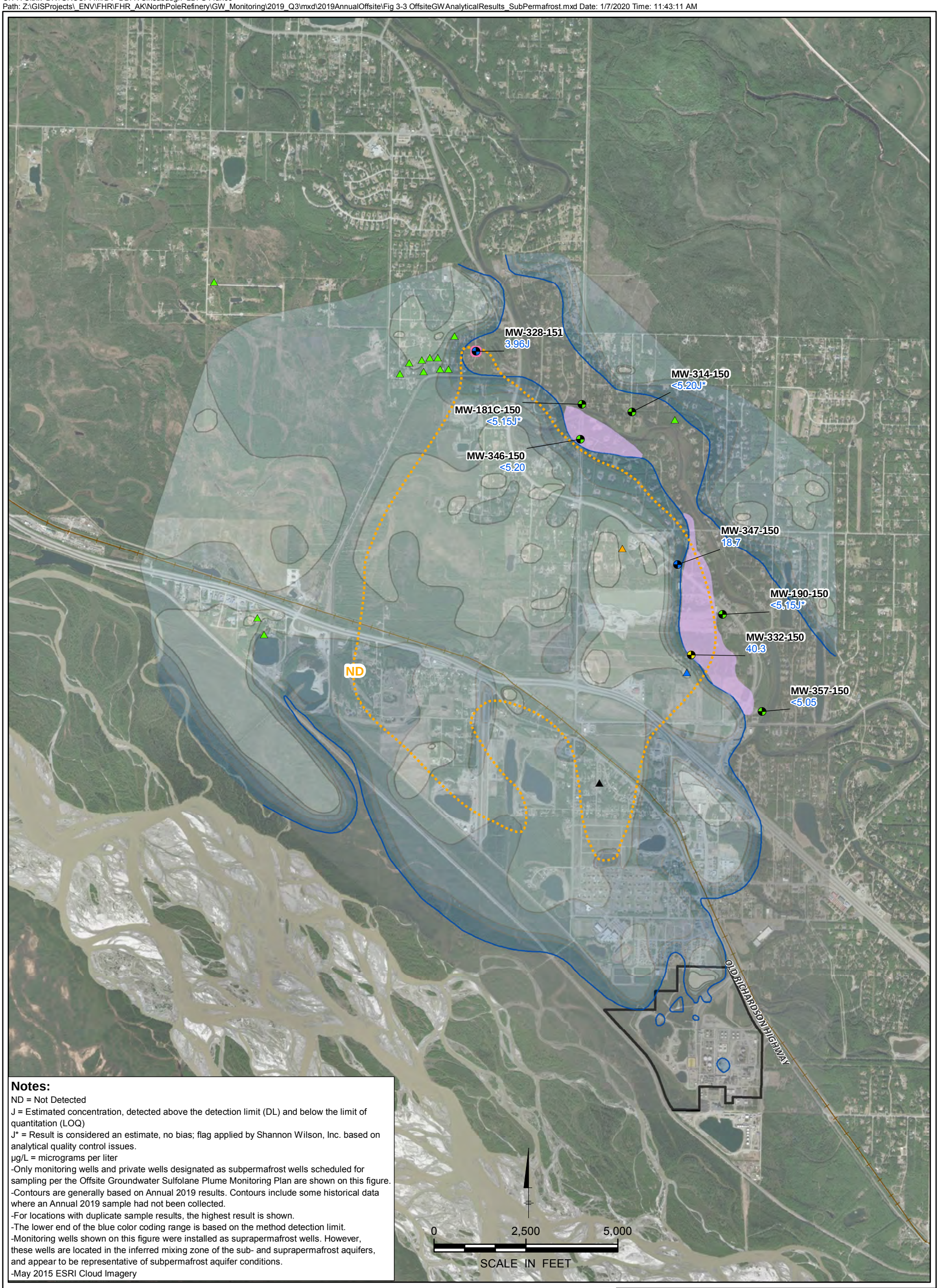
ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

ANNUAL 2019 GROUNDWATER ANALYTICAL RESULTS IN THE SUPRAPERMAFROST AQUIFER

ARCADIS

FIGURE
3-2

CITY: Citrix DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig 3-3 OffsiteGWAnalyticalResults_SubPermafrost.mxd Date: 1/7/2020 Time: 11:43:11 AM



Notes:

ND = Not Detected
J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
J* = Result is considered an estimate, no bias; flag applied by Shannon Wilson, Inc. based on analytical quality control issues.
µg/L = micrograms per liter
-Only monitoring wells and private wells designated as subpermafrost wells scheduled for sampling per the Offsite Groundwater Sulfolane Plume Monitoring Plan are shown on this figure.
-Contours are generally based on Annual 2019 results. Contours include some historical data where an Annual 2019 sample had not been collected.
-For locations with duplicate sample results, the highest result is shown.
-The lower end of the blue color coding range is based on the method detection limit.
-Monitoring wells shown on this figure were installed as suprapermafrost wells. However, these wells are located in the inferred mixing zone of the sub- and suprapermafrost aquifers, and appear to be representative of subpermafrost aquifer conditions.
-May 2015 ESRI Cloud Imagery

Legend

- Monitoring Well
- Point-of-entry treatment system sample collected
- Private Well
- Initial Detection
- Approximate Sulfolane Isopleth
- Inferred Suprapermafrost and Subpermafrost Mixing Zone
- Property Boundary

Private Well Sulfolane Results

- Not Detected
- 1.0 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L
- 200 - 300 µg/L
- 300 - 400 µg/L
- Greater than 400 µg/L

MW-314 Monitoring Well Location ID
70.7 Sulfolane Concentration (µg/L)
< Not detected: detection limit listed

Monitoring Well Sulfolane Results

- Not Detected
- 3.1 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L

Depth to Permafrost in feet

- < 10
- 10 - 30
- 30 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- > 150

NORTH POLE TERMINAL, NORTH POLE, ALASKA

ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

ANNUAL 2019 GROUNDWATER ANALYTICAL RESULTS IN THE SUBPERMAFROST AQUIFER

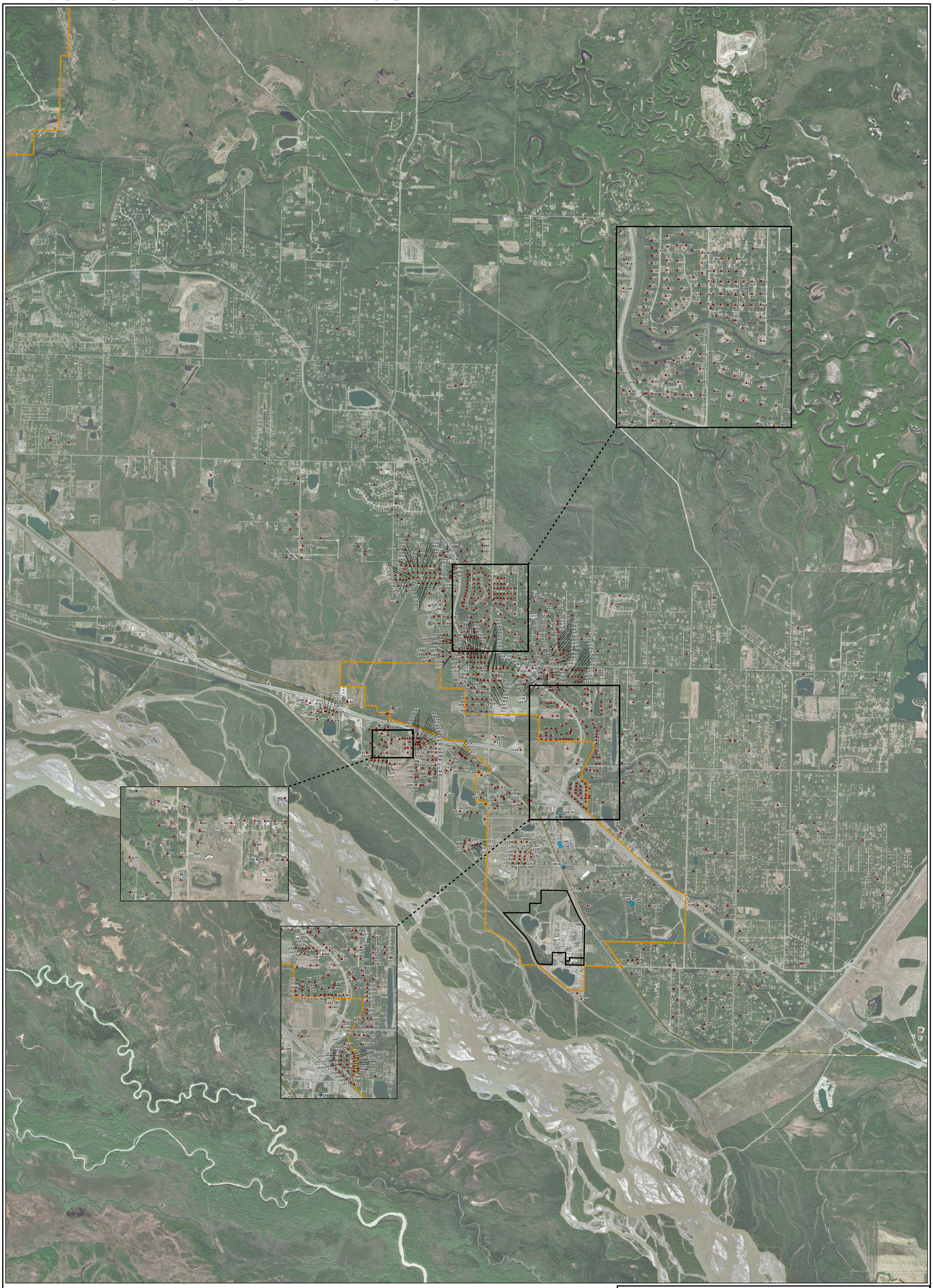
ARCADIS

FIGURE
3-3

APPENDIX A

Supplemental Figures

CITY: Citrix DIV/GROUP: ENV/IM DB: K Sinsabaugh LD: G FRANCE
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig A-1 PrivateWells_SizeD_3Q18.mxd Date: 12/17/2019 Time: 11:02:52 AM



Legend

- Private Wells
- Municipal Wells
- Statewide Railroads
- North Pole City Boundary
- Property Boundary

Notes:
-Private wells shown have been assigned a PW-ID because a sample has been collected
-Municipal wells CNP-5F and CNP-4F are labeled as private wells PW-1491 and PW-1492, respectively on this figure
-May 2015 ESRI Cloud Imagery

0 1,200 2,400 4,800
Feet

NORTH POLE TERMINAL, NORTH POLE, ALASKA

ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

PRIVATE WELL LOCATION MAP

ARCADIS

FIGURE
A-1

CITY: Citrix DIV/GROUP: IM/DV DB: K Sinsabaugh LD: G France
Path: Z:\GISProjects_ENV\FHR\FHR_AK\NorthPoleRefinery\GW_Monitoring\2019_Q3\mxd\2019AnnualOffsite\Fig A-2 PrivateWell_Sulfolane.mxd Date: 12/17/2019 Time: 2:06:59 PM

Notes:
-Sulfolane dataset displays the most recent private well sample results received from November 8, 2018 to November 7, 2019.
-The lower end of the blue color coding range is based on the method detection limit.
- For locations with duplicate sample results, the highest result is shown.

LEGEND:

- Private Well
- Point-of-entry treatment system sample collected
- North Pole City Boundary
- Property Boundary

Private Well Sulfolane Results

- Not Detected
- 1.0 - Less Than 20 µg/L
- 20 - 100 µg/L
- 100 - 200 µg/L
- 200 - 300 µg/L
- 300 - 400 µg/L
- Greater than 400 µg/L

0 2,500 5,000
SCALE IN FEET

NORTH POLE TERMINAL, NORTH POLE, ALASKA
ANNUAL 2019 OFFSITE PLUME MONITORING REPORT

PRIVATE WELL SULFOLANE RESULTS

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FIGURE A-2